

AMSTERDAM SMART CITIZENS LAB

TOWARDS COMMUNITY DRIVEN DATA COLLECTION

A PUBLICATION BY WAAG SOCIETY & AMS INSTITUTE

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THE AMSTERDAM SMART CITIZENS LAB
TOWARDS COMMUNITY DRIVEN DATA COLLECTION

ISBN 978-90-806452-4-0

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Waag Society runs the ASCL in conjunction with Gemeente Amsterdam (CTO), HvA, RIVM, SenseMakers, Alterra, AMS, Amsterdam Economic Board, Fablab Amsterdam, and the Open Wetlab; and internationally with Fablab Barcelona, Microgiants, FutureEverything, Dundee University, and others.

With special thanks to Mara Balestrini, Ger Baron, Co de Boer, Pieter van Boheemen, Alessandro Bozzon, Jonathan Carter, Roberta Colavecchio, Guillermo José Rodríguez Fernández, Ester van der Geest, Christine van den Horn, Joske Houtkamp, Qijun Jiang, Folkert Lodewijks, Emma Pareschi, Edith van Putten, Cindy Regalado, Pinar Temiz, Hester Volten, Maurice de Vries, Mathijs de Weerd, Joost Wesseling and all the participants in the Lab.



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***What would happen
if everyday Amsterdammers
were empowered by technology
to make the city they love
an even better place to live
in the future?***





NATASHA DE SENA
*Programme Developer Research
AMS*

“AMS Institute functions as a place where science, technology and design come together with bottom-up initiatives, citizens and industry to find real-world solutions that will transform cities into prosperous, dynamic and adaptive living environments. The connection between the Amsterdam Smart Citizens Lab experiment and AMS Institute’s scientific research was a great experience and brought together important stakeholders in order to discuss citizen sensing and empowerment. It was one more step towards a greatly adaptive and user-centred urban environment, and we are surely ready for the next ones!”



FRANK KRESIN
*Research Director
Waag Society*

“The Amsterdam Smart Citizens Lab is an ongoing investigation enabling citizens to shape their cities, using open source technologies and shared knowledge. It has been a collaborative effort, built upon previous experiments in Amsterdam and abroad, involving strong and committed partnerships. In this publication we share our approach and the lessons learned, as well as our future plans. We greatly welcome your questions and remarks, which will be invaluable in bringing this topic further.”

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01 INTRODUCTION

In late spring, farmers from Noordoostpolder to Bollentreek survey the sinuous petals of their iconic tulips crops as they sway in the wind like a flock of birds that have descended to form an amorphous mass of bobbing iridescent heads and feathers obscuring the horizon. As dusk sets in and gives the sun some relief from its incarceration behind the perennially cloudy Dutch skies, the colonies of greenhouses that inhabit the *groene hart* of the Netherlands ignite with the gentle hum of citrine-colored incandescent blubs cloaking the once starlit nights of our forefathers captured so succinctly by likes of van Gogh, Rembrandt, van der Neer and Cuyp.

The thin strip of light vaguely gliding in the distance reveals itself to be an NS commuter train. Careening north, the monotonous grid of polders, farmhouses and nameless towns gives way to the seductive glass facades of ultra-modern high rises and research parks awkwardly grafted on to the charming historical cities of Delft, Den Haag and Leiden as it slithers deeper and deeper into denser strata of urbanity. Eventually, the lights of a cityscape become more prominent and the mechanical yellow beast finally comes to a stop in nucleus of these lowlands: *Amsterdam*.

“Like any other city, Amsterdam wants to grow and prosper while maintaining its world-class reputation and a high quality of life for its citizens.”

Amsterdam’s reputation precedes itself. Along with being the political, economic and cultural capital of the Netherlands, Amsterdam is one of the most popular tourist destinations in Europe and is consistently ranked as one of the most livable cities in the world. Putting the splendors of picturesque canals and architectural aesthetic aside, Amsterdam is a collection of talented and hardworking individuals concerned about their city’s future. From the fishermen who transformed it from a medieval backwater into one of the wealthiest and most cosmopolitan urban centers of the 17th century, to the *Kabouters* of the 1960s and 70s whose tireless advocacy of progressive housing and social programs earned Amsterdam the distinction of being ‘the world’s most liberal city’¹, Amsterdammers are known for their ambition, individualism, tolerance and international outlook. In his historical account of the city, writer and New York Times columnist, Russell Shorto summed up Amsterdam’s disposition as ¹‘together, we maintain a society of individuals’.

Today, the greater Amsterdam metropolitan area is home to about 2.4 million people, a relatively young and diverse population characterized by a large number of internationals and single-person households with higher levels of education compared to other regions of the country. Its service-oriented economy generates about € 61.5 billion annually, representing about 8.5 percent of the total Dutch economy^{2,3}. Despite these accolades, the city is not without its challenges.

Like any other city, Amsterdam wants to grow and prosper while maintaining its world-class reputation and a high quality of life for its citizens. But because of its dense and somewhat fixed urban infrastructure, unchecked growth will make the downsides of urban living like traffic and air, water, and noise pollution more pronounced unless alternative adaptive strategies are investigated and implemented. This begs the question: what would happen if everyday Amsterdammers were empowered by technology to understand urban environmental and make the city they love an even better place to live in the future?

In 2015, Waag Society and its partners aimed to answer this very question with the first edition of its *Amsterdam Smart Citizens Lab*. Leaving Amsterdam Central Station, be sure to take a left down Prins Hendrikkade towards Zeedijk. After navigating through teeming schools of bicycles and the throngs of tourists with their ‘I Love Amsterdam’ scarves and selfie sticks in tow you will eventually arrive upon the Nieuwmarkt, one of Amsterdam’s most iconic squares, and discover a prominent brick building at its center called the Waag.

Though it may be difficult to surmise from the quaint restaurant-café that now inhabits the handsome wooden interior of its rustic main hall, what looks like a dwarf castle was once the eastern gate of the city’s 15th century protective wall. It is one of Amsterdam’s oldest secular buildings and home to the eponymous Waag Society, a world-renowned research institute founded in 1994 that has built a reputation for being at the nexus of arts, science and technology.

For over two decades Waag Society has functioned as a collaborative thinking and maker space where curious Amsterdammers, artists, designers, hackers, university researchers, government officials and socially-minded entrepreneurs come together to understand how the latest technological innovations ought to be appropriated for solving societal issues from the perspective that users themselves are, in fact, the best designers of the solutions⁴. Along with its team of top-notch researchers and many partners, Waag Society wants to tap into the expertise, skills and creativity of Amsterdammers to discover the possible uses of sensor technology to illuminate the city’s persistent urban environmental issues and influence public policy.



02

FROM SMART TO ILLUMINATED CITIES

Through technological ingenuity, our society is going through what some have argued to be the most materially abundant and wealthy periods in history. Yet, at the same time the intractable and interrelated crises of rapid population growth, urbanization, economic inequality, political conflict, resource scarcity, environmental degradation and climate change threaten the long-term viability of both the biosphere and the 7 billion people in 196 countries trying to live their comfortable and abundant lives on a planet whose seemingly limitless bounty has proven to be a naive illusion of the previous century.

These are the biggest challenges our species has ever faced, and even in countries that thus far have been relatively unaffected, you cannot go one day without reading an article or watching a news broadcast about distressing events that oftentimes seem nebulous and disconnected. To be sure, there are no easy answers.

The fact that these crises are not continuously experienced by the majority of humanity, especially those in the wealthier countries of the global North, has resulted in a lackluster and uncoordinated global response. Regardless, there is one irreconcilable truth that our species must face: the planet is undergoing rapid, unpredictable change and human activity has become such a driving force on geological and biological processes that scientists have labeled the current epoch in natural history the anthropocene: the age of (hu)man.

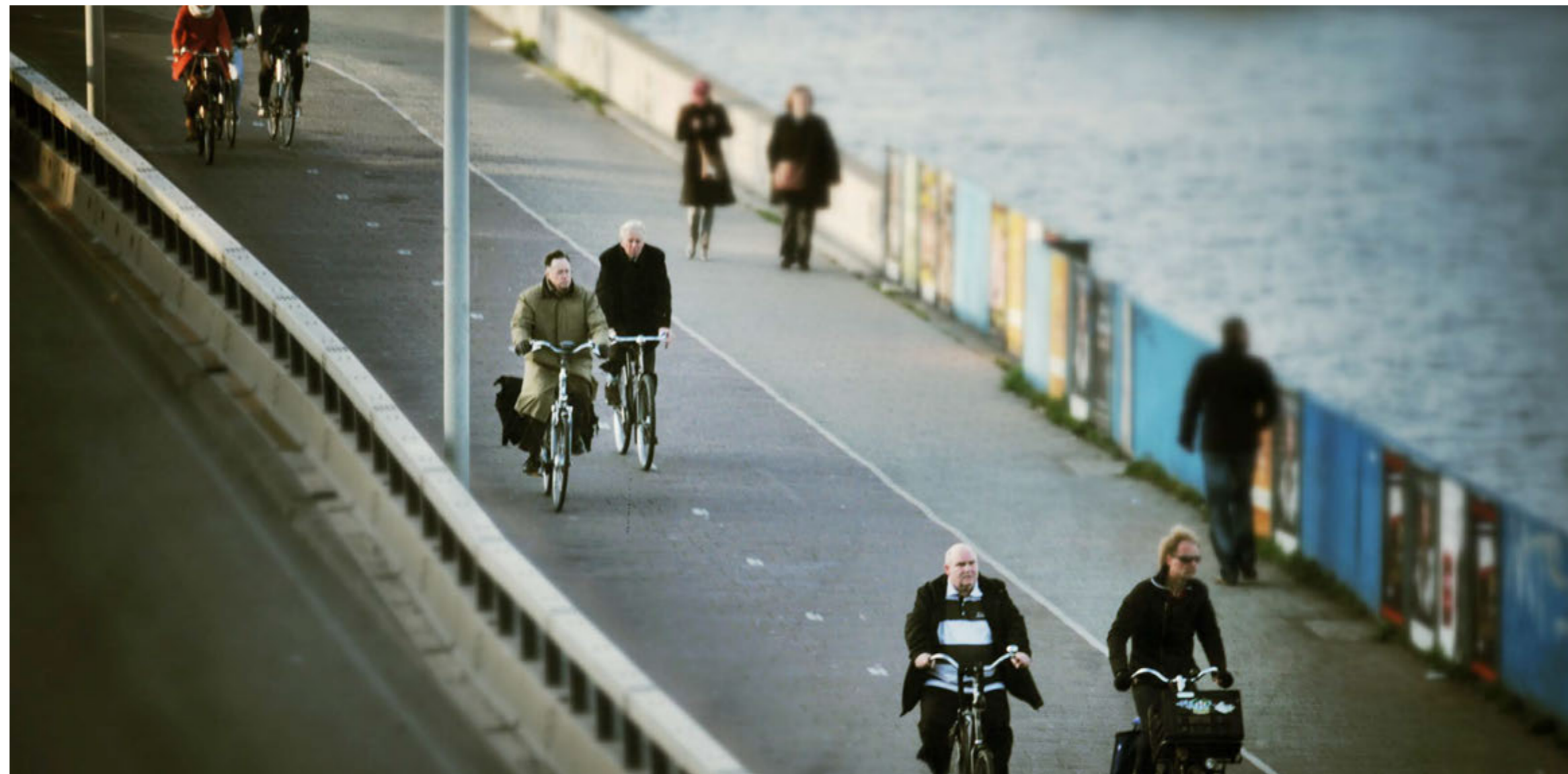
Furthermore, the effects of climate change will intensify as increased biodiversity loss, extreme weather events (such as floods and droughts) and resource scarcity may create upwards of 200 million climate refugees by mid century⁵.

Since 2008, over 50 percent of the 7 billion people on earth now lives urban areas. According to the UN, 66 percent of our projected population of 9.3 billion people will live in cities by 2050⁶, 600 of which will concentrate the vast majority of the wealth, creativity, innovation and industry⁷.

Along with this global shift to urban living, computer scientist Abe Mowshowitz has argued that society has ‘cultivated a special relationship to technology wherein needs and conflicts are almost invariably formulated as technical problems requiring technical solutions⁸.

Historian Joseph Tainter made a similar claim when he said that society is best understood as a problem-solving machine that has overcome environmental challenges with increasingly complex and energy intensive technological solutions⁹.

These dilemmas are too great for any one person, community or country to solve alone. What can be certain is that these critical crises are made-made, and that taking the fatalistic, business-as-usual path will eventually unravel the painstaking progress our species has made thus far.



The optimistic conclusion of the COP21 conference held in Paris illustrates that governments from around the world are working hard to come up with viable and equitable social, political and technological solutions to these intractable problems. But on a more local and familiar scale, what steps should cities like Amsterdam take to improve the urban environment and ensure the future well-being and prosperity of their inhabitants?

Traditionally, urban problems have been solved through policy generated by municipal officials and urban planners in collaboration with the private sector. Over the last 10 years, a growing number within public policy, IT and business consulting circles have opined that information and communications technologies (ICTs) like predictive algorithmic software, big data, urban sensor arrays and the Internet of Things (IoT) can be utilized to streamline municipal governance and transportation infrastructures, rejuvenate local economies, and transform the urban environment to make it more sustainable, livable and socially inclusive. This paradigm is known as the so-called 'smart city', a theory of urban development that connects technologically led solutions with economic, political and socio-cultural change¹⁰.

The smart city has its ultimate origins in cybernetics, a transdisciplinary scientific field that uses sensing and feedback control mechanisms to create generalized models of system and infrastructures in order to organize and control them more efficiently.

When applied to urban contexts, being 'smart' is about using sensors and algorithmic software to gather data and make sense of the city to assist with the day-to-day management of energy, water, waste, control and transportation infrastructures and guide public policy^{11 12}.

To tackle climate change, the EU aims to reduce its greenhouse gas emissions by 41 percent by 2030 through innovations in energy production and distribution infrastructure, mobility and transport, and 'smart' systems¹³.

The smart city approach has become a hot topic since its inclusion as a research priority within the EU Horizon 2020 Program for Research and Technological Development, the largest funding mechanism for academic and applied research in the EU. This recent surge of interest is not necessarily indicative of universal appraisal. According Alberto Vanolo, a professor of geography at the University of Torino, despite complaints from EUROCITIES, a network of elected municipal and public officials representing Europe's 130 largest cities, that 'too much of the smart city agenda has been by led by competing corporations offering their own technology to cities as an ostensibly comprehensive solution to every urban problem', there is a concerted effort being made by EU technocrats to make the smart city the preferred urban identity of Europe¹⁴.

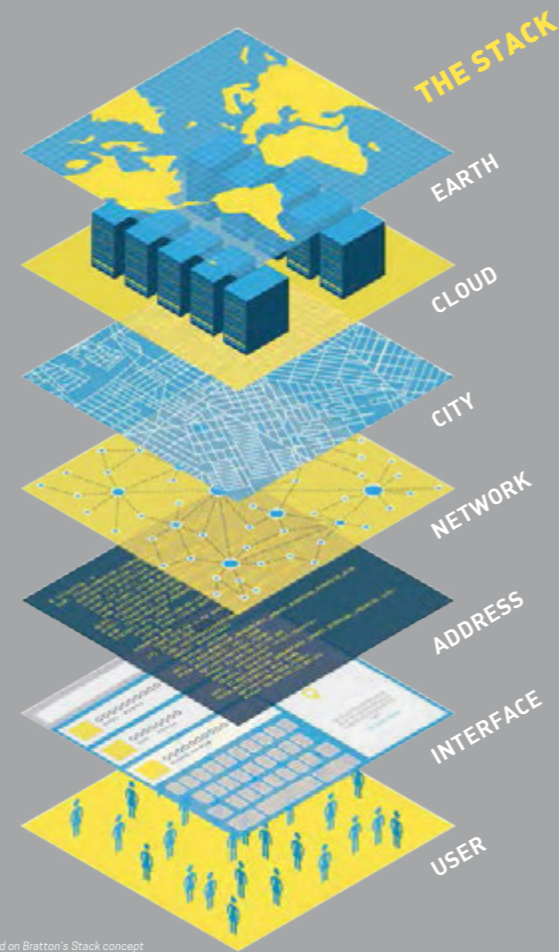


Ubiquity & the Illuminated City

From Smart to Intelligent Urban Environments

Written by Prof.dr.ir. Arjan van Timmeren and Laurence Henriquez

Designed by Alexandra Reynolds



In *Ubiquity and the Illuminated City* (2015), van Timmeren and Henriquez investigated the smart city and found out that, for the most part, its biggest proponents are the largest IT companies in the world, which makes sense considering that framing smart technologies to municipal governments as the next urban infrastructure is an extremely lucrative business. To be sure, while smart technology was shown to be beneficial in improving the sustainability and efficiency of transportation and aspects of local governance, its other purported rewards are dubious at best.

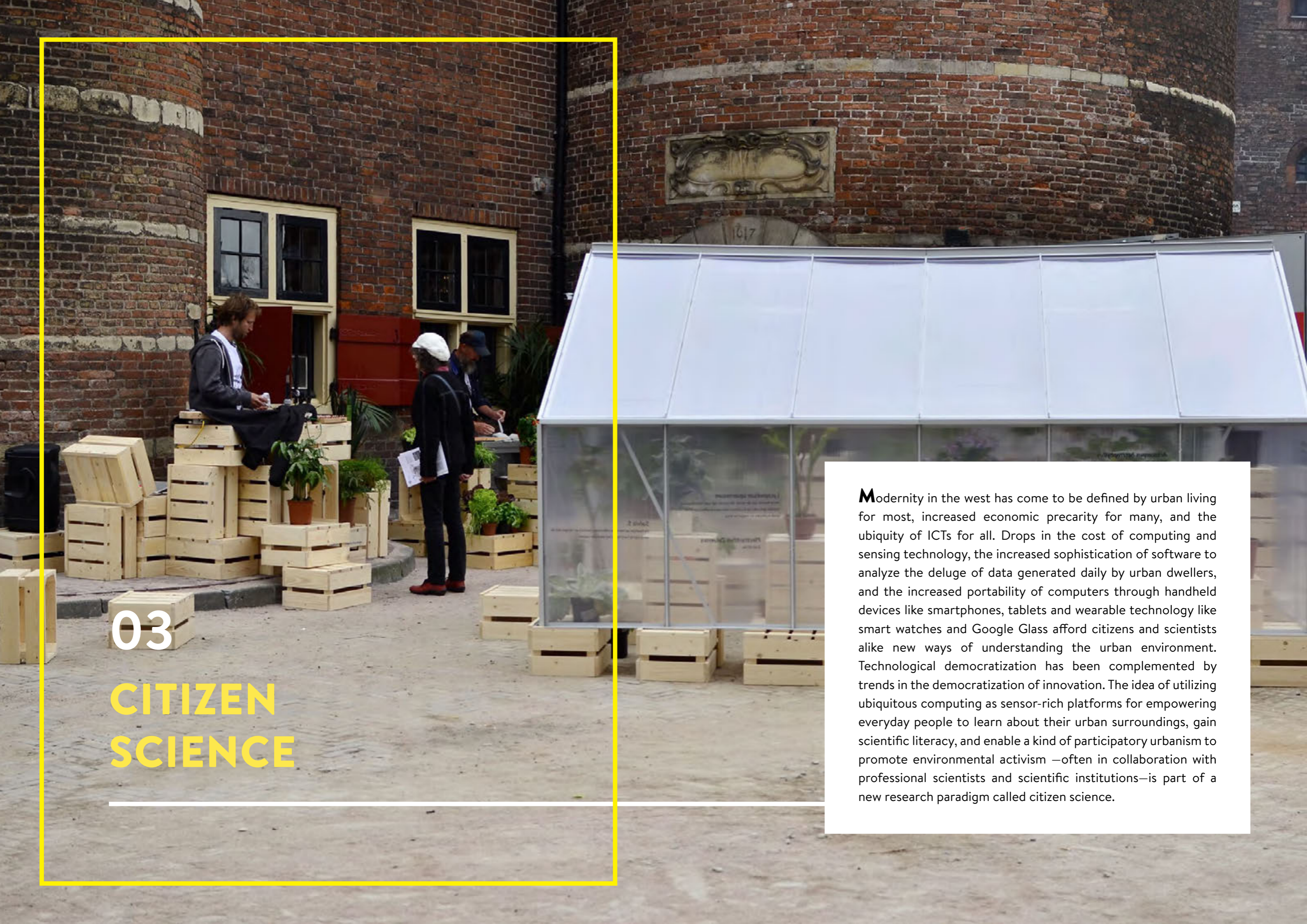
Van Timmeren and Henriquez found that IT-led urban development is based on the assumption that it is possible to distill societal complexity through simplified, standardized computer models and use historically correlative data to generate effective public policy based on those predictions, a kind of blind faith they call 'ubiquity'. Smart cities were shown to be expensive; stifle innovation through emphasizing proprietary software; non-democratic and monopolistic in character; market-led instead of citizen-oriented; and reduce individual autonomy through indiscriminate tracking.

“Cities should not be conceived as a singular abstraction that can be ‘enhanced’ through technology.”

There is also the potential that smart cities would eschew the opinions of thematic experts in favor of ‘apolitical’ algorithmic models and punish non tech-savvy communities (like the poor, the old, immigrants) who are increasingly becoming irrelevant in an economy that it is expected to shed upwards of 47 percent of employment over the next 20 years through computer automation¹⁵. And finally, they argue that the smart city ignores the simple fact that the world’s most pressing urban problems like extreme poverty, economic inequality and ethnic discrimination are sociopolitical, not technological, in nature.

At the end of the book, they offer an alternative to the Smart City™ called the ‘illuminated city’, or ‘ a citizen-focused, community-defined, and open-source city that harnesses technology to enhance democracy and distributed governance, support individual and collective autonomy, community participation in urban planning, and enshrine the citizen’s right to privacy and protection from data commodification.’ The Illuminated city is a metaphor that recognizes the possibilities of technology, but asserts that there is no such thing as technological panaceas to social ills, and that urban problems can only be understood (and eventually solved) by local governments and citizens themselves.

Cities should not be conceived as a singular abstraction that can be ‘enhanced’ through technology but as a cohesive assemblage of people; and a core idea to the illuminated approach is that cities need open and collaborative infrastructures. Van Timmeren and Henriquez join a growing cacophony of voices (such as Greenfield, Morozov, Hill and Townsend) who criticize the prevailing ‘smart’ city logic and call for a more decentralized, equitable, ethical and humanistic smart citizens approach. Frank Kresin, research director of Waag Society and lead scientist of the Amsterdam Smart Citizens Lab, agrees when he said that ‘citizens can become smart, engaged, and illuminated through mastering the technologies that help them express themselves, connect to others, share their resources and thoughts so they can decide the best course of action¹⁶’.



03

CITIZEN SCIENCE

Modernity in the west has come to be defined by urban living for most, increased economic precarity for many, and the ubiquity of ICTs for all. Drops in the cost of computing and sensing technology, the increased sophistication of software to analyze the deluge of data generated daily by urban dwellers, and the increased portability of computers through handheld devices like smartphones, tablets and wearable technology like smart watches and Google Glass afford citizens and scientists alike new ways of understanding the urban environment. Technological democratization has been complemented by trends in the democratization of innovation. The idea of utilizing ubiquitous computing as sensor-rich platforms for empowering everyday people to learn about their urban surroundings, gain scientific literacy, and enable a kind of participatory urbanism to promote environmental activism —often in collaboration with professional scientists and scientific institutions—is part of a new research paradigm called citizen science.



BASIC CITIZEN SCIENCE: KITEMAPPING
@ NIEUWMARKT AMSTERDAM

Intel researcher Eric Paulos¹⁷ has proposed citizen science as a way to ‘celebrate ubiquitous information technologies in their new role as personal measurement instruments capable of sensing our natural environment and empowering collective action through everyday grassroots citizen science across blocks, neighborhoods, cities and nations.’

While not exclusive to the topic, many citizen science initiatives concern environmental monitoring. One of the most prominent examples due to its scientific credibility, data maturity and extended user base is SafeCast. A community of concerned citizens and scientists from around the world began to organize when they realized that the Japanese people lacked trustworthy information about environmental radioactivity after the destruction and devastation of the earthquake, tsunami and subsequent nuclear meltdown at the Fukushima Daiichi power plant that rocked Japan on March 11, 2011.

Embracing open source hardware and software and 3D printing technologies, they developed cheap, reliable and scalable sensors for measuring and recording radiation levels.

The initiative was so successful that ‘SafeCast data was quickly recognized in Japan and abroad and soon became the essential “go-to” independent source of information on radiation issues in Japan and elsewhere.’¹⁸ By 2015, SafeCast had aggregated and published more than 27 million data points and provided information on nuclear risks and air pollution in several countries including Japan, China, South Korea, Australia, Ireland, Austria, and the United States¹⁹.

Citizen science is not without its criticisms. Aoki et al²⁰ and Corburn²¹ have criticized the politics of participation because many citizen science projects are top-down in nature. This is not outside scientific orthodoxy. Science has always been a highly technical and elite enterprise requiring specialized knowledge outside the purview of the vast majority of everyday people. Citizens are seen, at best, as subjects of study with little or no agency in the processes, practices, models-, and ethics of science itself. The result is that in past citizen science studies volunteers mostly ended up being nothing more than ‘citizen sensors’, i.e. tech-enabled corporal data collectors for academic and governmental research. This presents a challenge to the field: how is it possible to transform ubiquitous computing technology into artifacts for collaborative, interdisciplinary research that will help people to better understand the world around them, promote mutual learning between experts and lay people, activate community creativity and encourage citizens to embrace active, environmentally conscious and responsible lifestyles?

The citizen science approach could be considered a form of social innovation, or strategies, concepts, products and services that meet the greater needs of society while generating social capital by fostering new relationships and collaborations between scientists, designers and everyday people that would otherwise not occur²². This is contrasted by traditional innovation in the private sector where social needs are usually ancillary to increasing the value of shareholder dividends.



IF YOU THOUGHT THAT THE AMSTERDAM SMART CITIZENS LAB WAS WAAG SOCIETY'S FIRST FORAY INTO CITIZEN SCIENCE, YOU WOULD BE WRONG.

In 2014, an EU funded study revealed that there were over a 1000 projects and organizations in Europe dedicated to digital social innovation, defined as 'a type of social and collaborative innovation in which innovators, users and communities collaborate using digital technologies to co-create knowledge and solutions for a wide range of social needs and at a scale that was unimaginable before the rise of the Internet'²³. What would happen if the power of digital social innovation could be harnessed to help people to do citizen science and understand their local environments for the benefit of themselves and the society in which they live?

IMPLEMENTING THE AMSTERDAM SMART CITIZEN KIT

For citizen science to work you need accessible open technologies. Presently, Amsterdam has a network of 11 official air quality measurement stations. Each station is equipped with an array of highly accurate sensors, that give a reliable picture of the actual air quality. Alas, they are very expensive and the network is too small to be able to create a real time map of street-by-street level pollution, even though pollution levels vary greatly from street to street, and local measures can have a great effect, for better or for worse. Therefore, in 2013 Waag Society's researcher, in collaboration with the Amsterdam Smart City initiative and the Amsterdam Economic Board, started searching for an alternative solution that would be affordable and inclusive of Amsterdammers, while also benefitting from enhanced levels of ownership.

After considering their options, they decided to investigate the efficacy of citizen science. They hypothesized that the best way to do this was to host some workshops in which volunteers come together and work with an out-of-the-box, low cost, sensor kit and receive proper mentorship from in-house experts. Along with the goals of increasing technological proficiency and creating greater community awareness of urban environmental issues, it was hoped that the workshop would function as an inclusive design space where citizens could organize around urban issues they care about, propose meaningful solutions, and create a fruitful interplay between citizens, researchers and policy makers that would translate the will of the community into progressive public policy.

Between February and July 2014, Waag Society and its partners conducted the Smart Citizen Kit workshop series. They worked with open source low cost sensor kits developed by Fablab Barcelona that included sensors for measuring toxic gases like CO and NO₂, air temperature, humidity, light intensity and sound; an Arduino computer board for processing the data; a Wi-Fi module for sending the data to web portal; and a mobile app and API for on-the-go access. Seventy-three Amsterdammers were equipped with Smart Citizen Kits and over 50 of those readily contributed data to the network.

While there were many technical issues with the sensor hardware and software, participants reported that they learned a lot about climate issues and that they were satisfied with the project and interested in being involved with similar projects in the future. David de Jonge, senior project manager at the Air Quality Bureau of Amsterdam, and Marita Voogt, a research scientist at TNO, two outside experts that were involved in the SCK, gave diametrically opposed opinions about the outcomes of the project²⁴.

De Jong bluntly labeled the kit as 'rubbish technology' that produced unreliable results. Voogt, on the other hand, had a more optimistic analysis, claiming the initiative was a success because much more people than expected participated in the workshops. She also emphasized that the kit was 'just at the beginning' and that sensors will soon improve in the future.

In their final report²², researchers concluded that the level of citizen participation and generally positive feedback suggested that Amsterdammers, are in fact, interested in learning about their environments, sensors and sensing strategies. They stressed that DIY sensors tend to produce data that is of a much lower fidelity and reliability when compared to professional sensors and that the workshop should be understood as an exploration of urban sensing strategies and technologies that are only in their neophytic stage. On the other hand, the cost of professional sensors has thus far prohibited their widespread deployment and scientific measuring bodies have only been able to get a reliable picture a very limited part of the city.

They recommended future workshop practitioners should work with a larger sample group, utilize better-calibrated hardware and software to generate more reliable data and spend more time on the analysis of the problem space. With these lessons in hand, Waag Society and a consortium of partners including the CTO Office of Amsterdam, Amsterdam Institute of Advanced Metropolitan Solutions (AMS), Rijksinstituut voor Volksgezondheid en Milieu (RIVM), HvA, Wageningen University and Amsterdam Sensemakers decided to continue the citizen-led exploration of the urban environment with the Amsterdam Smart Citizens Lab, which was chosen as a primary case study in an AMS Institute report concerning bottom-up participatory sensing²⁵.

04 SMART CITIZEN APPROACH



For the past few years, Waag Society has been advocating that to become active and self-directed citizens in our technologically infused societies, people have to become fluent in both writing and reading technology themselves. This view has been summarized in five ground rules and hypotheses for applying and understanding technology. First, beyond their nearly limitless capacity for discovery and connectivity, ICTs ought to be able to furnish platforms that link communities of practice and support an inclusive dialogue to understand its role in tackling the multitudinous problems our society is facing. Second, instead of seeing people as passive consumers of technology, the act of ‘making’ gives citizens agency in our increasingly automated and digitally-rendered society. Third, everyday people can learn almost anything given enough the time, effort and proper guidance. Forth, open source tools, DIY design ethics, and knowledge sharing are crucial to understanding the modern world. And fifth, the best kind of consumer is an empowered producer, or prosumer, that innovates on his or her own terms for the problems they care about the most.

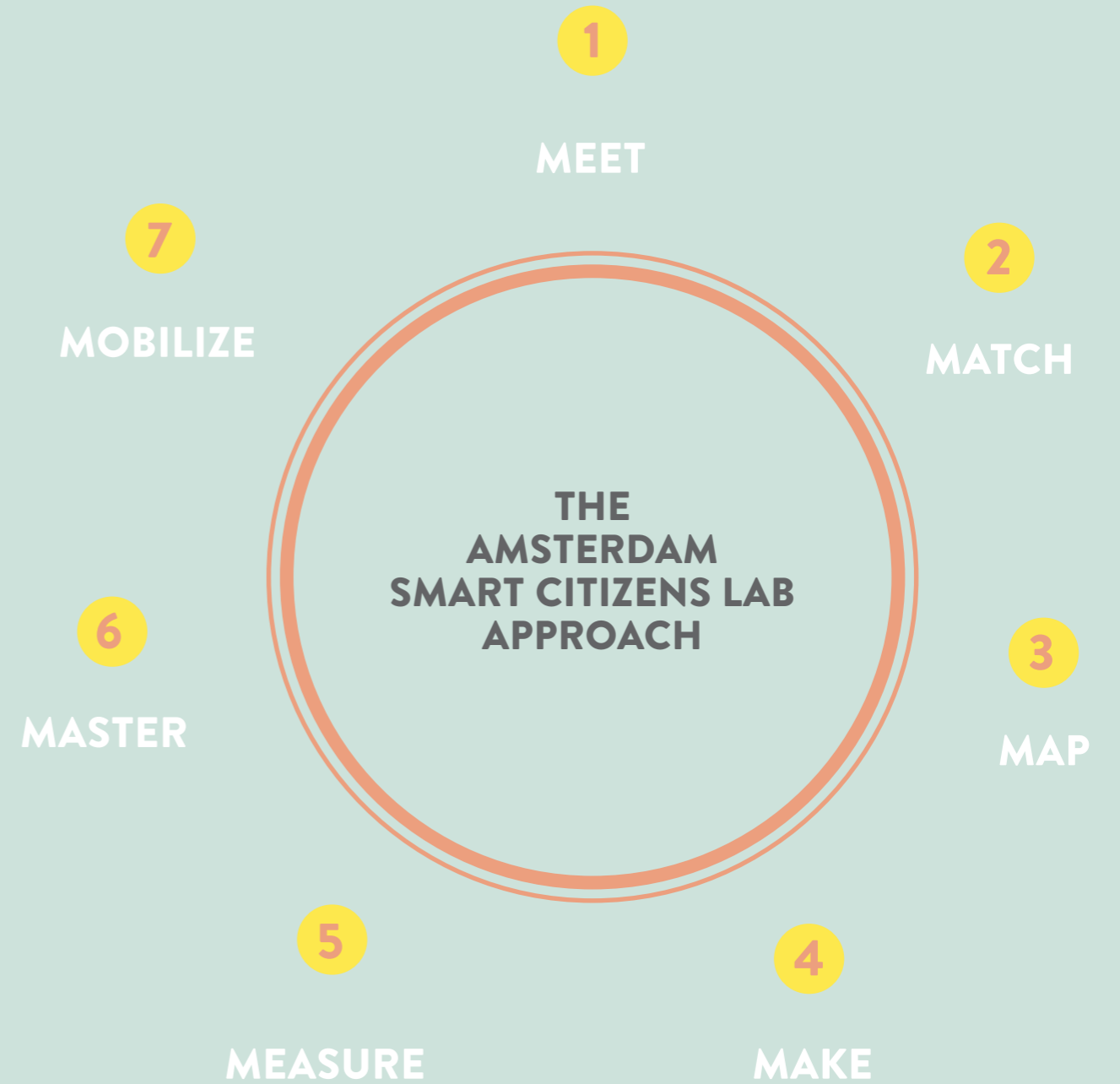
THE 7-STEP RESEARCH METHODOLOGY

Working with these hypotheses and the experiences with the Smart Citizens Kit, Waag Society and its partners developed a 7-step research methodology called the Amsterdam Smart Citizens Lab Approach. Over the course of 7 months, between May until December 2015, sufficiently inquisitive citizens were free to participate in six workshops hosted at the Waag’s Makers Guild and Fablab, a spacious classroom and research facility that take advantage of the austere stucco walls and exposed interior wooden frames typical of medieval Dutch architecture and the very latest in additive manufacturing and fabrication tools to furnish the ideal learning environment and maker space.

The approach begins with community building. The lab maintained an open-invitation model and used the local newspaper, partner websites and social media channels to generate public interest.

A Meetup page was set up to complement workshop lectures and open design days with an interactive digital space for facilitating group communication, announcing meetings and sharing member experiences. The next workshop functioned as a technical analysis, where Waag Society and RIVM researchers gave in-depth lectures concerning the myriad affordable DIY sensors available on the market and their differences from professional sensors

Participants were introduced to successful online sensing platforms like Zooniverse, the Public Lab, various middleware technologies like Arduino boards, Wi-Fi, Bluetooth, and GSM modules, and additive manufacturing techniques, that together make DIY sensing networks possible. Researchers decided to drop the exclusive use of the Smart Citizen Kit in favor of a more open innovation model that gave the groups free use of the various fabrication tools found in the Waag’s Fablab after lectures. On open design days (hosted every Tuesday) participants could ideate, design and build their own sensor assemblies with the hands-on assistance and mentorship of Waag Society experts.



1
MEET

First, after an open invitation in the local newspaper and online via newsletters of partner institutes, people sign up and meet at a space in town center that is perceived to be safe (to speak up) and neutral (without its own hidden agenda). A collection of presentations and exercises is used to introduce the participants to each-other and sensitize them to possible questions, approaches and outcomes, as well as on the roles they will have to take to turn it into a success.

2
MATCH

Step two consists of encouraging people to form groups based on shared interests, experience and/or levels of commitment. To make the resulting groups more effective (and possibly self-sufficient, care should be taken to mix people), with different (levels of) expertise and background. It was made clear that the groups themselves will be responsible to get to the desired results, so they should self-organize as much as possible, for example by using on-line tools for sharing calendars and progress.

3
MAP

The next step is helping the groups to understand and map in more detail both the problems and/or opportunities, and possible approaches to solve them. The help of experts is sought and valued because problems related to the environment are complex in nature, and much is already known. This step ends with developing a sensing strategy: what is to be measured, in which quantities, and which kind of technologies are used to get there.

4
MAKE

The fourth step consists of making the hard- and software to be able to measure the desired variables. This typically means putting together one or more existing, low-cost sensors with a circuit to (pre-)process and store or send the resulting data to a server that will collect it for further analysis and visualisation. It typically entails devising and building a specialised casing that will help the electronics to withstand the conditions that the sensor will be put in (rain, cold, warmth or even submerged). The Amsterdam Smart Citizens Lab strongly encourages the use of open source software and hardware for reasons of bootstrapping the development process, adaptability and flexibility in application and development, typically lower cost, availability of development expertise and the sharing and further development of the outcomes.

5
MEASURE

The fifth step consists of carrying out the measuring strategy from step three with the hardware and software developed in step four. It starts with calibrating the hardware, and then deploying the sensor(s) in one or more locations, during a specific amount of time as prescribed in the strategy. Typically, things turn out different than expected in terms of actual data collected, which gives rise to ad-hoc changes in the measuring strategy and sometimes to changes in hard- and software. The data are collected for further analysis.

6
MASTER

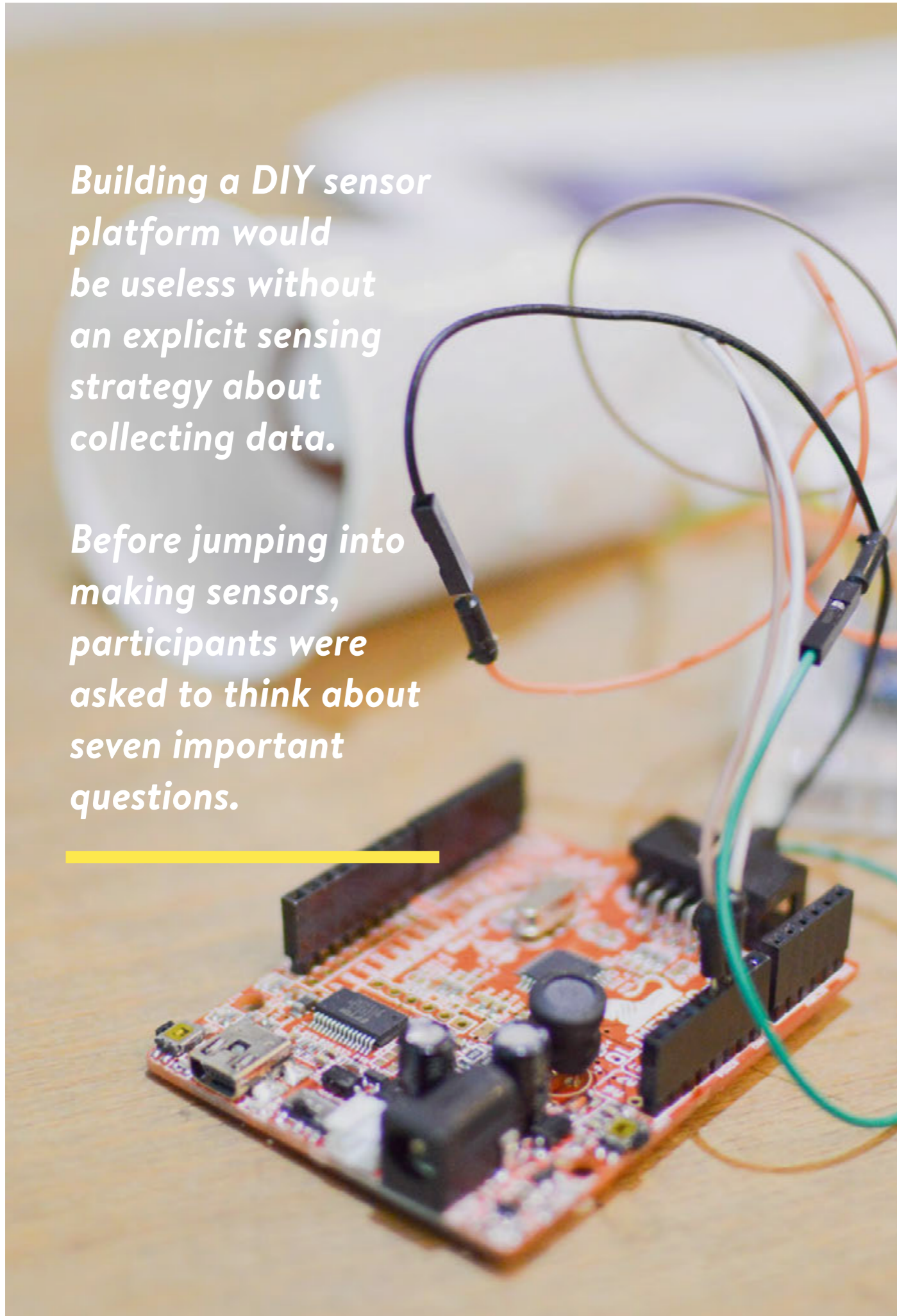
Step six consists of mastering the data: analysing and possibly visualising them to understand what they mean. Typically, existing software is used to perform this step. Depending on the complexity, the help of external experts is sought, that help in technical procedures for cleaning and analysing data, as well as interpreting and giving credibility to the results.

7
MOBILIZE

The final step entails mobilizing either citizens, public authorities, or both, to take action on the findings. This is potentially a huge step, involving (mass) media, spokespersons, ambassadors, political parties and spin doctors. Depending on the desired results and the vested interests, this is also the hardest step that might take years to get to. Small-scale mobilization, however, is also possible, which would consist of one's behaviour or convincing neighbors to do so.

Building a DIY sensor platform would be useless without an explicit sensing strategy about collecting data.

Before jumping into making sensors, participants were asked to think about seven important questions.



WHAT DO YOU WANT TO MEASURE?

WHAT ARE YOU TRYING TO LEARN FROM MEASURING IT?

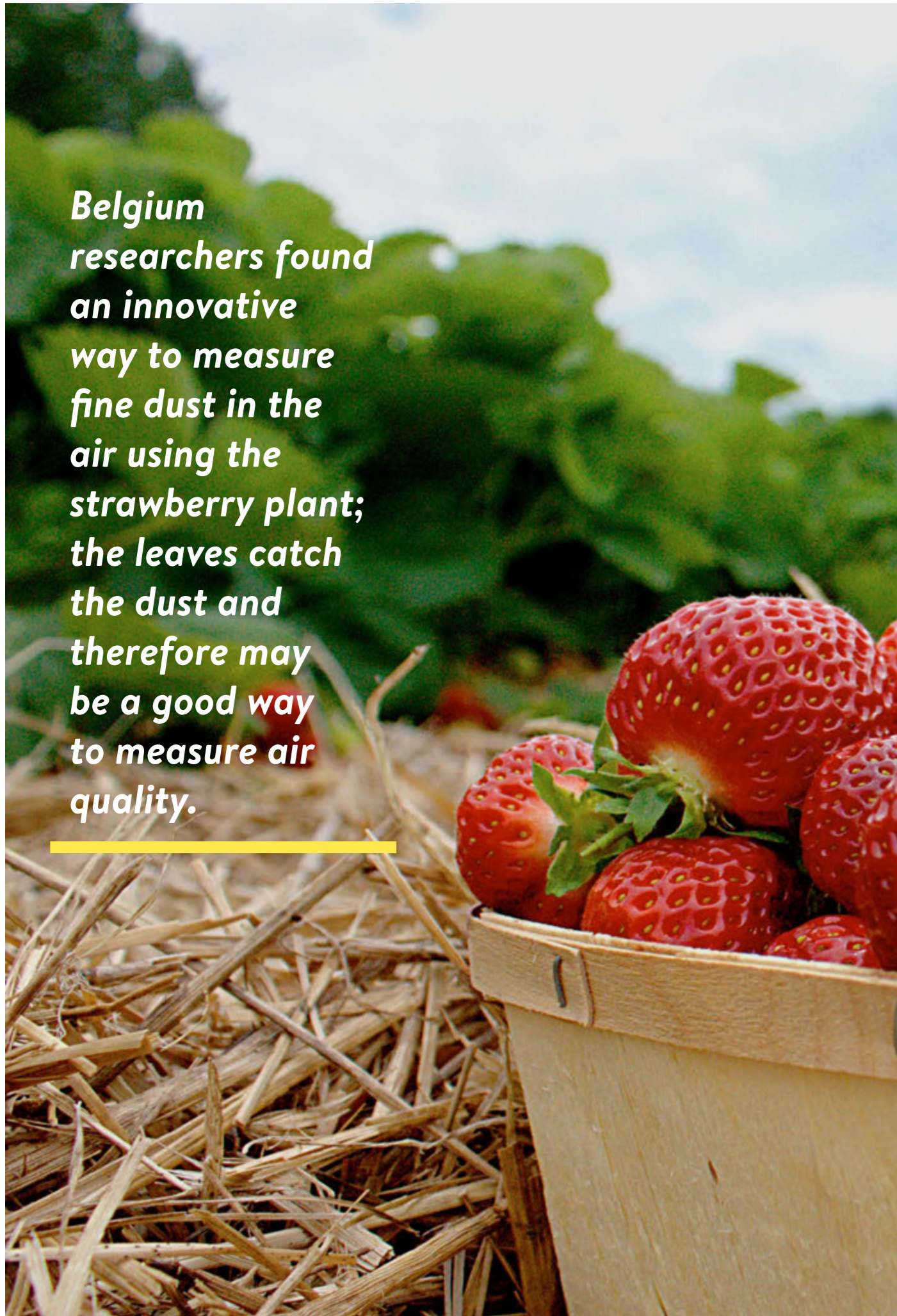
HOW MUCH DATA MUST BE GATHERED TO GENERATE VALUABLE CONCLUSIONS?

WHAT TYPE OF ANALYSIS WILL BE DONE?

WHAT KIND OF DATA IS NEEDED TO COMPLETE THE ANALYSIS?

HOW MUCH MONEY, TIME AND RESOURCES ARE AVAILABLE?

WHEN WILL YOU CONSIDER YOUR EFFORTS A SUCCESS?



Belgium researchers found an innovative way to measure fine dust in the air using the strawberry plant; the leaves catch the dust and therefore may be a good way to measure air quality.

LOW-TECH SENSING STRATEGIES

One lecturer from RIVM told the participants outright (because they were working with limited resources and cheap sensors that aren't very reliable), that they should shy away from using high-tech sensing strategies: the more complex the strategies and sensors become, the higher chance something will go wrong, leading to at best bad data and at worst a sabotaged experiment. To inoculate the groups against technophilia, Roeland Samson, an environmental scientist from Universiteit Antwerpen, was invited to introduce the possibilities of low-tech sensing strategies through his work as a lead scientist of the AIRbezen project.

AIRbezen set out to measure the spatial distribution of traffic related pollution in the city center of Antwerp, Belgium.

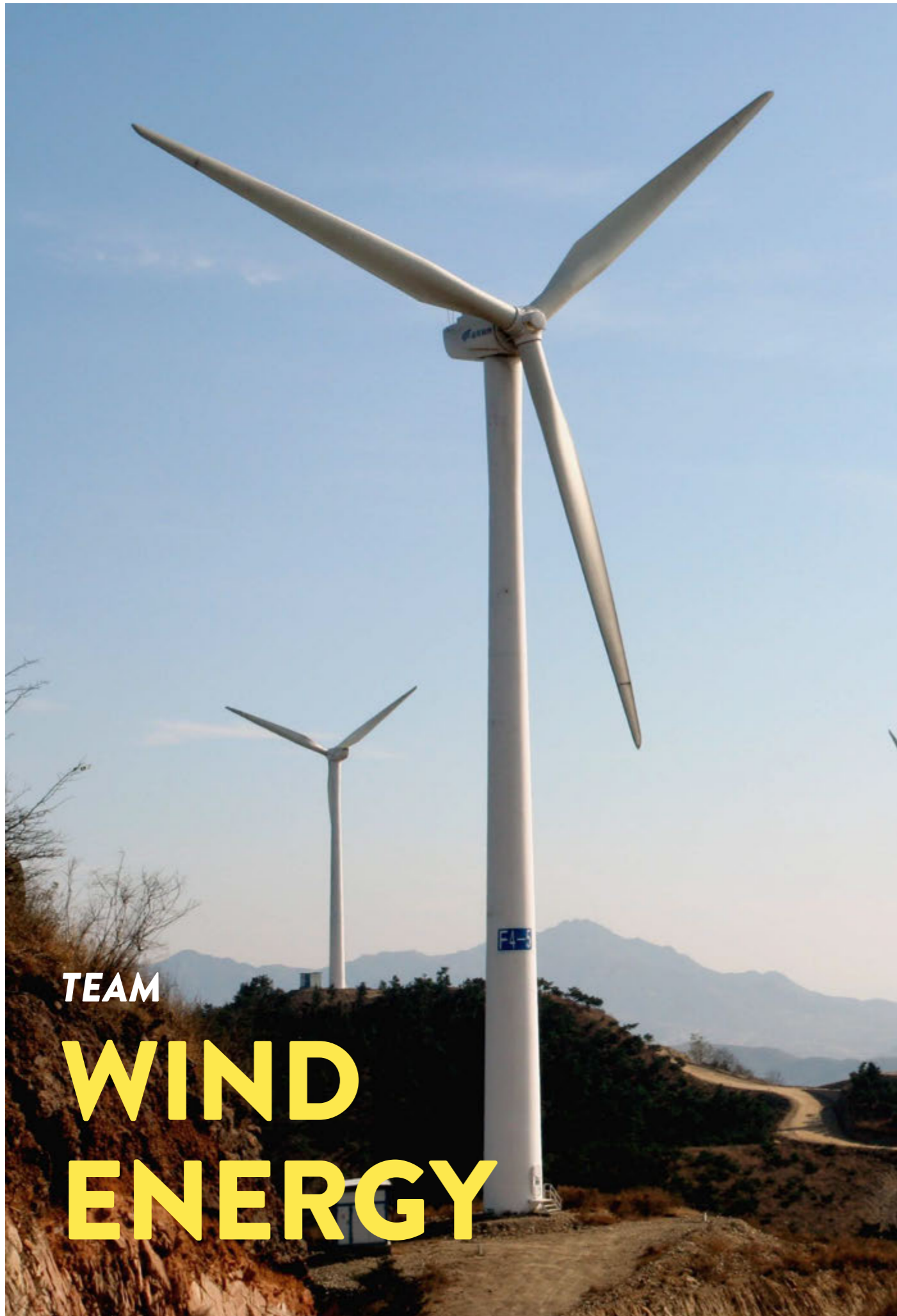
Instead of using an expensive sensor array, they used a much cheaper and socially engaging alternative.

Researchers worked with volunteers to distribute over 1000 juvenile strawberry plants all around the city, and asked them to take care of the plants and mail in leaf samples to a lab for analysis. In time, there was citywide, and eventually a nationwide, clamor to participate. As it turns out, strawberries are not only delicious: with the proper tools their leaves are also well suited for scientific research.

**MEET
OUR**

**SMART
CITIZENS**





TEAM

WIND ENERGY



Who are you, where are you from, and what do you do?

My name is Guillermo José Rodríguez Fernández and I am from Burela in Lugo Galicia. am a software engineer and I have been travelling around Europe for the last 10 years trying to get a grasp on all the different cultures in Europe.

Why did you choose to come to the Netherlands?

Well, my main reason was love! But, I was working in Ireland and my girlfriend was living here and we were living separated for two years travelling back and forth between Ireland and the Netherlands. After a certain point we decided we had to make a move and I moved here!

How did you find about the Amsterdam Smart Citizens Lab?

I have always been curious about how people live together in the city because I come from a very small town of 10,000 people and I was active in organizing cultural initiatives. I heard about smart cities when I was studying and kind of left it there for a while.

But, when I came to Amsterdam I saw some activity on Twitter so I Googled it and found the Amsterdam Smart Citizens Lab website, and I decided to come to the first workshop.

What were your expectations before joining?

For me, I was surprised because I thought it was going to be a single presentation about smart cities but then I realized it was going to be an entire workshop series! I was not sure if I was going to be able to commit because if I join something I want to try and give 100 percent of my effort. So I thought to myself and said, ‘well, this is my chance!’ and I am very happy I made the choice to join.

What do you value in participating?

First, I enjoy getting to meet and work with people from different backgrounds. I learned a lot about new technologies like Arduino and other cheap hardware that can be easily bought to measure different environmental variables. To know that there was something like Waag Society and the Amsterdam Smart Citizens Lab where you can go and use their tools to build whatever you want and the open source culture where you can leave the design in Creative Commons, that is something that really amazed me.

TEAM

AIR QUALITY



Who are you, where are you from and what do you do?

My name is Qijun Jiang. I am from Chengdu, a city in southwest China, and I have lived in the Netherlands for two years now. I came to pursue my PhD in geo-information science and sensors, in the Laboratory of Geo-information Science and Remote Sensing (GRS) chair group, a research group within the Environmental Sciences department at the Wageningen University.

Why did you choose to come to the Netherlands?

I got the chance to continue my studies here.

How did you hear about the Smart Citizens Lab?

I heard about the Smart Citizen Kit project through Waag Society's website. They told me that the project had decent hardware and software and citizen participation, but the data quality was low: the air quality sensors were not suitable for urban air quality monitoring. So I kept in touch with Waag Society and was informed about this project; and since I had some really nice ideas and some background in the field, I decided to join.

What were your expectations before coming into the Amsterdam Smart Citizens Lab?

First, I came as an observer. Citizen science projects like these are closely related to my own research, so I really wanted to learn about how the public cooperates and uses open source sensing technology to collect data to contribute to public organizations and their motivations for participating (because not everyone has a scientific background as I do). I also wanted to try my best to contribute to the community and help to develop the platform with my background in sensing technology and data analysis.

What do you value in participating?

My research field is environmental sensing. Smartphones, sensing technologies and computing platforms like Arduino are getting a lot cheaper, and they can easily become a valuable data source and citizens because they can monitor the urban environment by themselves. If researchers or local governments integrate official data with data gathered by citizens through sensors, this might give overall results more fidelity. For example, in cities like Amsterdam, only a handful of stations monitor air quality and it's really not enough. Locals want more real-time data about their daily life, such as route planning. This, and the fact that the hardware and software are open source, is very interesting to me. I want to get deeper into this area not only out of personal interest, but mainly for my academic purposes, moving beyond simply technology research to the social implications. I am not sure how much I can incorporate the work I do at Amsterdam Smart Citizen Lab into my academic research, but we will see!



TEAM

NOISE POLLUTION

TEAM



Who are you, where are you from, and what do you do?

My name is Pinar Temiz. I am from Istanbul, Turkey. I work as a sound designer at Guerrilla Games and as a sound artist within the Soundlings Collective and also independently.

Why did you choose to come to the Netherlands?

I moved to the Netherlands for my studies in sound and music design and later continued my stay for work. The cultural, social and mindset differences I've experienced here also had an immense influence of course in my decision.

How did you find out about Amsterdam Smart Citizens Lab?

I've already been following Waag Society, occasionally participating in their workshops and events, but mostly online. I've found the news item at a time that was more convenient to get involved.

What were your expectations before joining?

Getting in contact with relevant people in the field (in my case, my interest was in noise and sound pollution), learning about tools and existing research and also finding out what other citizens are interested in and what we can do without big budgets and expensive equipment.

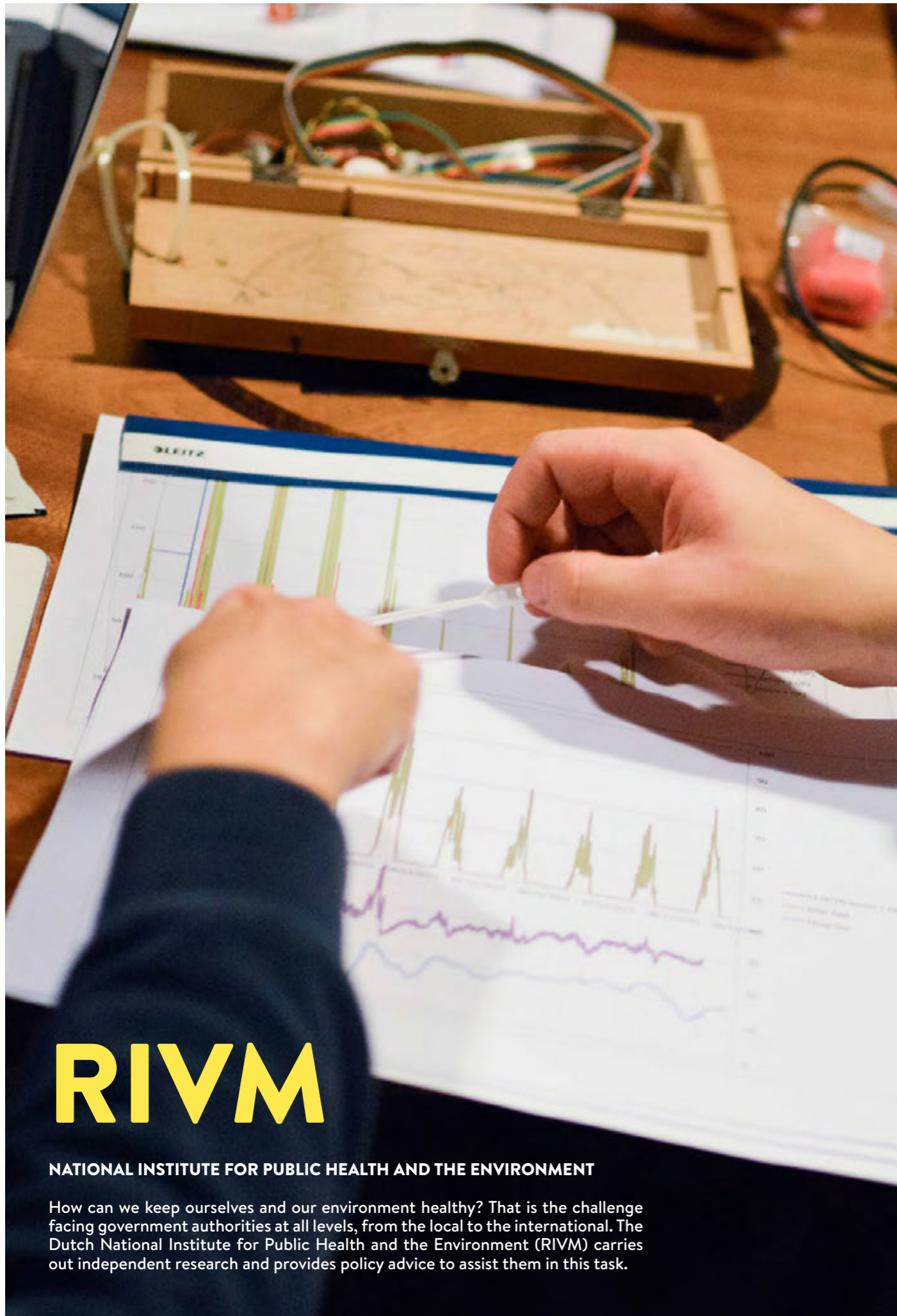
What do you value in participating?

It allowed for collaboration and brainstorming that were quite inspiring with people I wouldn't otherwise have met. Also I've gotten to learn about past and ongoing projects that I haven't heard of before.



**MEET
OUR**

**SMART
EXPERTS**



RIVM

NATIONAL INSTITUTE FOR PUBLIC HEALTH AND THE ENVIRONMENT

How can we keep ourselves and our environment healthy? That is the challenge facing government authorities at all levels, from the local to the international. The Dutch National Institute for Public Health and the Environment (RIVM) carries out independent research and provides policy advice to assist them in this task.



Who are you, where are you from, and what do you do?

My name is Hester Volten, I am from the Netherlands and an RIVM air quality scientist.

Why did you choose to become involved with Amsterdam Smart Citizens Lab?

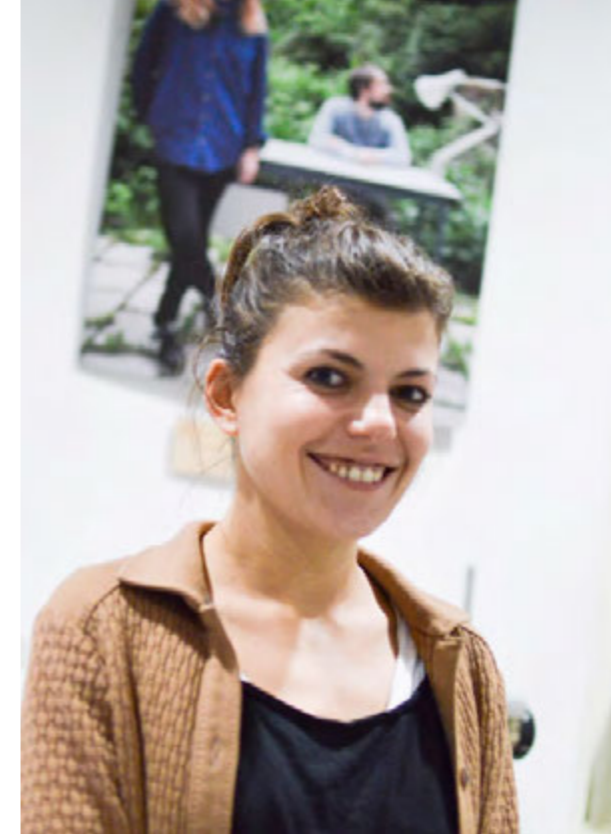
I got involved with the Amsterdam Smart Citizens Lab because I am interested in technology. I love building things and I have joined similar kinds of initiatives before like the iSPEX project where we developed an iPhone-based sensor and a mobile app for measuring atmospheric dust and worked with citizen volunteers to create a countrywide air quality map.

Many people say, 'if you want to know something about sensors, go to RIVM', but we are also still learning about small sensors. They are so new! We are not only looking into all sorts of technologies but also into new, innovative strategies for conducting science and who we need to involve, i.e. citizens, to be successful.

What do you value about citizen science?

At RIVM, we recognize that the world is changing and we need to change with it. In the past scientists told the world the way things were and what direction we should take, but it's not the same anymore. We are looking into new ways in which we interact with society, and we think developments like citizen science are fantastic! We are still grappling with issues like how is RIVM going to go about conducting citizen science and how can we support it best?

Citizen science itself is a fairly new field that is not without challenges. The cheaper sensors allow us to collect a lot of new data that is of an 'inferior quality', the challenge is in developing the statistical techniques that can be used to compensate for the inaccuracy. We need to build new kinds of expertise and scientific models that take data uncertainty into account.



Who are you, where are you from, and what do you do?

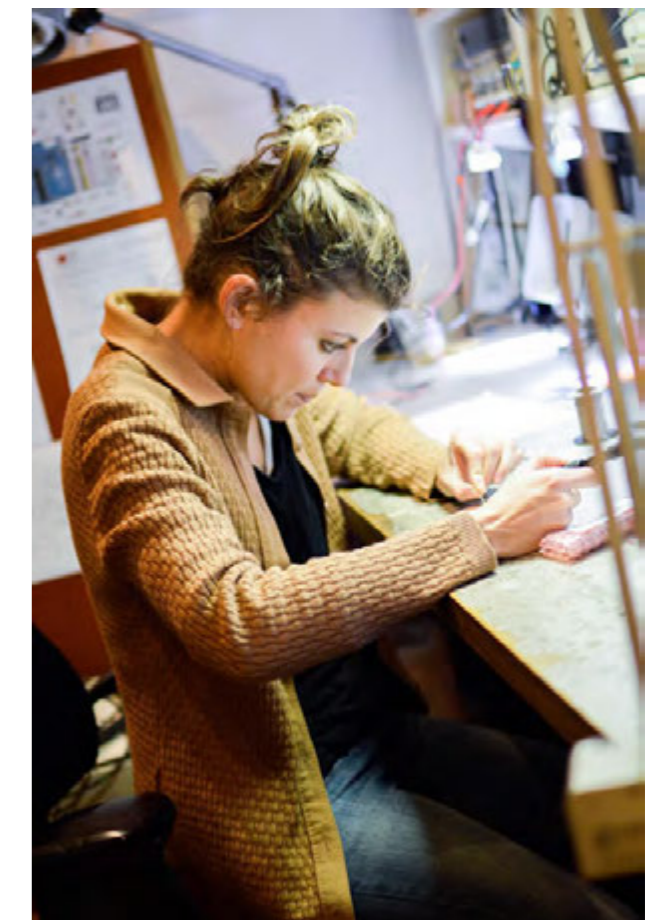
My name is Emma Pareschi and I am from Italy. I have been working at Waag Society as a hardware developer and I am one of the main researchers helping the Amsterdam Smart Citizens Lab participants to develop their sensors.

Why did you choose to come to Amsterdam?

I have been in the Netherlands for about 3 years now. Before, I studied here as part of the FabAcademy, a six-month educational program dedicated to the Fablabs, an international network of laboratories. I found out about a tech position at Waag Society one year ago and have been here ever since.

What do you value about citizen science?

What I like about citizen science research projects like the Amsterdam Smart Citizens Lab is to see the approach normal people have to technology because it is usually something that is very strange for most people. Nowadays, technology has reached a point where it can be used even if you don't understand exactly what its inner workings, you don't need hardcore programming skills to program a simple Arduino board. There are so many open source online resources that it makes hardware and software design more accessible to people. In this way, citizen science reduces the distance between people and technology.





SENSE MAKERS

INTERNET-OF-THINGS COMMUNITY

SenseMakers is a meetup dedicated to Internet-of-Things, sensor(networks), electronics/hardware, open hardware/source and hardware startups. They get together once a month to discuss Internet-of-Things (related) subjects. The community works with with Arduino, RaspberryPi, BeagleBone and Intel Edison.



Who are you, where are you from, and what you do?

My name is Jonathan Carter and I am originally from the UK, but have been living in the Netherlands for quite some time now. I am the co-founder of Glimworm, an IT company, and the co-organizer of the SenseMakers, a community of technology professionals interested in the IoT, building sensors and sensor networks and open source hardware and software.

Why did you choose to come to Amsterdam?

I came to Amsterdam with my job but quickly came to love the Netherlands as it is one of the last remaining social economies. I got involved with the lab because the lab was organized by people that know what they are doing. And, of course, the facilities are simply amazing and I really enjoy working with a community of like-minded people.

What do you value about citizen science?

Citizen science is a new and open field where like-minded people can collaborate on hacking things, building technology and learn about the issues they care about with a social conscience.

It also gives the participants a certain level of independence to explore their own interests. Thankfully, most citizen science experiments thus far are still non-commercial and made up of real communities. If it becomes too commercialized the community ends up feeling fake, and therefore less motivating because you end up not being as good as those who develop technology commercially for a living. Also being involved in the early stages makes you a pioneer in the field, so you might be doing something really unique that's never been done before.



05

**CAUTION:
CITIZEN SCIENCE
IN PROGRESS!**

Thursday's dusk Between May and June signaled reverie and jubilation at the Waag as eager Amsterdammers ascended the groaning steps of the north tower's ancient spiral staircase to occupy one of the five large working tables of the Makers Guild, swilling on complimentary refreshments and exchanging salutary introductions before the lectures.

Thanks to community building efforts, well over 40 strangers showed up to the first workshop, where they were introduced to citizen science and some of the urban environmental issues that persist in Amsterdam. Later, a matchmaking exercise was conducted to familiarize participants with one another and to ideate about possible sensing topics. Despite the spacious facilities, the room could barely accommodate all the citizens that showed up. Who were all these people? Where did they come from? Why did they come in the first place?

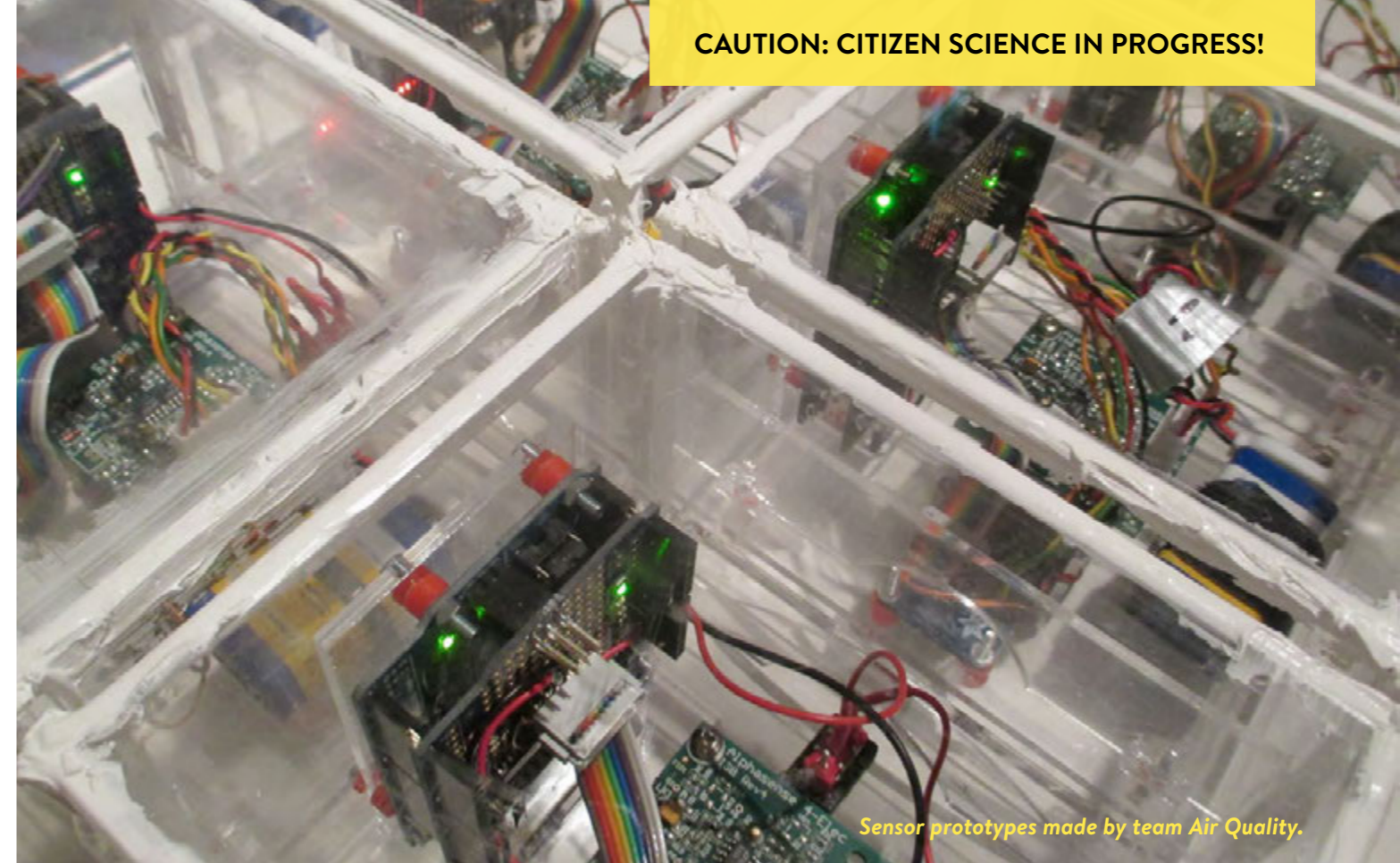
TEAM DEVELOPMENT

A quick scan of the faces around the room revealed most to be of an older stock, about 30 years old and above. Half were internationals and tended to be male (3:1), highly educated, and coming from professional, but not necessarily IT, backgrounds. Lab partners RIVM, SenseMakers, Wageningen University, Applied University of Amsterdam and the Amsterdam Institute of Advanced Metropolitan Solutions were also represented. At the second workshop citizens proposed, voted on, and formed groups around four sensing topics: air quality, noise pollution, wind and road bumpiness. Weekly lectures from inspiring speakers gave way to tables rumbling with activity as participants spent the remainder of their evening brainstorming about what they wanted to measure, how they were going to do it, and planning for the weeks and months to come. Because of the workshops' relatively late start time (19:30), most group work was conducted at the Fablab on Tuesdays and on the participant's own time.

By the third workshop, the groups had a clearer idea of their research goals.

Initially, there was such an overwhelming enthusiasm to participate in the air quality group that for the sake of efficiency it was split into outdoor and indoor categories. The outdoor air quality group decided to focus on measuring NO₂ gas, a traffic pollutant that Amsterdam is known to have relatively high levels of despite being overpopulated with bicycles.

The outdoor air quality group decided to focus on measuring NO₂ gas, a traffic pollutant that Amsterdam is known to have relatively high levels of despite being overpopulated with bicycles. The indoor air quality group were unsure what course of action to take but were eventually inspired by the AIRBezen project to try using a plant-based sensor to measure a yet-to-be decided indoor air pollutant.



Sensor prototypes made by team Air Quality.



Team Air Quality during the fifth Amsterdam Smart Citizen Lab session.

“The wind group wanted to deploy sensors all around the city to create a ‘wind map’ that would be accessible through a mobile app so bicyclists could alter their route to avoid severely windy roads.”

Those in the sound group, many of which belonged to the SenseMakers, wanted to understand the relationship between measured urban noise and citizen wellbeing. They planned to do this by deploying a sensor array in a designated area of the city that could identify and measure sound and designing a mobile app to ask locals that lived close by about their mood after hearing these sounds. The wind group wanted to deploy sensors all around the city to create a ‘wind map’ that would be accessible through a mobile app so bicyclists could alter their route to avoid severely windy roads. This proved a bit too ambitious and they later decided to focus on developing a sensor that could measure wind speed and see how much energy could be generated from it. The road bumpiness group on the other hand was struggling to come up with a viable sensing strategy. At one point there was toying with the idea of using GPS systems found on smartphones to measure elevation differences and create a ‘bumpiness’ map of the city that would be accessible through a mobile application.

The summer came and went, and when the lab reconvened in September the outdoor air quality, sound and wind groups had made enough progress to merit mid-term presentations. While our citizens still had a long ways to go, as none had yet tested their sensors ‘in the wild’, in just two months they made considerable progress. Sadly, the indoor air quality and road bumpiness groups stopped showing up for reasons that will be discussed in chapter 7.

TEAM AIR QUALITY

The outdoor air quality group, which was fortunate enough to have members that were air quality scientists from RIVM and Wageningen University, developed five Arduino-based sensors and a shareware-based sensing platform. Group members individually tested their sensors at home and convened in the Fablab to compare results and properly calibrate their sensing hardware.



Sensor prototypes made by team Air Quality.

They originally wanted to gather data wirelessly but finally opted to use onboard SD cards due to financial constraints. They planned to deploy their sensors at 25 locations in the vicinity of the Waag to gather data and generate an air quality map.

Qijun Jiang, a PhD student at Wageningen University studying geo-information science, stated that while their NO₂ sensor was much more sensitive (and expensive) than the one used in the Smart Citizens Kit, it was still drastically cheaper than those currently installed at official air quality measuring stations.

Despite the air quality group’s considerable progress they still hadn’t quite worked out all the hardware and software kinks. Joost Wesseling, an air quality scientist from RIVM, said that their sensors were in fact too sensitive to moisture, humidity, sunlight and ozone. ‘The sensors we are using now are completely manufactured and calibrated by the company itself, but because there are so many cross sensitivities, it is almost impossible to correct for all of them, and we are not sure which sensitivity is causing the sensor to gather data incorrectly.’



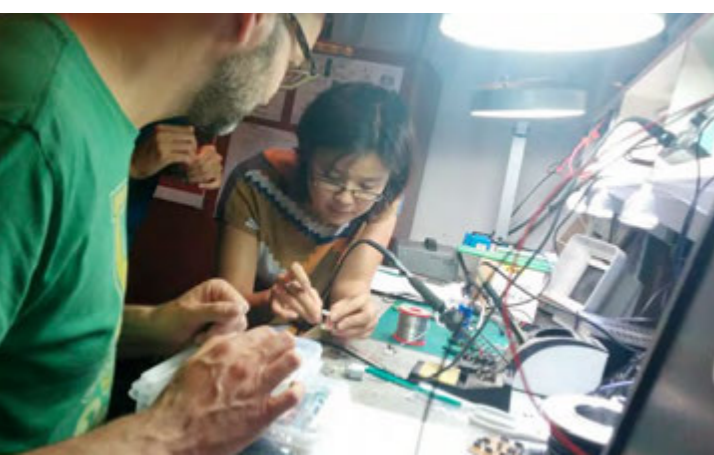
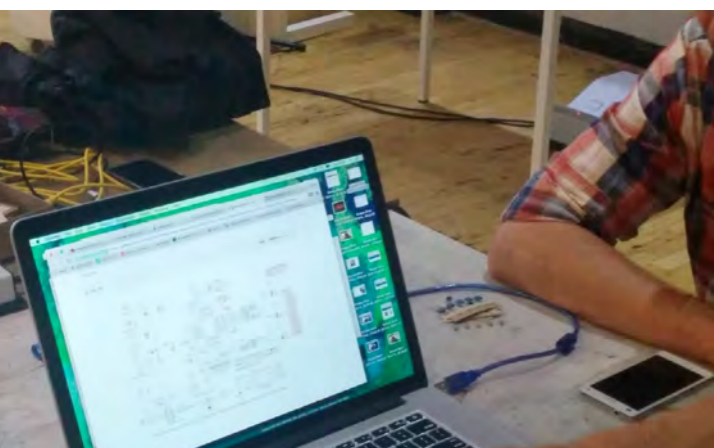
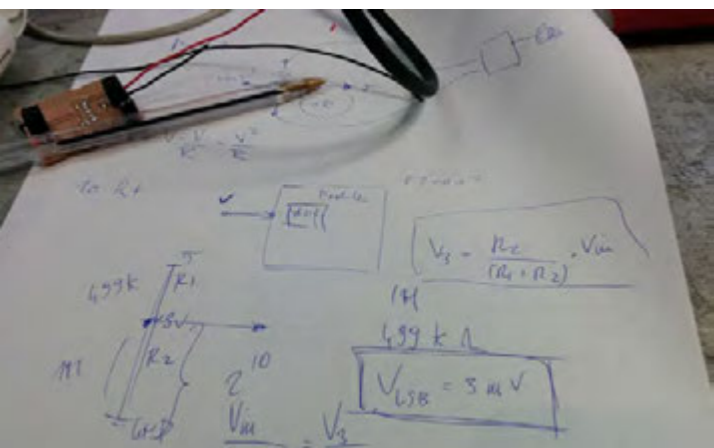
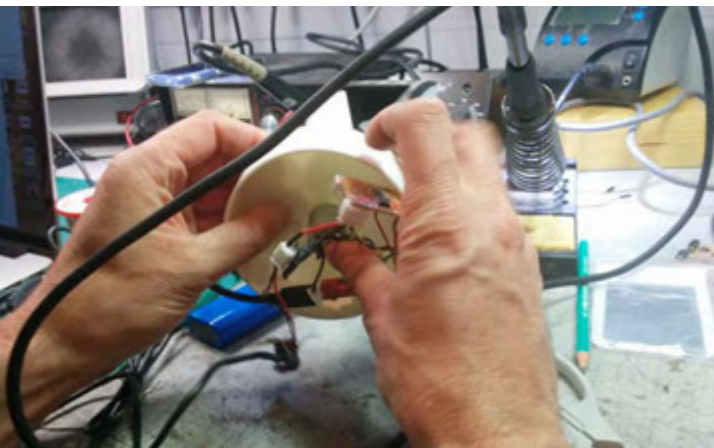
TEAM NOISE POLLUTION

The sound group’s progress was quite astonishing. By September, their sensor platform was almost full formed; all that was left to do was field-testing. SenseMaker organizer Jonathan Carter and Pinar Timiz, an aural artist and sound designer at Guerilla Games, developed the mobile application interface. ‘Our grand plan was to put the sensors in a small part of the city, and whenever the sensor would pick up a noise it didn’t understand, we just wanted to ask the people to report on their phones whether they recognized the strange sound and how it made they feel,’ Carter said. Their app was inspired by an app called Mood Meter, developed by a museum in Canada that uses a four quadrant color grid where each color quadrant represents a category of moods (angry, happy, sad, relaxed). Users are asked to rate their emotion in terms of how pleasant and unpleasant they feel (x-axis) and how high or low energy they feel (y-axis).

Maurice de Vries, a sensor expert and veteran maker in his own right, designed and constructed three sensors composed of a microphone, a frequency board and a Raspberry Pi-based gateway housed within a 3D-printed hardware case. SenseMakers as they were, the sound group’s sensing strategy was arguably the most experimental and ambitious of all the groups. Maurice fashioned a sensor network that used a 2.4 GHz frequency wireless data relay capable of real time sound sampling and transforming the audio spectrum (bass to treble, silent to loud) into an animation and store it on the cloud server.

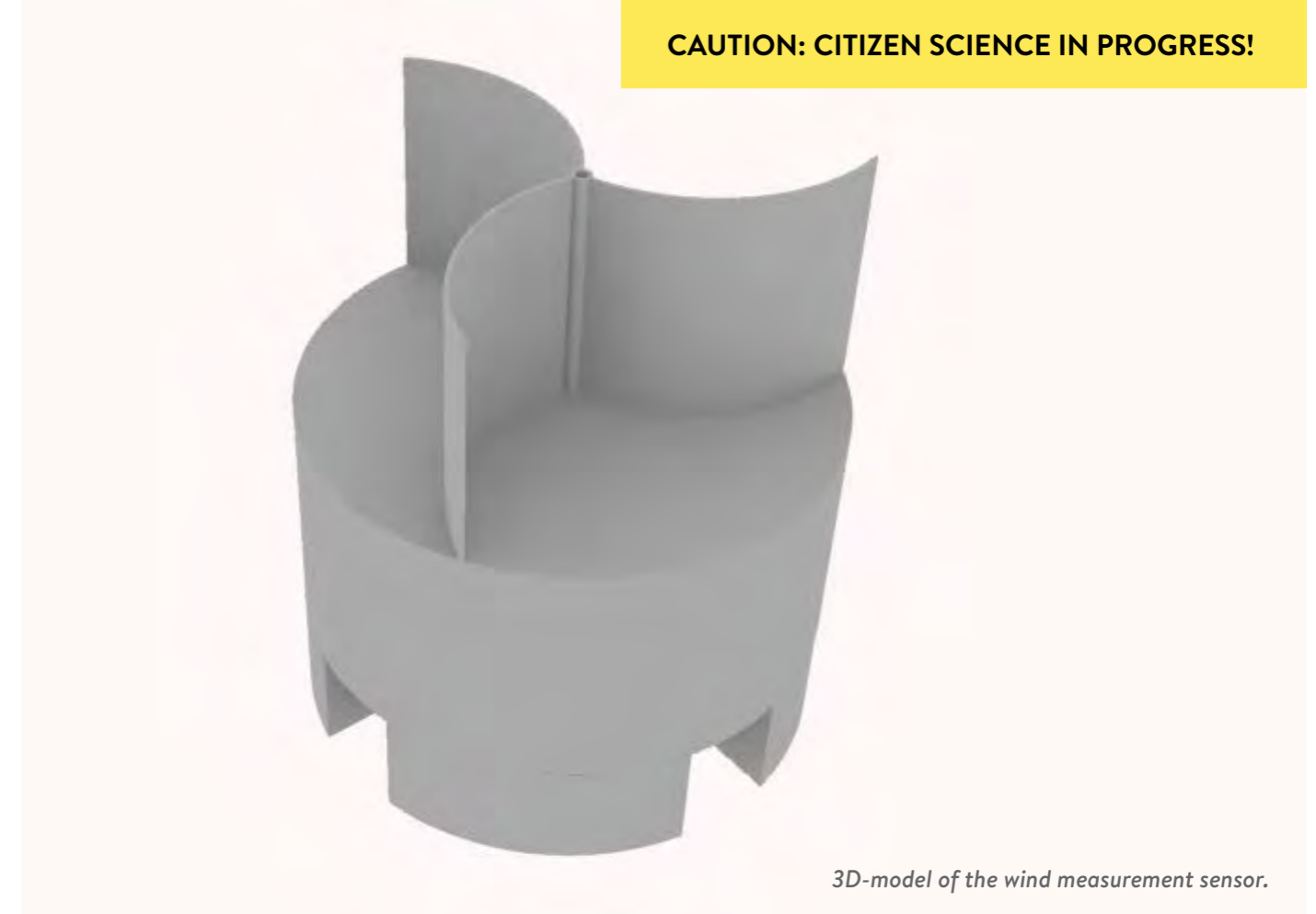
De Vries claimed even with having such a low budget that their system was more advanced than current examples of IoT technology, which generally record data about once an hour. Even with all his expertise, there were still a number of technical issues and logistical obstacles to overcome before field-testing that required weekly visits to the Fablab. ‘[The sensor] works, but its too rough a prototype, I can’t really put it outside yet...I guess you could put it in a silicon case, but its too high powered, uses too many components, and requires a external power supply,’ he said.





TEAM WIND ENERGY

The wind group was able to set up a data server and utilize the 3D printers at the Fablab to design and manufacture the propeller and a hardware case for their sensor. They did however encounter difficulties while developing their sensor network and had to temper their ambitions to what was possible with the skill of their members. Guillermo Rodríguez-Fernández, a software developer that was in charge of developing the web server, said that the original idea for an Arduino-based Raspberry Pi system proved to be too complex. ‘We were introduced to a more portable Wi-Fi module that could plug directly to the motor and send the data to our server, saving us a lot of space,’ he said. Even after this pilot, there were further software complications because the sensor firmware was not compatible with the latest Mac OS X operating system update, postponing group work for about a month until an alternative hardware solution was found.



3D-model of the wind measurement sensor.

Compared to the other groups, wind’s lack of hardware and maker expertise made the design and construction process considerably more difficult. ‘The hardware we are using is so sensitive that, if even a single wire is improperly connected, you are going to get bad readings and you don’t even know what part of the sensor is causing the problem,’ Rodríguez-Fernández said. The wind group’s skills handicap was eventually surmounted through working every week with Emma Parecshi, one of Waag Society’s hardware developers and sensor expert extraordinaire. Rodríguez-Fernández felt they were ‘really lucky’ to have her to guide them along the way. ‘Without Emma, it would have been impossible,’ he said. After she vacated the Fablab for summer holidays the wind group was even able to successfully work with the fabrication tools and develop their sensing hardware without explicit instruction.

Limited resources. Logistical setbacks. Technical conundrums. By summer’s end perseverance prevailed as outdoor air quality, sound and wind groups were able to mostly overcome these obstacles and exhibit remarkable progress. But, there was still work to be done, and a lot of it. Hardware needed tweaking, cases needed manufacturing, software needed debugging, sensors needed field-testing, and, most importantly of all, data needed to be harvested and visualized. And so, through the fall and into the winter our smart citizens continued the good fight, working diligently at home and in the Fablab toward the grand finale on December 10 when they would present their final results to the world at Pakhuis de Zwijger.



Hashtag:

#IAMSmart

06
THE
GRAND
FINALE

At last, the day had come for the lab's denouement at Pakhuis de Zwijger, a historical warehouse converted in 2006 into a restaurant and multidisciplinary community platform for Amsterdam's creative industry and 'the people who make the city what it is'. It also hosts an incredible amount of lectures and workshops, ranging in topic from design and art to social issues like the European migrant crisis, developments in urban resilience and transformations in health care.

For the first part of the evening's program, Mara Balestrini, research director of the think tank and consulting firm Ideas For Change, and Cindy Regalado, a community organizer of the Public Laboratory for Open Technology and Science, two intrepid and inspiring scientists whose work was inspirational to the Amsterdam Smart Citizens Lab, took the stage to share their expertise and wisdom to the jammed packed studio on the fifth floor.

“Users had the benefit of Waag Society’s institutional support and expertise, which goes to show that simply giving people technology doesn’t necessarily lead to empowerment; community support as it turns out, is integral to make participatory sensing work.”

Balestrini went over her work researching the implementation of the Smart Citizens Kit in Barcelona, Manchester and Amsterdam. She imparted one slide that compared the amount of data that was being shared by the Barcelona and Amsterdam sensors that indicated that while there were more Barcelona users that had installed sensors, Amsterdam users were contributing a lot more data. Why? The key difference was that in Barcelona the kits were crowd-funded by Barcelonans that wanted to support technology but did not necessarily have the adequate technical know-how, the institutional support, the desire or the patience to learn how to get the sensors to work. The numbers don’t lie: only 30 percent of those who crowd-funded the sensors actually even attempted to turn them on. Amsterdam was a different story. Users had the benefit of prolonged institutional support and expertise, which goes to show that simply giving people technology doesn’t necessarily lead to empowerment; community support as it turns out, is integral to make participatory sensing work.

Regalado’s research was really emblematic of this notion. The Public Laboratory for Open Technology and Science is a collaborative online platform that was started by a group of people with different professional backgrounds from around the world coming together with like-minded organizations, educational institutions and individuals to create and disseminate open source tools and techniques and use the DIY approach for investigating the urban environment. Regalado brought up a number of examples where communities and grassroots movements who used public lab’s tools to affect public policy.



Public Lab conduct aerial imaging documentation on various restoration islands in Jamaica Bay. Aerial maps document progress on the Army Corps of Engineers initiative to restore eroding salt marsh habitat with recycled dredge material, show shoreline and vegetation change over time, and document citizen participation in these efforts.

In Jerusalem, Israel, Allah Salam used Public Lab’s aerial mapping techniques to take aerial images of his neighborhood where the city was building a road that was not only divided the community and exacerbated tensions between Israelis and Palestinians, but also harmed the environment. He brought the map to MPs to show what was going on and created meaningful dialogue that otherwise wouldn’t have occurred.

In New York City, New York, USA, the Gowanus canal releases about 1 million gallons of sewage into the Hudson River every day. A group of concerned citizens wanted to know if it was possible to help the Environmental Protection Agency find a solution to this problem. They went around the canals with canoes and tied cameras too balloons (held down by string, of course!) to create a comprehensive low-altitude map.

This way, they noticed that garbage plumes didn’t accumulate in a certain part of the canal and weren’t sure why. They overlaid their map with a 300 year old geological map of the city and discovered that long lost streams thought to have been filled up and built over centuries prior were still flowing, causing vegetation to sprout through the asphalt roads and around buildings. The data generated through this project was recognized by the Environmental Protection Agency and has been used as evidence for restoration and conservation of local littoral ecosystems.



Gowanus Low Altitude Mapping (GLAM)
Brooklyn, New York



Use of Balloon Mapping to Temporarily Stall Eviction Proceedings
Kampala, Uganda.

THE CURRENT ECOLOGICAL DEBATE

Eymund Diegel, lead researcher of the project, said that ‘grassroots, bottom-up efforts provide granularity and nuance that renders these efforts inclusive of local issues, local knowledge, local politics and sustainable solutions because people are there and they know, and they provide that [data] granularity and nuance that the Environmental Protection Agency and other institutions can’t provide.’ Regalado concluded by stating that ‘what we learn from all this is that aerial photographs do not speak for themselves; they must be used by communities. Aerial images are grounds for interpretation and dialogue, they start conversations, they don’t end them.’

With the room sufficiently inspired by the success of citizen science from abroad, it was time for Amsterdam’s smart citizens show their mettle to the community-at-large.

First up, Rodríguez-Fernández was accompanied by Roberta Colavecchio for the wind group. After introducing the crowd to the team’s goals and challenges, they unveiled a final sensor design that was significantly different than their summer prototype. They completely redesigned their sensor’s propeller from a 2-blade to a 3-blade system and went from using a rechargeable to a non-rechargeable 5-volt battery. In the final few weeks they put in a lot of work and finally managed to send data from the sensor and collect it on a Github-based server, but weren’t able to render it visually—yet.

Though he said it was a ‘hard delivery’, Rodríguez-Fernández affectionately called the sensor his ‘little baby’ that he was very proud of’. He also presented concept art for a new sensor with significant design improvements that would make it waterproof and capable of being attached to a bicycle.

Reflecting on her group’s experiences, Colavecchio concluded by quoting the Smart Citizens Manifesto²⁶: ‘smart citizens take responsibility for the place they live, work and love; valuing access over ownership and contribution over power; value empathy dialogue and trust; appropriating technology instead of accepting it as it is; and unremittingly share their knowledge and learning because that is where true value comes from.’ She proposed that the smart citizen concept could be very useful in the current ecological debate to erase the commonly held separation between the natural and man-made world towards an idea of urban sustainability where communities use technology proactively to reduce their detrimental effect on their planet.

CHALLENGES

Next up, Co de Boer of the outdoor air quality group. Group members tested their five sensors at their homes and used their weekly meetings at the Waag to calibrate and align them to one another, later fashioning some waterproof hardware cases so they could be field tested. De Boer revealed that in their initial home tests the sensors took upwards of 60 minutes to 'warm up' before they were able to measure anything worthwhile. In the end, the group was successfully able to gather reasonable readings from over 27 locations around the city, store it on a Github-based server and generate a NO2 map that showed that high-traffic areas had significantly higher levels of NO2 while lower traffic areas had nominal levels. De Boer concluded by saying that while the sensors were sensitive, not as reliable as professional sensors, and difficult to interpret, the groups job was made a lot easier because it was a combination of both everyday people and air quality sensor professionals.

He said that future citizen scientists and sensor makers could learn from their findings to develop even better sensors in a shorter amount of time.

Finally, de Vries and Carter took the stage for sound. Unfortunately, despite their amazing progress after the summer, the group was not able to install their sensors or reach out to volunteers to test their mobile application, and therefore did not gather any data. Carter said that 'many other teams had this same problem and were very enthusiastic in the beginning, really engaged and ambitious, then vacation time came and time eventually ran out.'



On the other hand, unlike the other teams they were able to create a mobile app, and had three fully functioning sensors and scouted some potential locations for testing. De Vries commented that even though their initial prototype sensors were completely functional, in the final weeks he was working diligently with Emma to reduce the size of the devices, but they weren't able to get them working in time. Despite these setbacks Carter and de Vries said they will continue developing their sensor platform and that someone has already reached out to properly test the sensors in their neighborhood.

At the end of the program there was a panel discussion with Hester Volten, Jonathan Carter, Pieter van Boheemen, 'biohacker' and Programme Manager at Waag Society, and Ger Baron, Chief Technology Officer of the city of Amsterdam, where Amsterdammers had a chance to ask questions about the lab and the future of citizen science.

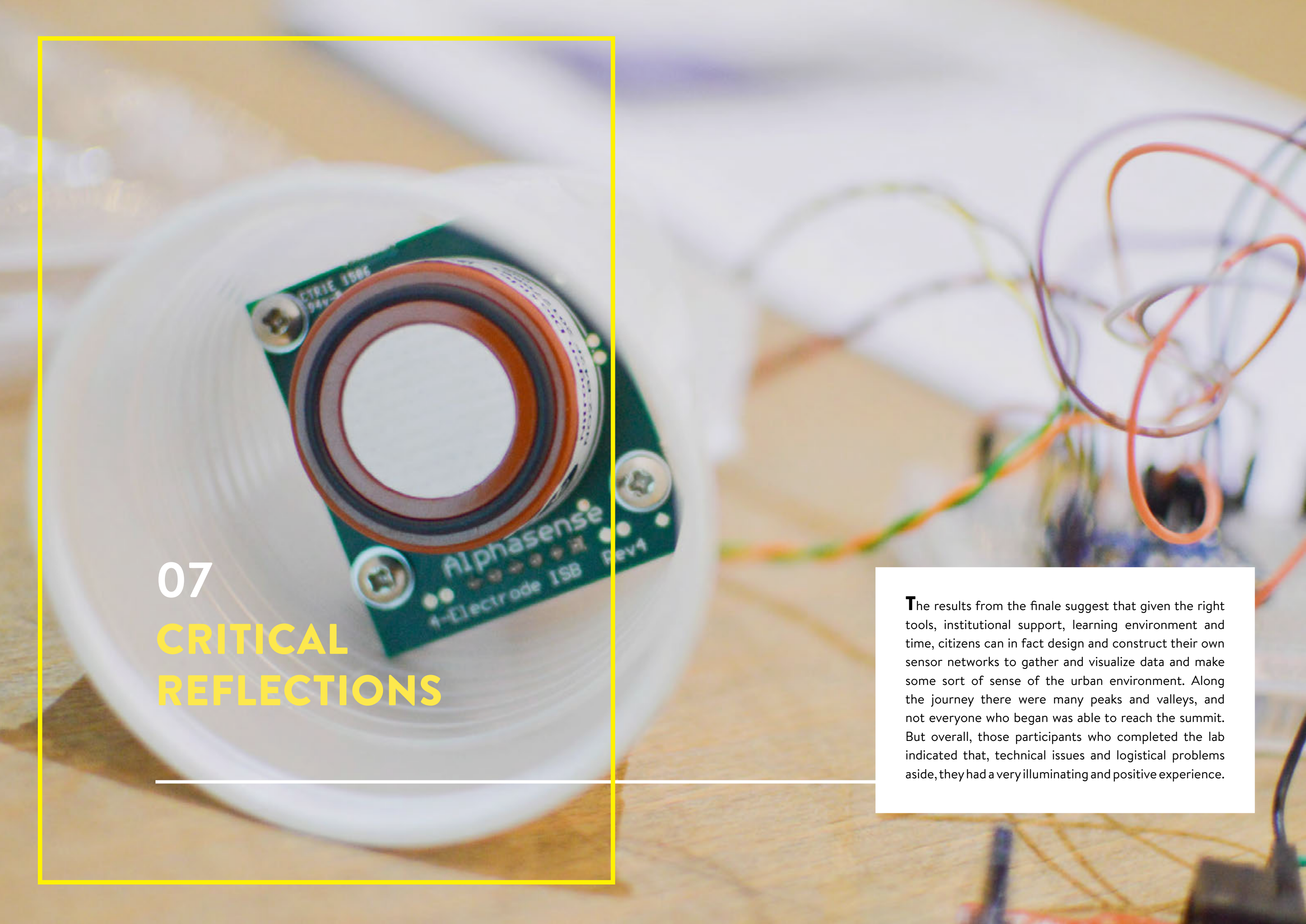
WHY CIVIC SENSING?

One of the more salient discussions occurred when a member of the audience asked about data ownership and the possibility of the government offloading key responsibilities to citizens that might already be too busy with their own lives to be measuring environmental data.

Balestrini chimed in and gave an anecdote about when she was part of a team tasked by the city of Bristol to figure out how to scale up participation in civic sensing. They came up with the idea of a common digital space to which Bristolians could contribute data, and be protected by a 'citizen contributor bill of rights' where they would be rewarded for their contributions. In regards to the offloading of governmental responsibilities, Volten commented that 'the government can't do everything.'

Technology gives people the chance, enables them to take your own responsibility. If you can do that, then why not?

RIVM is measuring what we think is important for the country as a whole, but if the citizens are concerned about what's happening in their streets, [the government] might not let us do that... the people should tell us what they think is important to them.'



07

CRITICAL REFLECTIONS

The results from the finale suggest that given the right tools, institutional support, learning environment and time, citizens can in fact design and construct their own sensor networks to gather and visualize data and make some sort of sense of the urban environment. Along the journey there were many peaks and valleys, and not everyone who began was able to reach the summit. But overall, those participants who completed the lab indicated that, technical issues and logistical problems aside, they had a very illuminating and positive experience.

Jiang felt as both a citizen concerned about environmental issues and as a professional GIS scientist that more NGOs, civil society, research institutions and governments should get involved in citizen science-based projects because they have a real potential to contribute to a city's environmental and public policy goals. The Lab helped him learn a lot of new things about hardware development and executing sensing strategies.

Even if people have different motivations and professional backgrounds, Jiang said that participation in citizen science could help everyday people 'gain knowledge about their city, scientific literacy, learn about technology and meet people in their community who care about the same issues.'

Rodríguez-Fernández enjoyed the lab's collaborative culture and friendly community so much he even began promoting it at work to his colleagues. 'I was able to find people that have the same interests and everyone is willing to help. People are curious about joining efforts and giving each other constructive feedback in a cooperative environment.' Timiz had the same sentiment, stating the lectures from experts were inspirational and that the workshops were a useful platform for collaboration and brainstorming with people she would otherwise never have met.

MAINTAINING PARTICIPANT MOTIVATION

Furthermore, an open source ethos, the open Tuesdays at Fablab, and the attentive support of experts proved invaluable. As Guillermo mentioned, without Emma's help the wind group's success, the only group to finish that did not have any sensor experts on their team, would have been 'impossible'. To be sure, even the air quality and sound groups which had scientists and sensor experts made sure to clear their schedules to be at the Waag Tuesday evenings to take advantage of the facilities and institutional support – not to mention the infinite supply of coffee.

That being said, the lab was not perfect and suffered from several issues that inhibited optimal results. One of the lab's biggest challenges was maintaining participant motivation. After the summer two research groups, indoor air quality and road bumpiness groups, dropped off the map completely and a significant number of the remaining participants from the other groups were missing for reasons that were not immediately apparent. So, what happened exactly? AMS scientists who were present at the first workshop asked the participants their motivation for joining the Amsterdam Smart Citizens Lab. According to the survey, while 30% were motivated by the subject of the experiment, around 70% said they joined because they were drawn to the challenge of gathering sensor data and 'learning technical skills'. The second most mentioned factor (50%) was meeting other like-minded people and creating a community²².



Trying out sensors during the fifth session.

Expectations of participants during the first sessions.

I want:

to GET INSPIRATION ABOUT HOW TO CONCEIVE AND CREATE AND CONNECT OBJECTS THAT CAN HELP US RE-BUILDING A SUSTAINABLE ENVIRONMENT (not only from an environment perspective but also more generally from a CULTURAL, INSTITUTIONAL ONE)

I need:

technical ^{help} and inspiration ~~to~~ and practice to ~~visualize~~ visualize better a project I have about MUSEUM ECOLOGY. (through internet of things) and SMART VISITORS.

TRIAL & ERROR

When the research groups were first established, some had upwards of 10 people and coordinating groups tasks that could fit into everyone's schedule over such a long period of time proved to be a lot more difficult than expected. Emma opined that the some participants stopped being involved because they could not personally dedicate enough time to meet outside of the workshops. 'You are either already well adept at making sensors or you need to dedicate time to research and study,' she said. 'Of course you can get suggestions and help from researchers like me, but you need to experiment and test the hardware and software. I don't know if you really need to be a sensor expert to reach a good result.'

Of course you need help, either personal, a book or online, but it can be done alone, it just takes time.'

De Vries said what drove away many people from his group by the fourth lecture was that the learning curve for programming and designing sensors for people that have no prior experience is extremely steep. 'In order to make sensors work you first need to learn the C programming language, which can be difficult because most people do not have any experience with programming... next to that there is the hardware, that's even more scary!' Rodríguez-Fernández agreed: 'I think people in my group became demotivated because we had a lot of problems configuring and programming the device...our grouped lacked hardware expertise...at one point the sensor worked and then because of software issues it stopped working and after that people stopped coming.'

Jiang said that even 'after [the air quality group] split up, some members were quite active while others not; maybe showing up once or twice and then disappearing.' His point shines light on another issue highlighted by some participants about the open invitation policy that allowed anyone to join the workshops even after the research groups were established. De Vries said that there were instances when new people would sit in on his group halfway through the lab, and instead of spending time after the lectures to ideate and plan for the weeks ahead they had to bring new participants up to speed even though they were never heard from again. 'The task of making sensors is already really difficult but now you have people coming halfway through and getting them back on speed didn't really work,' he said.



Participants mapping sessions during the first session.

Expectations of participants during the first sessions.

I want : to be inspired
by others and build and
contribute to social ex-
periments.

I need : Perimeters
more links to
different people with
completely other skills.
This platform basically

08

**MOVING
FORWARD**

Now that the first edition of the Amsterdam Smart Citizens Lab has come to a close, what lessons can be drawn from the experiences of the participants and practitioners to guide future projects? This will be key, as the results from this lab and a recent surge of interest in citizen science from governments, universities, research institutes and everyday people from around the world has led to several upcoming projects. The most ambitious one of those is Making Sense, a EU-wide project that will be similar to the Amsterdam Smart Citizens Lab, as it will include many of the previous partners, but will be executed on a larger and more ambitious scale with the participation of Dundee University (UK), the Institute for Advanced Architecture of Catalonia (ES), the Join Research Center (BE) and the Peer Educators Network (KS).

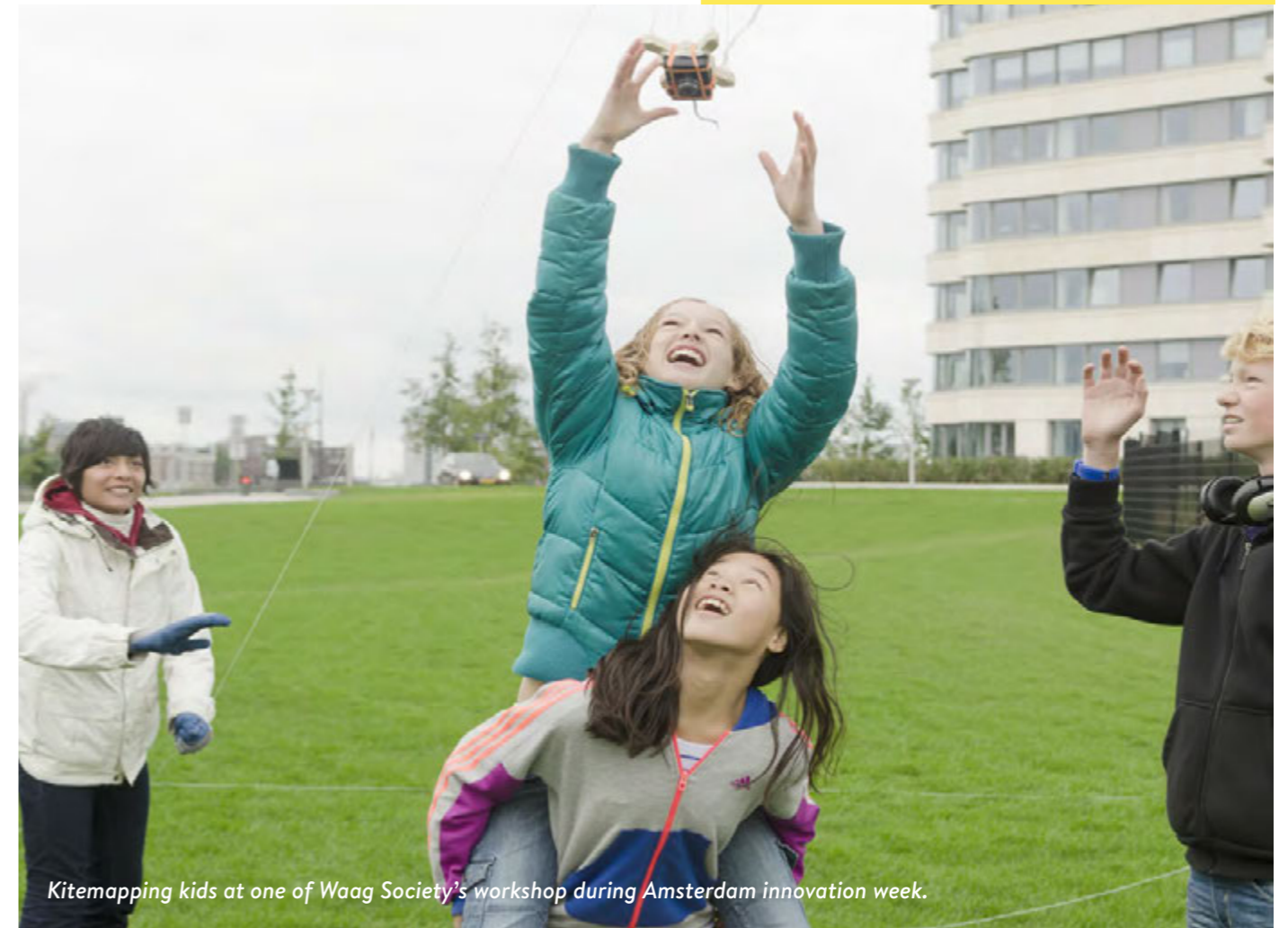


SHARING KNOWLEDGE

The Lab has demonstrated how citizen science can democratize the scientific enterprise by being inclusive of more stakeholders at both the expert and community level. At its best, citizen science is an epistemic tool that can complement, not replace, the tried and true methods of expert-driven scientific inquiry. It is an evolving field whose potential is not yet fully realized or understood. Working with new forms of technologies without prior experience can be a highly frustrating—and potentially rewarding—experience. With the right institutional support, it is possible for everyday people to create their own sensor networks and gather environmental data without significant investments. Furthermore, people’s motivations for joining citizen science projects may have less to do with the end goals of the research itself than with acquiring new skills and being part of a community of people who want to learn about the nuts and bolts of DIY sensor technology. Many more iterations and experiments will be required to improve this new research paradigm so that it becomes more pervasive and relevant within the urban context.

The Amsterdam Smart Citizens Lab partners plan to follow the Public Lab’s lead and digitally document all design prototypes and data generated during the lab for posterity so future citizen science practitioners can continuously build on previous efforts. Speaking at the expert panel at the Pakhuis de Zwijger event, Carter agreed that continuity of knowledge is very important. ‘The SenseMakers worked on a sensor a few years ago called the Air Quality Egg, a kind of version 1.0 prototype...the Smart Citizens Kit was 2.0 version of that and [the Air Quality group] sensor is a kind of 3.0 version,’ he said. ‘A lot of people have stuck in and were involved in all three... important knowledge is building and we should continue to iterate and involve a wider amount of people from the public each time.’

“With the right institutional support, it is possible for everyday people to create their own sensor networks and gather environmental data without significant investments.”



Kitemapping kids at one of Waag Society’s workshop during Amsterdam innovation week.

The AMS Institute has proposed a speculative class of tools for consolidating participatory sensing knowledge dubbed the ‘Urban Knowledge Collider’ (UKC)²⁷. The UKC is a web-based collective awareness platform that will ‘allow relevant urban stakeholders to engage with each other and leverage their collective expertise and experience in an environment combining virtual worlds based on actual physical models, real-time, multimodal data streams, and sophisticated visualization tools to support actions, assessments, and decision-making.’ The strength of such a platform will come from combining citizens’ contributions in terms of data and questions with experts contributing knowledge, analysis, sense making; (on-demand) participatory sensing/crowdsourcing; machine learning / AI / algorithms and data science; and data coming from official sources.

The difficulty of learning software and hardware skills and sustaining motivation were some of the biggest issues that inhibited long-term participation in the Lab. Emma commented that while the groups may have needed some additional technical support, what they really needed was ‘additional workshops where participants could be taught a bit of coding, visualization tools, and other key skills required to build the sensors themselves.’ Our sensor doctor’s astute observations have been duly noted. On a broader scale, partners want to create partnerships with high schools and universities to get more students, who tend to have more free time than working professionals, involved with the lab either as sense makers and/or testers.



Participants during the Open Tuesday evening, where they get some last hardware advice from Emma.



KEEP EXPERIMENTING

First and foremost, the Amsterdam Smart Citizens Lab should be understood as an exploration of a very new research paradigm. Unlike those who participated in the Smart Citizens Kit, who had the advantage of having hardware and software tools ‘out-of-the-box’, the Lab had much more ambitious goal of working with citizen volunteers, mostly without any hardware or software experience, to develop their own sensors and sensing strategies from the ground up. Yes, it is true that not everyone who started the Lab was able to finish, but this fact should not overshadow the success and resoundingly positive experiences of those who did. The Lab is an experiment, and in the words the great Henry Ford, ‘the only real mistake is the one from which we learn nothing.’

But, wait a minute, that’s it? Now that we’ve gathered the data are we just going to sit on it? Does teaching people how to make sensors automatically ‘empower’ them to change the world? Any answer in the affirmative would be tenuous at the absolute best. People might be able to use sensors to become more aware of certain kinds of environmental conditions and become engaged with communities to articulate their concerns, but we don’t live in bubbles or in a completely decentralized and anarchistic society. Human beings exist within communities that make up towns and cities that are themselves situated within nation-states interacting within a globalized economic system. The only way to make that data useful and influence society for the better is through that age-old—and at times extremely annoying—human institution: politics.



**AMSTERDAM, LIKE ANY OTHER CITY,
IS A MICROCOSM OF SOCIAL,
POLITICAL AND
ECONOMIC RELATIONS.**



Amsterdam, like a city, is a microcosm of social, political and economic relations. The word politics is derived from the Greek word, *politikos*, meaning ‘of, for, or relating to citizens.’ Nowadays, it is generally understood as ‘activities that relate to influencing the actions and policies of a government or getting and keeping power in a government.’ Politics is more than anonymous individuals and communities voting for members of political parties in government or supporting ideologies based on privately held opinions. According to philosopher Hannah Arendt, our collective lives are dominated by the coalescence of public and private matters in a communal form, giving primacy to what she dubs the *vita activa*, the active life²⁸.

Christina Dunbar-Hester, a professor Media Studies at the University of Southern California put it best when she said²⁹, ‘Sensors and smart phones will not, in themselves, solve issues. The Do-It-Yourself approach itself does not necessarily challenge or address the systemic issues and limitations that oppress people. DIY tools and sensors do make issues visible, they do help us ask questions, but what really matters is the people, how we interact together and the values that we hold and create together.’ Following these notions, the Amsterdam Smart Citizens Lab partners wants to investigate ways to transform sensor-based insights into community action and passive data into ‘evidence-based’ storytelling and campaigning. Regalado concurs, ‘The way we tell our stories is going to become increasingly important... the way we acknowledge plurality and create spaces that facilitate interconnectedness and link to the bigger picture is how we will find equitable solutions to our problems.’

The world has become an increasingly digitized, globalized, fragmented, distracted and at times overwhelming place. Our problems are myriad and there are no easy answers. The learning curve will be steep, but building a better tomorrow cannot happen without coalitions between educational institutions, makers spaces, civil societies, NGOs, public authorities, and, most importantly of all, dedicated and involved smart citizens, so we may alter the flow of our data driven world towards one of inclusion, engagement and sustainability.

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THE AMSTERDAM SMART CITIZENS LAB

A publication by Waag Society & AMS Institute

A growing group of citizens take the future of the places in which they live, work and play into their own hands. They become “smart” by mastering and sharing technologies that help them to express themselves, connect to others, share resources and ideas, and reflect; so they can decide the best course of action – for themselves.

One of the most striking examples of this movement is the *Amsterdam Smart Citizens Lab*. It empowers citizens to use open source technology to understand their environments better, and take action based on their findings. They are coached by experts who answer their questions and help them to measure, analyse and interpret data that would have been beyond their reach even a few years ago.

From May till December 2015, over fifty ‘Amsterdammers’ joined the lab to start measuring. This book tells their story, gives some context, shows their results, and imagines a future. It is a story with no end: it’s a beginning that begs for you, dear reader, to appropriate it and make it your own. We would love to hear from you.

