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ORIGINAL PAPER

Public Lab: Community-Based Approaches to Urban and Environmental Health and Justice

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Abstract This paper explores three cases of Do-It-Yourself, open-source technologies developed within the diverse array of topics and themes in the communities around the Public Laboratory for Open Technology and Science (Public Lab). These cases focus on aerial mapping, water quality monitoring and civic science practices. The techniques discussed have in common the use of accessible, community-built technologies for acquiring data. They are also concerned with embedding collaborative and open source principles into the objects, tools, social formations and data sharing practices that emerge from these inquiries. The focus is on developing processes of collaborative design and experimentation through material engagement

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with technology and issues of concern. Problem-solving, here, is a tactic, while the strategy is an ongoing engagement with the problem of participation in its technological, social and political dimensions especially considering the increasing centralization and specialization of scientific and technological expertise. The authors also discuss and reflect on the Public Lab's approach to civic science in light of ideas and practices of citizen/civic veillance, or "sousveillance", by emphasizing people before data, and by investigating the new ways of seeing and doing that this shift in perspective might provide.

Keywords Aerial mapping · Water quality · Civic science · Sousveillance · Participatory design · Open source · Community engagement · Open hardware · Do-It-Yourself

Introduction

In a world of "Big Data", public participation in democratic politics is being pushed aside by increasingly data-centric and techno-centric societies. Top-down decision making processes regarding environmental, economic and social issues are controlled by small groups of experts who produce, interpret and apply data in decisions that affect many. Inhabitants in rural and urban areas—both citizens and non-citizens—are often disempowered by the lack of access to tools, techniques, information and knowledge needed to influence or participate in decision-making processes that directly or indirectly affect their lives, particularly regarding environmental health and the management and stewardship of the landscape.

This paper explores three cases of Do-It-Yourself (DIY), open-source technologies developed within the diverse array of topics and themes in the communities around the Public Laboratory for Open Technology and Science (Public Lab). These cases focus on aerial mapping, water quality monitoring and civic science practices. The techniques discussed have in common the use of accessible, community-built technologies for acquiring data. They are also concerned with embedding collaborative and open source principles into the objects, tools, social formations and data sharing practices that emerge from these inquiries. The authors also discuss and reflect on the Public Lab's approach to civic science in light of ideas and practices of citizen/civic veillance, or sousveillance, by emphasizing people before data, and by investigating the new ways of seeing and doing that this shift in perspective might provide.

"Citizens' Veillance" has been offered as a conceptual framework for describing projects in which "cognitive alertness and knowledge production are proactively oriented towards the protection of common goods" (Nascimento et al. 2014, p. 4). It is a form of decentralized information collection and sharing that fits neither the hierarchical, "panopticon" (Foucault 1975) model of "sur-veillance", nor the sort of "sous-veillance" (Mann et al. 2003) countermeasures that attempt to "watch the watcher", nor the increasingly pervasive "participatory panopticon" (Cascio 2005) structures in which the surveilled carry out a surveillance agenda not fully in line with their own values (Marx 2002, 2007). This latter includes corporate platforms like Facebook, Google and Twitter whose business models are comprised of the centralization and aggregation of large amounts of personal data which are then filtered and sold in the data marketplace and often handed over to government authorities. Instead of the passive self-surveillance of the participatory panopticon, "Citizens' Veillance" points towards recent innovations in Information and Communications Technology (ICT) that are enabling novel, collective forms of knowledge generation towards some shared, common purpose—typically, the securing of rights, resources, and/or solidarity among members of a community.

Important epistemic, ethical and practical questions have been raised by Susana Nascimento and colleagues (2014) concerning the ways in which particular social and technical structures do or do not effectively support a "Citizens' Veillance"' mode of collective knowledge production. How is useful knowledge generated—what counts as useful, and for whom? What is considered to be legitimate knowledge? How do communities with overlapping but diverse goals collectively decide upon the goals of knowledge production? How are technologies that promote common goals, created and embraced while being consistent with shared values? In order to examine such questions, they must be embedded in a set of additional, nested challenges, posed by the diversity of roles, professions, cultures, and values found within community organizations. Communities and institutions have differential perceptions and experiences of expertise, reputation, and authority. Different groups employ varying legibility, accessibility, legitimacy, and mutability of information technologies and data. There is tension between the promotion of transparency and sharing, and the preservation of privacy and context, particularly in marginalized communities and low-resource contexts.

This paper, presents three cases from within the Public Lab,[1] a community of practitioners focused on the practice of "civic science" in the service of environmental health and justice issues, where civic science is a science "that questions the state of things, rather than a science that simply serves the state" (Fortun and Fortun 2005: 50). These stories are offered by writers who tell different stories from three different countries—Israel/Palestine,[2] Spain and the US, in an attempt to explore some of the questions mentioned above, and offer provisional answers to them. The first two cases concern the use of DIY aerial photography.[3] Pablo Rey-Mazón describes his work using the balloon mapping toolkit for community building in Castellón, Spain, and Hagit Keysar reflects on a collaborative project in East Jerusalem, Israel/Palestine, using aerial imagery to document lived experience of children living under conditions of ongoing political conflict. The third case study, written by Catherine D'Ignazio and Don Blair, focuses on Public Lab's open science water monitoring projects in Cambridge, US.[4]

[1] https://PublicLab.org.

[2] The term Israel/Palestine is chosen here to refer to the contested status of sovereignty in East Jerusalem and the occupied Palestinian territories (see also footnotes 28, 29 and 37).

[3] https://publiclab.org/wiki/balloon-mapping.

[4] http://publiclab.org/wiki/riffle.

The cases follow a brief account of Public Lab's history and the technology of aerial mapping (common to two of the narratives). After each case study, is a discussion through the lens of Citizens' Veillance with an eye to some of the important questions listed above. In particular, we focus on (1) the multifarious understandings of expertise; (2) situating the development of technology within social and political contexts; and (3) developing critical perspectives and solutions to the possible contradictions between openness/transparency and the need to protect the privacy and security of vulnerable communities.

Overview: A Public Laboratory

In April 2010, the Deepwater Horizon rig exploded in the Gulf of Mexico, killing eleven workers and launching one of the largest human-made environmental disasters to date as almost five million barrels of oil discharged into the Gulf. Despite having a massive impact on residents and the environment, Gulf Coast communities received relatively limited information from official sources. As news of the severity of the disaster spread internationally, three of Public Lab's seven co-founders convened in the Gulf Coast.[5] Using helium balloons, kites and simple point and shoot cameras, the team, with the backing of a growing community of "grassroots mappers" conceptualized a plan to work with residents along the Gulf Coast to launch their own "community satellites" as the oil spread across the Gulf.[6]

The aerial imagery techniques that emerged were shared widely among "DIY mappers" throughout Louisiana, Mississippi, Alabama, and the panhandle of Florida. The structure of the kit used in the following case studies (see the Public Lab Guide in Fig. 1) is a more recent version of the initial kits, containing modifications provided by the community over the last 5 years that have been intended to enhance ease-of-use and the ability to obtain materials locally. Versions of these kits have now been used in various locations throughout the world, and the data and designs are shared online.

While aerial mapping features in two of the three case studies presented below, the scope and focus of projects within Public Lab has expanded greatly since 2010 to include a wide range of other "veillance" or monitoring technologies including: a cardboard, foldable spectrometer intended to identify contaminants (in response to Gulf residents' questions about possible oil on their beaches);[7] an infrared photography project that aims to develop a tool for assessing the impacts of pollution on vegetation;[8] and a low-cost water monitoring prototype.[9] The organization itself

[5] Public Lab's co-founders are Liz Barry, Shannon Dosemagen, Adam Griffith, Mathew Lippincott, Stewart Long, Jeff Warren and Sara Wylie.

[6] Jeff Warren, Oliver Yeh, Stewart Long, Shannon Dosemagen and Kris Ansin were the organizing team.

[7] https://publiclab.org/wiki/spectrometer.

[8] https://publiclab.org/wiki/near-infrared-camera.

[9] https://publiclab.org/wiki/riffle.

has grown to include local chapters[10] across the US and western Europe, as well as Jerusalem (Israel/Palestine), Santiago (Chile), Rio de Janeiro (Brazil), Lima (Peru), Bourj Al Shamali refugee camp (South Lebanon) and a chapter covering a few cities in Australia. Public Lab has active mailing lists for communication and exchange by contributors from advocacy groups, technologists, journalists, professional environmental scientists, and individuals from a wide range of other backgrounds—including those who are simply interested in knowing more about suspected pollution nearby. In addition to the mailing lists, Public Lab's online infrastructure includes wikis and "research notes" (essentially, blog posts) intended to facilitate knowledge sharing and attribution. The goal of Public Lab projects—the aerial photography, spectroscopy, infrared imagery, and water monitoring projects, in particular—is to create or curate live archives of data, collected and produced in a decentralized manner. On the one hand, these data support scientific investigation, advocacy, and, in some cases, regulatory actions. On the other hand, they foster diverse participation and collaboration of concerned residents and local organizations in the development of techno-scientific tools and methods.

The following case studies are examples of the depth and context of Public Lab's diverse practices and membership in relation to knowledge production and monitoring of the environment. There is further discussion of the themes and complexities that emerge from these cases, including some that challenge Public Lab's own founding aspirations around openness and transparency.

Case Study 1: Aerial Photography and Community Building in Castellón, Spain, 2014

The narrative below is written by Pablo Rey-Mazón, an organizer for Public Lab and co-leader of the Spanish non-profit organization, Basurama[11] *("trash-o-rama" in Spanish). Basurama uses art and design techniques for expanding civic engagement in issues around waste and trash in the landscape.*

Basurama was invited to participate in the art exhibition "7,000,000,000"[12] at the "Espai d'art contemporani de Castellón", a municipal art space. The group was asked to produce a piece related to the region of Castellón that documented the Spanish real estate bubble effects on the landscape. To accomplish that goal, we organized a 3-day aerial photography workshop focused on low cost and open-source tools to create collectively, with local organizations, a series of maps to be displayed along with the tools that helped to produce them. The project focused on bridging disciplines by using an art space and funding to work with scientific,

[10] Local chapters are groups organized around Public Lab tools and methods in local areas around the world for the purpose of investigating environmental, social, and political concerns. They interconnect the knowledge of various affected communities as well as that of relevant experts and share toolkits.

[11] More information about the Basurama association can be found at http://basurama.org.

[12] "7,000,000,000" exhibition was curated by David Arlandis and Javier Marroquí. More info at http://www.eacc.es/7-000-000-000/info/.

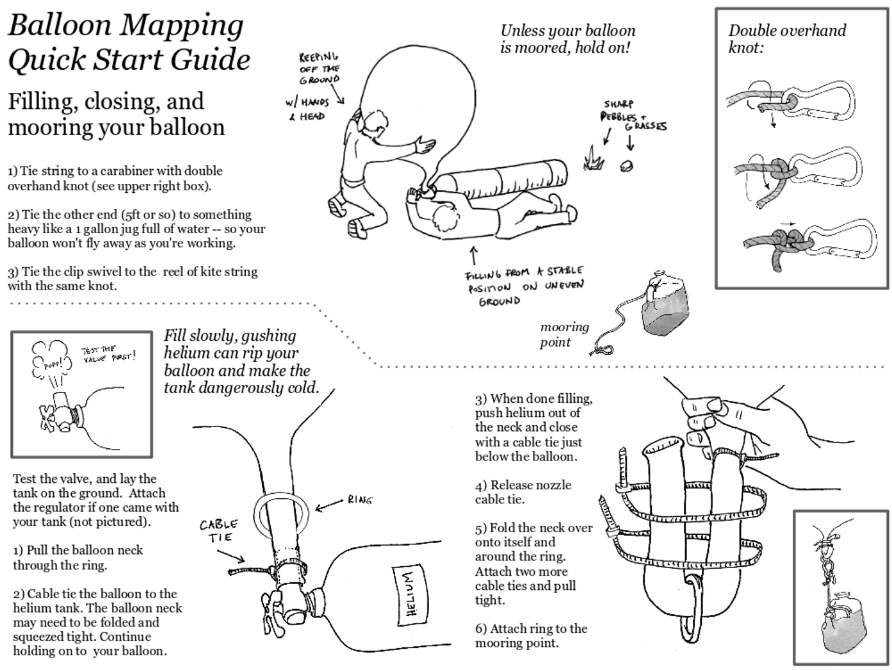

Fig. 1 Page extracted from the Balloon Mapping Quick Start Guide by Public Laboratory. Available at http://publiclab.org/sites/default/files/BalloonMappingQuickStartGuide1English.pdf

environmental and activist approaches. A secondary goal was to show/prove that it was possible for non-experts to quickly learn aerial mapping techniques.[13]

Process: Mapping from the Air and Building a Community

The project[14] started by building an online community in advance of the in-person gathering. Initially there was an open call[15] to ask for collaborators interested in learning aerial photography, and in brainstorming its applications in Castellón. A key element was working with local environmental and scientific organizations to gain knowledge of the place and to produce maps that could be useful for these stakeholders. A multidisciplinary group of environmentalists, artists and local activists resulted from this outreach. During the second stage of the project, participants

[13] We had explored this option when we mapped the Saugus Ash Landfill for the Trans Trash exhibition organized at MIT. More info at http://basurama.org/transtrash/2011/10/19/saugus-ash-landfill-map/.

[14] All the information related to this project "Defend the territory from the sky" can be accessed at http://basurama.org/proyecto/documentacion-territorio-desde-aire-publiclab.

[15] The open call was published in Basurama's website http://basurama.org/novedad/a-305-metros-del-suelo-con-los-pies-en-la-tierra.

were asked to submit locations[16] so that the group could decide which places should be documented during the workshop. That information was used to build an online map[17] of all the potential places that could be examined.

The workshop was organized to provide a basic conceptual and technical background on aerial photography before focusing on field practice. It started on a Friday evening with a 3-h lecture on theory (e.g., digital cartography and aerial photography) and a hands-on session to learn how to stitch photos to create a map using Public Lab's software, Mapknitter.[18] It ended with an open conversation about which locations should be mapped, based on the list previously created, proximity and accessibility.

On the following day, Basurama explained the basics of how to set up a compact camera rig hanging from a kite or balloon. The hands-on lesson included how to build a plastic bottle rig to hold the camera and how to inflate a balloon with helium (see Figs. 1, 2, 3). Our first flight was at the industrial area of El Serrallo (Fig. 3), in the harbour of Castellón de la Plana. In this area, there is a British Petroleum refinery, an incinerator plant for hazardous substances, and two thermal plants.

The afternoon session was in the municipality of Moncofa, a landscape that is iconic of the real estate bubble. The streets have been built, but no buildings constructed. Overall, the resulting photos had good quality, but they lacked sharpness. That evening the technical challenges were shared with Public Lab's Grassroots Mapping email list.[19] There was a quick and helpful response which resulted in an answer that could be transmitted back to the workshop participants: the cameras, Canon Powershot A1400 and A1300 priced at less than 90€ each, do not have sufficient quality and resolution to create maps from the height the balloon reached.

The last day of the workshop took place in El Saler on the outskirts of the city of Valencia. Avinença,[20] a regional association of grassroots groups that focus on land rights, had asked to document how the CV-500 road separated villagers from Albufera, a neighborhood lake. Their goal, with the collaboration of the local association Associació Juvenil Amics de la Casa de la Demanà,[21] was to advocate for the conversion of the road into a low-traffic street to recover their historic access to their harbour lake. After the aerial photography session with the balloon, there was a quick demonstration to show the images taken and a workshop on how to stitch images with Mapknitter.

Throughout the weekend the balloon had to be inflated only once, which meant a huge savings of one of the more costly parts of the project: the helium. Keeping the balloon inflated in order to save resources is a technique learned by participating in

[16] We provided a web-based collaborative real-time editor to collect all the locations https://titanpad.com/Castellóndesdeelaire.

[17] The map can be accesed at https://mapsengine.google.com/map/u/0/edit?mid=zNhzprsQQoOE.kn5zVioGMFkk.

[18] http://www.mapknitter.org.

[19] Check the email thread with the doubts and responses/solutions in the Grassroots Mapping list https://groups.google.com/forum/#!topic/grassrootsmapping/wjQd2Twq_pY.

[20] Avinença http://custodiaterritorivalencia.org/.

[21] Associació Juvenil Amics de la Casa de la Demanà http://www.saler21.com/.

the Public Lab community and by doing previous aerial mapping sessions. Helium is usually the most expensive part of every flight, so once inflated, the balloon was transported in a van (Fig. 4). After 3 days of intense balloon flying, discussions and workshops, the images were selected, stitched together, and printed in maps for exhibition. While the goal had been to do this process collaboratively with local groups, that was not possible due to time constraints and lack of a reliable internet connection.

Results: Printed Maps, Research Notes, and Future Campaigns

This process had three direct outputs: the production of printed maps for the exhibition at The Espai d'art contemporani de Castelló, the publication of a research note on the process for the benefit of the Public Lab community, and the use of the digital maps and other aerial mapping techniques in the campaigns of participating organizations. After a long and intense stitching session with Mapknitter,[22] Basurama had the three maps ready (see Fig. 5). They were printed and hung on the wall of the exhibition, a major show for the regional art space which was viewed by over 2800 people during the 3-month showing.

Public Lab's website consists of "Research Notes" where tool builders and users publish the findings from their experiments, whether successful or not. One research note for the Public Lab website[23] generated 13 comments and responses from the community, as well as some new ideas for how to support multilingual Public Lab chapters.

Finally, the images of the maps were used for two separate advocacy campaigns run by local organizations.[24] One balloon mapping kit stayed as a publicly available resource in the Castellón-Valencia region where participants could use and share it. To date, two different projects[25] have used the kit and others are able to borrow it through the Spanish email list of Public Lab.[26] Moreover, the balloon mapping events, workshops and public exhibition served to spur community development in the region. Participants belonging to environmental groups such as Ecologistes en Acció del País Valencià, Amics de Palanques and Molts Mons reported that the workshop served to help the organizations get to know each other, in some cases re-connect, and to establish relationships that have led to the development of joint projects.

[22] Although there were some problems with the tool crashing while trying to export all of the maps at the same time, quick help arrived through the Grassroots Mapping email list https://groups.google.com/forum/?hl=en#!topic/grassrootsmapping/OXpnqxgBmgk.

[23] Information about the project and feedback can be found at http://publiclab.org/notes/pablo/02-12-2014/mapping-with-balloons-in-Castellón-and-building-community#c8248.

[24] The "Ecologistes en Acció from La Vall d'Uixó" used the image for the posters for an event that they organized. The "Associació Juvenil Amics de la Casa de la Demanà" in El Saler used the photos for an advocacy campaign.

[25] Documentation about the evolution of Els Clots, a natural region in La Valldigna (Valencia) http://cargocollective.com/elsclots and a documentation of the outskirts and empty plots of Castellón de la Plana by Agustón Serisuelo http://www.agustinserisuelo.com/index.php/projects/terrain-vague.

[26] The "Laboratorio Publico" email list, in Spanish, can be publicly accessed at https://groups.google.com/forum/#!forum/laboratoriopublico. More information about the Spanish chapter can be found at http://publiclab.org/wiki/spain.

Fig. 2 Setting up the camera in a plastic bottle rig developed by Public Lab and attaching it to the balloon. The camera is set on "continuous mode" and takes pictures in short intervals during the time it is in the air

Fig. 3 Image of workshop participants at the El Serallo industrial area in the Harbour of Castellón de la Plana

Fig. 4 The balloon in the van before the flight in La Vall d'Uixó

Discussion: Transparency, Agency, Aesthetics, and Civic Imagination

The Castellón aerial mapping case illustrates important aspects of the deployment of technology in a monitoring project. The goals of a participatory monitoring project need not always be directed at a particular agent or entity, or directly aimed at securing a particular good. In fact, as part of the process of negotiating "what is to be done", it may be important for initial projects to be exploratory and provisional in nature. One way of conceiving of the Castellón deployment is as an open-ended offering of a tool to a community, thereby equipping citizens with tools that they may find useful for projects in the future. This mode would focus on the way in which community organizations in Castellón could now use aerial mapping to solve as-yet-unidentified needs. At the same time, there are deeper and broader aspects of landscape monitoring technologies that were facilitated in the Castellón case: *transparency*, *agency*, *aesthetics*, and *civic imagination.*

First, with respect to *transparency*, a large, tethered balloon, with a dangling, downward-facing camera, is a completely "un-obfuscated" veillance technology. Everyone nearby can easily notice and understand its operation, and can visually connect the observational technology (the camera on the balloon) to the operators. By its very design, it offers a counterpoint to the typically invisible modes of "surveillance", many modes of "sousveillance", and the ubiquitous, invisible data streams of the "participatory panopticon".

Fig. 5 Map of the abandoned residential area in La Vall d'Uixó, Castellón, Spain. Balloon height: approximately 200 m

Second, balloon mapping is an activity that is approachable and fun. Even "walk-ons" who arrive to the scene by chance feel empowered to offer help and guidance. It is thus a technology that immediately invites a sense of *agency*, and offers a non-intimidating space for collective judgement and deliberation. This is vital, as a typical environmental monitoring project will often assemble a range of stakeholders, with a diverse collection of interests.

To this end, the *aesthetics* of the large red balloon—a beautiful, large, improbable object—is not merely decorative, but can serve as an organizing tactic in a community monitoring project. Fun and wonder help to engage and connect diverse civic audiences, including youth. The conversations that occur as a group deploys a balloon and draws a crowd bring everyone into a space of shared inquiry: "I wonder what this place looks like from above?" "I wonder if we can see into that vacant lot behind the fence?" These can act as a preface to a broader, wide-ranging deliberation about what projects can accomplish together. This sort of event can thus serve to seed "civic imagination" (Azoulay 2008, 2015; Jenkins et al. 2016), which Henry Jenkins and colleagues define as "the capacity to imagine alternatives to current social, political or economic conditions. One cannot change the world unless you can imagine what a better world might look like."

Case Study 2: The Aerial Testimony: Silwan, East Jerusalem, Israel/Palestine, 2011

The narrative below is written by Hagit Keysar, an organizer with Public Lab who experimented with the application of DIY aerial photography in spaces of ethnonational conflict, in Israel and the Occupied Palestinian Territories.[27]

Jerusalem is usually considered to be a divided city, with its western side predominately populated by Israeli-Jews and its eastern side by Palestinians who comprise more than a third of the city's inhabitants (Pullan et al. 2007; Yiftachel and Yacobi 2002). Within the literature of divided cities, Jerusalem is understood as a city that is highly politicized and contested and where processes of stabilization and the establishment of security are ongoing endeavors by the state (Dumper 2013). One result of current urban planning policies and practices[28] is that the Palestinian residents in Jerusalem experience a severe housing crisis which has led to numerous acts of building without permits. However, building without permits is criminalized, leading to harsh enforcement measures by the authorities.[29] In addition, constant surveillance of such building is undertaken by the Jerusalem municipality aided by extensive use of aerial/satellite imagery and regular use of surveillance balloons.[30] Observing the surveillance balloons hovering above the city's skyline, the question arises as to what kind of role DIY balloon/kite mapping practices might play in such a highly controlled and contested urban environment.

[27] This case study is based on ethnographic work with a Palestinian community in Silwan, East Jerusalem and reflects the perspectives of the author, as well as the youth and activists with whom we have worked. See also: http://cargocollective.com/hagitkeysar.

[28] Preserving a 'demographic balance' of 28–72% has been an official government policy since the 1990s that shapes the master plans prepared for the city's development, and is mainly enforced by a strict control over the allocation of housing (Felner 1995; Weizman 2007). See b'tselem.org regarding policies in East Jerusalem and Bimkom.org on the Jerusalem Master Plan 2000.

[29] For more details on the housing crisis and the scope of Palestinian building without permits see the report by Bimkom, a non-governmental organization (NGO) of architects for human and planning rights: Bimkom.org in English: http://bimkom.org/eng/planning-survey-and-planning-assistance/.

[30] Also, constant surveillance raises concern about violations of privacy. See: http://www.jpost.com/National-News/Jerusalem-launches-police-surveillance-drone-363107 (accessed 11, December 2017).

Process: Satellites for their Own Community

The workshops in Silwan were organized and planned with a group of local information activists in the Palestinian neighborhood of Silwan who collaborated with Public Lab's organizers Hagit Keysar and Shai Efrati, and Public Lab member and co-founder, Jeffrey Warren. The idea to independently create aerial photographs of the neighborhood was in line with the activists' efforts to free themselves from dependency on United Nations agencies and local human rights organizations. These organizations offer aerial images for the uses of the community but in most cases, they are not up to date and do not necessarily fit residents' needs.

We planned the DIY mapping workshop especially for children ages 10–12. It was important for the community activists we worked with, to develop tools, workshops and afternoon activities that would keep the youth busy, productive and away from the streets, which are constantly surveilled by military and police. The kite-mapping workshop seemed suitable; it is a fun, outdoor learning activity and by creating the aerial photograph the youth could contribute in a meaningful way to their own community.

The kite-mapping workshop was spread over 2 weeks in which the youth experienced participatory mapping practices, a tradition that has been theorized as Public Participatory Geographic Information Systems (Elwood 2006; Sieber 2006). We created maps by drawing and making use of found objects, and experienced digital mapping through a playful navigation game based on sensors and body movements.[31] In one single kite flight that sent the camera as high as 350 m we created images that covered most of the neighborhood area, thanks to the youth's ingenious kite flying skills. The youth also stitched the aerial photographs they created in Mapknitter, making a map of the whole area. However, because the up-to-date, high-resolution geographic information they produced would have been accessible on the web, and because the activists we worked with did not want to make this politically-sensitive geographical data freely available, a password was created that allowed only authorized persons to access the map.[32]

After the youth stitched the map together, they annotated it with their own stories (Figs. 6, 7). Their discussions and annotations of the aerial view exposed a detailed composition of the ways in which surveillance measurements take shape in Silwan, within their everyday lives. A recurring element in the children's stories was the constant presence of the military and police and the constant feeling of being watched and observed. They immediately identified and tagged their homes and other points in their streets in which Israeli security forces, CCTV cameras, and private armed guards are present. The view from above opened a way of seeing that exposed a surveillance machine that can be fully seen and grasped only by those who are being

[31] For a more detailed account of these activities see http://cargocollective.com/hagitkeysar/DIY-drones-in-Silwan.

[32] A new version of the open-source software Mapknitter has been released and provides instructions and a video to help independent installation of the tool. They can be accessed at https://github.com/publiclab/mapknitter.

watched. The "geospatial information" they created was immediately intelligible to them. Although conventionally it is considered to be the work of professionals, they interpreted and annotated it with their own knowledge and experiences, bypassing the need for expert analysis, or more correctly, clarifying the urgent need for a different kind of knowledge for interpreting the image. By flying the camera tethered to a kite, creating the photographic map and later hovering above the aerial image, one can say that the children became satellites for their own community. The aerial photograph they created allowed for acts of storytelling that were accompanied by empirical, visual and spatial evidence. A few months after the workshop, the aerial photograph and the annotated poster that told the youth's story were published on the web with the agreement of the community activists.[33]

Discussion: Producing the 'Civic View from Above'

Today, a wide variety of civil society organizations use aerial photographs for documentation and monitoring purposes. However, while increasing accessibility of commercial aerial and satellite imagery might be making geospatial information more visible than ever, it is not very legible or useful to the general public (Herscher 2014). Although it is possible to use commercial imagery from Google Earth or Bing services, these technologies often have several significant limitations such as copyright restrictions, low resolution and outdated imagery. Google and other American companies that produce satellite imagery reduce their commercial images to 2.5 m per pixel, as per international legal agreements between Israel and the United States.[34] Civil uses of commercial aerial and satellite imagery of Israel and the Occupied Palestinian Territories are thus very limited, expensive and unattainable for local, grassroots organizations. How might tools and techniques of citizens' veillance serve residents who wish to use the aerial perspective to make public and visible the spatial and political discrimination they experience?

In Silwan, independently creating geospatial information by community members for their own purposes provided "ground truth"—an observation based on corroborating aerial information with the contextual, local knowledge of a person standing on the ground. More importantly, the geospatial information that was brought forth by the children who annotated the aerial photograph could not have been produced using any other map or commercial aerial photograph. The aerial photograph that was created by the children in Silwan reached an average resolution of 3 cm per pixel (in contrast to 2.5 m/pixel in commercial platforms, as mentioned above). This is a powerful form of citizens' veillance in which Palestinian youth could surveill, annotate and discuss the surveillance structures that permeate and shape their everyday lives. In this case, DIY aerial photography becomes a powerful form of "watching back" and talking back to power. The low altitude and high quality DIY aerial

[33] The poster is available here: https://flic.kr/p/gsVmuS (accessed 11, December 2017).

[34] See more in 'Whither high-resolution satellite imagery of Israel?' http://ogleearth.com/2011/06/whither-high-resolution-satellite-imagery-of-israel/ and the Public Law (1996) 'Sec. 1064. Prohibition on collection and release of detailed satellite imagery relating to Israel.

Fig. 6 Children from Silwan annotating the map they had created

image produced in Silwan made possible a photographic density of details that enabled the Palestinian youth to connect, identify, analyze and intervene in the aerial photo in unconventional ways.

A common question that we encounter with the use of the aerial mapping toolkit is "Why don't you use a drone?" especially now that drones are becoming cheaper, accessible and popular. The way to answer this question is not by ranking which technology is "universally" better, but rather asking which tool could best serve particular goals and specific contexts. In a politically sensitive environment such as Silwan, and Eastern Jerusalem in general, a kite or a balloon is a much more appropriate tool for surveilling the local environment. First, the size and type of kites and balloons used for aerial photography do not reach aviation regulation,[35] and so their use bypasses state limitations on flying aircrafts and there is no risk of illegal activity. This is particularly important in relation to mapping in the highly-militarized neighborhood of Silwan. Independently producing aerial photography is an activity likely to raise authorities' suspicions and might result in the arrest of participants. Kites, on the other hand, are constantly seen in the skies above Silwan. If we had used drones, we would have been assuming a much higher risk. We worked together with the community activists to openly discuss risks and they made the ultimate decisions in this case.

[35] Though each state has its own regulation.

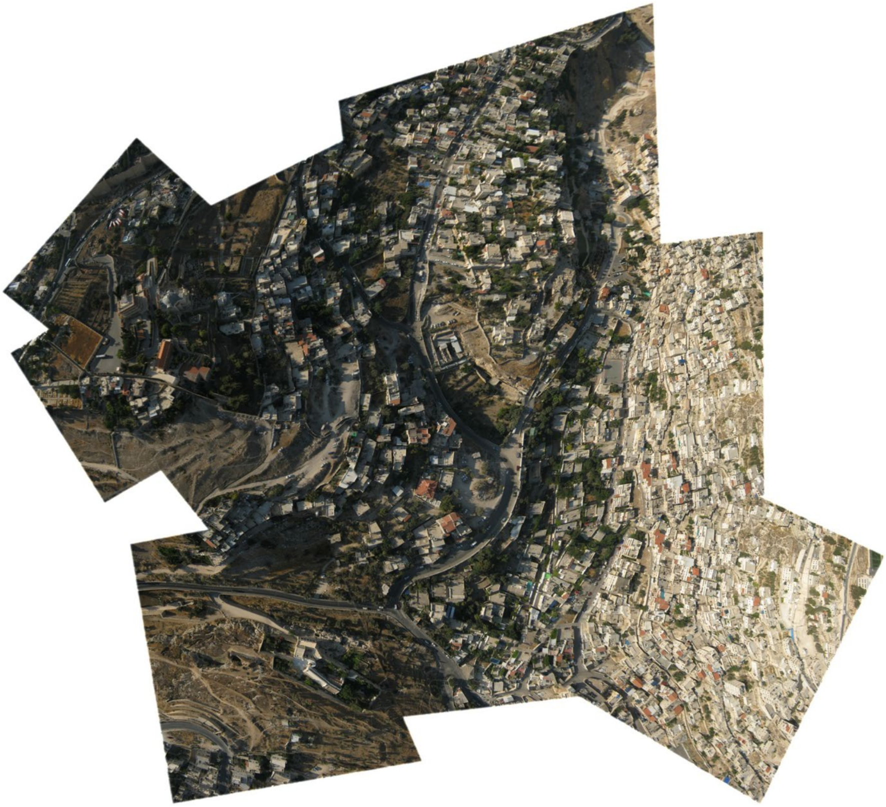

Fig. 7 DIY aerial photography created by youth aged 10–12, Silwan, Eastern Jerusalem

Second, apart from risk, there are other reasons why kites may be preferable to drones based on the ethics and values of the project. A kite, or balloon, is always directly connected by a string to the person flying it. In contrast to aerial surveillance technologies, it is visible and trackable, and therefore it makes public the very act of creating aerial photography. The act of making things public (Latour and Weibel 2005) is embedded in the DIY technology itself; during workshops participants build their own kit for flying a camera tethered to a kite, and, by doing so, they take a step into the materiality of the technological process, rendering it visible and graspable to those who engage with it. By using everyday objects, like cheap, compact cameras or reused plastic bottles, to house and protect the camera, we try to demystify and ease the access to technology, and open opportunities for raising critical questions on the authoritative and exclusive use of the aerial perspective. Here the choice of materials is driven by values of accessibility and legibility to participants regardless of expertise. Working with humble materials, participants usually mention that this or that technique could be improved, and feel empowered to appropriate and modify the tools at hand. In this context, the best technologies are not the ones that magically do the user's bidding but the ones that are open and can be constantly developed and adapted to needs by citizens and residents. Promoting a culture of open modification also promotes a sense of ownership and authority throughout the process (Barry et al. 2013; Dosemagen et al. 2011; Warren 2010).

Aerial mapping with kites in Silwan both elucidates and complicates a number of issues around citizens' veillance. It is a compelling case of utilizing DIY monitoring techniques to "watch back" and create a visual and spatial testimony that talks back to power in an environment that is permeated by constant government and military surveillance (Keysar 2014, 2016). But in this case, the Palestinian youth who are doing the monitoring are non-citizens. In fact, they are two times removed from citizenship, first by their age, and second because of the uncertain status of Palestinians who live within borders claimed by the Israeli state.[36] The term "citizen" implies a certain relationship with a nation-state that civic actors may not always hold, particularly if they come from vulnerable geographies or populations (such as undocumented residents in the USA). We believe the term "civic veillance" might be more appropriate in this context to account for the fact that there are important civic actors that fall outside the category of citizenship.

Another complicated factor that this case addresses is the balance between privacy and transparency. Public Lab explicitly adheres to open source values and encourages community members to make their work public. However, for politically vulnerable communities this means assuming a level of risk that should be carefully considered. As a community that primarily defines itself as "open", it is important to constantly keep Public Lab's "openness" in question. Openness may be a privilege (rather than an inherent "good"), and might serve to obscure embedded social, political and economic power structures. Therefore, the case of DIY aerial photography in Silwan allows one to draw the outline of a "civic view from above" that exposes not only the opportunities but also the problems of "open" and "civic" technologies. As a "civic view from above" it suggests that aerial vision, in contrast to the exclusive and militarized technologies that usually enable it, is a broad visual practice that is rooted in lived experience and encompasses environmental, embodied, and sensual dimensions (Keysar 2016).

Case Study 3: Open Water Science for Civic Veillance

While the prior cases discussed deployments of existing Public Lab technologies in specific contexts, Public Lab also develops new tools and techniques. Co-authors Catherine D'Ignazio and Don Blair present their goals and challenges in creating an open and accessible development process for a water monitoring tool.

[36] The majority of Palestinian residents in eastern Jerusalem are non-citizens, holding a vulnerable status of "permanent residents" of Jerusalem. As Danielle C. Jefferis (2012) writes, a Palestinian's permanent residency in East Jerusalem is an intermediate legal status between citizenship and its revocation. Increasing this inherent instability, Israel has been instituting various measures and policies that institutionalize and legalize statelessness among Palestinian Jerusalemites (2012, pp. 9–10).

Does Your River Have a Fever? An Early Warning System for Water

Water quality is a concern for many people in the world, yet assessing water quality is a challenge. In contrast with some other environmental measurements which can be measured from a distance (e.g., via aerial imagery), most of the important questions about water require making direct measurements of it. While water sampling and testing in a laboratory is the definitive assessment of contaminants, the expense in terms of labor spent collecting, transporting, and analyzing samples adds up. There has long been an interest in making ongoing, automatic measurements of parameters such as temperature, conductivity, and turbidity to assess water quality. By selecting simple water parameters that are related, directly or indirectly, to worrisome contaminant concentrations, an "early warning system" can be established for water.

In a presentation to members of the Public Lab community at the Massachusetts Institute of Technology Media Lab in 2013, Mark Green, an Associate Professor of Hydrology at Plymouth State University in New Hampshire, USA, characterized the current technologies used by hydrologists for electronic water monitoring. The devices were sufficiently expensive so as to be prohibitive for most non-professional investigations. Only academics, government agencies, and well-funded community water monitoring groups could afford them. The hardware designs were all proprietary, blocking modification or innovation, and the data format was encrypted, so that even communities who used the technology regularly found sharing data difficult.

Ben Gamari, Laura Dietz, and Don Blair, physics and computer science graduate students, and part of the Public Lab community, set about designing an open-source water monitor device, based on an open-source hobby electronics platform, the Arduino.[37] After months spent designing the device, it was given a name: the RIFFLE—Remote, Independent, Friendly Field Logger Electronics.[38]

As the RIFFLE project took shape, Catherine D'Ignazio, now a professor of Civic Media and Data Visualization at Emerson College, saw the RIFFLE's potential for citizen monitoring applications. This growing team, in conversation with hydrologists like Jeff Walker of the US Geological Survey, and scientists like Patrick Herron of the Mystic River Watershed Association, soon revealed that the sorts of parameters that are plausible for a low-cost, DIY electronic device to measure do not, in fact, provide definitive tests for particular contaminant concentrations. They do not enable individuals to determine whether their water is or is not "safe to drink". Rather, the parameters that can be measured are more akin, in analogy with human health, to using temperature in assessing the presence or absence of a fever. If an individual's body temperature is above average, it may be an indication that further concern and medical investigation may be warranted. Similarly, abrupt changes in water temperature, conductivity, and turbidity, i.e., deviations from the baseline, can be useful indicators of important changes in a water ecosystem (perhaps due to pollutants), prompting further investigation.

[37] https://www.arduino.cc/.
[38] https://publiclab.org/wiki/riffle.

Building a Community to Build a Tool

Even to arrive at the initial concept, the "fever thermometer" took many consultations with people with diverse expertise. The inherent complexity of the electronics, the relative difficulty with which its output is interpreted (for example, the typical units of conductivity are microSiemens per centimeter), and the difficulties of deciphering the import of the data it generates, have all led to a development process and outreach effort that relies on many forms of expertise. What sorts of questions can be addressed by temperature, conductivity, and turbidity? How ought the device be deployed in order to answer those questions effectively? What deployment strategies are plausible for which communities? What peer education and stewardship structures might support communities who seek to maintain a monitoring program and interpret the resultant data? How will the results be disseminated throughout the community, and to a wider audience? How might they impact policy, or trigger regulation? These are questions spanning hydrology, statistics, community organizing, community education, journalism, the arts and public health. The relevant necessary expertise is located in academia, government, and on the ground, within the various communities that have a stake in monitoring their water's health. As the RIFFLE project grew, it required the coalescence of a diverse collection of contacts and allies in all of these areas in order to build an effective water monitoring veillance technology. Here the idea was not that "everyone can and should be a hydrologist" but rather that an open development process would facilitate conversations across a variety of domains and connect and leverage the knowledge of a variety of experts.

At the present point, the RIFFLE has found application in several contexts, including: *(1) As the centerpiece of a "sensor journalism" project*. John Keefe of the radio and television station WNYC in New York City has worked with journalism professors at West Virginia State University in exploring the potential application of the RIFFLE in "sensor journalism" projects, in which it is imagined that investigative journalists might use low-cost monitoring tools when reporting on environmental issues in much the same way as they use cameras when reporting on other types of stories. He and his class deployed several conductivity measurement devices along a local river, placing them upstream and downstream of a local factory (see Fig. 8 and below).[39]

(2) As an early warning system for mining pollution. The University of Los Andes in Bogota, Colombia has organized a project to distribute water monitors in Bucaramanga, a northern, mountainous region of Colombia with rivers that are strongly impacted by mining operations. In this case, monitoring by the Colombian government is minimal, and the issue of mining pollution is highly politicized. About twenty monitoring devices have been distributed to communities along the river, in workshops focused on facilitating ongoing stewardship of community-based monitoring programs (see Fig. 9).[40]

39 http://johnkeefe.net/monitoring-the-monongahela.

40 https://publiclab.org/notes/donblair/10-19-2015/surata-visible-part-i.

(3) To illustrate and critically discuss sensor journalism in a classroom. In her Data Journalism classes at Emerson College in Boston, Massachusetts, Catherine D'Ignazio has been using local water quality issues and the RIFFLE to explore the concept of "sensor journalism". Students with no technical or scientific background build simple conductivity sensors and reflect on possible applications of these technologies in journalism and community monitoring projects as well as discussing the legibility and interpretability of the resultant data for a wide variety of potential audiences.[41]

Discussion

Across these water monitoring cases, several important general lessons have emerged for the intentional design of such projects: (1) determine which questions are answerable, and understand the evidential requirements. It is important to understand and to clearly convey what is knowable in an environmental monitoring project. For issues like water quality, which can directly impact environmental health, there is a desire to know the answer to questions about basic water safety that most DIY technologies cannot yet fully address. On the other hand, emerging regulations and guidelines for road salt impacts on local waterways need only demonstrate that water conductivity is far above a minimum threshold, obviating the need for highly accurate instrumentation. Understanding these evidential requirements in a monitoring project allows a community of practitioners to spend their time and resources appropriately in developing and maintaining only the level of technology necessary to answer the questions that matter to them.

(2) Find ways of making abstract data visceral and comprehensible. In building a conductivity device, we stumbled across audio as a data format. For the particular circuit we had developed, the conductivity level could be directly listened to as an audio frequency, so that increases in conductivity corresponded to increases in pitch.[42] This "audio data format" greatly increased the comprehensibility of the data, and offered an element of "fun" that was otherwise missing from the technology. This simple, audio version of the RIFFLE is an electronic circuit that indicates water conductivity levels via an audible, variable tone output, which was dubbed the "coquí" after the sonorous Puerto Rican frogs. D'Ignazio and other educators use the coquí in introductory workshops with students. Other Public Lab members who are artists and designers have explored other creative experiments with water data, including "painting" thermal imagery[43] and creating talking sculptures.[44]

(3) Begin with existing practices; translation, not unification. A common impulse in open data approaches to environmental monitoring is to seek to establish data platforms or projects that will serve as repositories for all the data, specifying a standardized data format and allowing data collected in a

41 https://publiclab.org/tag/sensor-journalism.

42 http://publiclab.org/wiki/coqui.

43 https://publiclab.org/notes/kgrevera/07-22-2015/mare-liberum-fishing-bob-workshop.

44 http://www.kanarinka.com/project/the-babbling-brook/.

Fig. 8 RIFFLE conductivity and temperature prototype used in John Keefe's West Virginia deployment

decentralized manner to be analyzed easily in aggregate. What one finds when engaging with the diverse array of water monitoring groups, academics, and government agencies is an equally diverse range of practices, epistemic norms, and standards. The emerging picture is that it is far more tractable to focus on tools for translating across epistemic practices, and allowing decentralized datasets to be curated for particular purposes, than it is to dictate unified norms across these communities. This process of translation does not seem amenable to being fully automated. It requires an understanding of local practices that can be developed only by significant, sustained interactions and relationship-building.

(4) Decentralized environmental monitoring requires trust and shared norms. At the end of the day, monitoring projects that depend on data for achieving their goals are only as good as the data that are collected, and it is impossible in most cases to verify algorithmically the veracity or quality of collected data; instead, community members rely on one another to establish, negotiate, and support epistemic norms in their practices. Establishing such norms, especially for more technical procedures, is a challenge, but can be facilitated through regular in-person meetups, online dialogue, and community structures.

Fig. 9 Members of the Surata Visible RIFFLE workshop in Bucaramanga, Colombia

Conclusion

The case study in Castellón is an example of how Public Lab tools have been used to build geographic relationships by focusing on activities that are fun, accessible and "beautiful". They use pleasure and a sense of agency as ways of gathering diverse stakeholders and activating the civic imagination. The case study in Eastern Jerusalem offers a framing of DIY aerial photography as a tool for documenting and visualizing lived experience in a situation of ongoing political conflict. Vulnerable communities used low-cost tools in their own grassroots efforts to create awareness and accountability around issues that affect them. Citizen (or civic) veillance, in this case, is predicated on bypassing state restrictions on geographic information (such as censorship) and circumventing dependencies on the professional culture of human rights discourse, methods and tools. Whereas these first two case studies present applications of a relatively mature technology (aerial imagery), the last case study focuses on the early stages of tool development in the Public Lab community. In the case of the RIFFLE, the data generated by this tool are less comprehensible, and less easy to interpret, than the corresponding data from the aerial mapping technology. It is a technology that requires building relationships among advocates, designers, engineers, and hydrologists, and devising new social and educational structures to make the process and the products intelligible to non-specialists.

Who Knows? Epistemic Norms Across Diverse Communities

The diversity of interests gathered within the Public Lab community are associated with varying epistemic norms. Standards of evidence are seen to vary not only with the particular type of question being asked but also relate to expectations and assumptions associated with particular modes of empirical inquiry: legal, journalistic, in pursuit of personal health and safety, in support of activism, and in scientific activity. Professional scientists often aim, reflexively, to select the most precise and accurate instrument allowed by available resources, and tend to discount the legitimacy of data collected by non-credentialed scientists; advocacy groups and artists sometimes consider conservative scientific interpretation to be of lesser importance in the context of broader social and ethical issues, which require a variety of tools and perspectives for interpreting, visualizing and arguing with data. Social scientists might investigate public participation through the use of civic science—putting people before data—while technologists might focus on the technical aspects of the application of tools in different social and geographical settings.

Negotiating epistemic norms across diverse interests, audiences, and cultures thus poses a significant challenge to citizens' veillance projects, like those in the Public Lab community, that seek to bring together practitioners from diverse backgrounds into collective investigations. The aerial mapping technologies with which Public Lab began are an effective attempt to bring forth contested interpretations of visual, photographic evidence. As a result, the issue of conflicting epistemic norms is, at times, not so much a problem that needs to be solved as it is an effort to problematize and question forms of visual representation. On the other hand, cases in which the very accuracy of measurements are difficult to verify, such as the raw numbers generated by the RIFFLE in the water monitoring case study, or the interpretation of air quality monitoring data, require advanced expertise in order for the data to be meaningful at all.

This issue of epistemic norms may at first seem obscure, yet it may arise whenever an advocacy organization or an individual with limited time and resources wishes to collaborate with a diverse techno-scientific community in order to produce evidence that is useful in court or an advocacy campaign. This is true in the case of East Jerusalem in which a community of activists took the initiative to experiment with civic techno-scientific tools for resisting state control over space and geo-information, and for advancing community organizing goals. In the case of Castellón, however, producing accurate and reliable data was secondary to bringing together organizations and individuals to collaborate around environmental concerns while learning new forms of DIY science. In contrast, a project seeking to identify the most egregious pollution sources in a community water supply will typically not meet the stated goals of the collective monitoring project if the data set collected is insufficient to allow for any conclusion to be reached. As the water monitoring case study demonstrates, the use of water conductivity to document the presence of fracking fluid contamination in a private well used to supply drinking water for a family might justifiably be held to stricter epistemic standards than might be applied in the identification of areas in which road salt is being applied too liberally and may impact water reserves only decades hence. In other words, a group ought not to spend unnecessary time fretting about data quality, if the primary goal of their citizen veillance project is focused on increasing their community's awareness of an issue, and promoting public action. But it should also be noted that Public Lab participants have been seen to quickly lose interest in mapping when, during the learning and training process, images turn out blurry or the camera stops working mid-flight and only a few images are captured. The lesson to be drawn is that the negotiation of epistemic norms cannot be assumed in advance: experience shows that the meaning of the data is complex and dynamic, and constantly needs to be addressed through dialogue and engagement. Therefore, these techno-scientific experiences deeply contest the tendency to adopt a priori, rigid epistemic guidelines.

Another significant theme of citizens' veillance projects is that the utility afforded by the recognition of a concentration or enhanced level of skill—which is often denoted by the term "expertise"—has been, in many cases, misused used to bolster imbalances in power. When the status of expert is awarded only, or preferentially, to credentialed individuals or institutions, it becomes an honorific that diminishes important voices in a dialogue and ceases to recognize the variety of forms that skilled inquiry can take (Collins 2014).

Aerial imagery, for example, is typically considered the domain of experts, associated with institutions that can support plane- or satellite-based technologies. Similarly, assessment of impacts to local water quality is usually considered the sole province of government agencies. The case studies presented here challenge this framing. Conversations in the Public Lab community have long focused on the ways in which different forms of expertise that are exhibited by many types of inquirers, for example, in local ecology, community process, education, technology development, etc., might contribute to broader, collaborative monitoring projects.

The three case studies within this paper illustrate the ways in which the creation of novel spaces within which people can act as experts (community balloon mapping, community water monitoring) might help to close the divide between the typical "expertise-haves and expertise have-nots" (Hoffman 2011, p. 46), to break through the pervasive and persistent cultural barriers to collective inquiry that typical use of the term "expert" can represent. Case Study 2 illustrates the way in which these spaces might allow people to emerge from the margins that usual constructions of "expertise" have dictated (DeChiro 1997).

Just as the term "veillance" opens up the concept of collective, purpose-driven investigations beyond mere "sur-" or "sous-" topologies, it would be problematic to characterize this more expansive notion of the development of "expertise" simply in terms of "bottom-up" and "top-down" contributions to knowledge production or technology development. The actual path taken by the technologies represented in these case studies is complex. The initial design of the aerial mapping kit was honed and driven by the specific needs of a community, in a particular, local context (the Deep Horizon oil spill). Nonetheless, its deployment and meaning in other settings, around different issues and local contexts provided new insights in regard to its techno-social meanings and values, as the Silwan case demonstrates. Much of the work that Public Lab does in archiving designs and data and facilitating conversation is predicated on the notion that designs generated in one context may 1 day find useful application in another, completely unforeseen context. Appropriate technology development is therefore not as simple as championing "development in context", or "grassroots development", over other types; instead, there is a complicated, iterative interplay of innovations emerging horizontally from various locales.

We agree with the suggestions of Nascimento and colleagues (2014) that "Engineers and information systems engineers should work together with ethicists and lawyers in order to build collective transdisciplinary knowledge of the relationships between technology and normativity. Normativity that is consciously and unconsciously inscribed in, and embodied by, artefacts should be made as explicit and transparent as possible before and during the design phase, a crucial stage in development when normative decisions are taken and transformed into programs and functions." (Nascimento et al. 2014, p. 18). However, convening such consultations is sometimes difficult, or impossible, in the initial stages of a decentralized, distributed, iterative grassroots design process. That is, there is no "initial design phase" in most Public Lab projects. Many times innovations "on the ground" emerge spontaneously, as sudden modifications of long-extant technologies. Design decisions which initially appear to be "ill-considered" are later found to be very useful. So, in lieu of an initial, intensive design review in order to coordinate disparate norms and values in designed artifacts, the Public Lab community, following the open software community, has begun to move towards regular, iterative, periodic reviews of technology designs, and relies on ongoing, community-wide dialogue and deliberation about design decisions and ad-hoc modifications. Despite a focus on accessible materials and ease-of-use, it is simply the case that many of the people who might most benefit from these citizens' veillance technologies do not possess the resources (the spare time, access to technology, or the technical skills) to contribute in a meaningful way to all of the technologies that they might find useful.[45] In some cases, this imbalance can serve as a prompt to a better distribution of resources and the development of new skills. In other cases, communities may be interested in immediate deployment of tools that require little construction or further development.

Appropriate Flows: Transparency, Privacy, Context

Finally, another theme to highlight in these case studies is the complex nature and value of "openness". A unifying impetus for many projects and critiques that emerge within the Public Lab community is a shared frustration with obfuscated, proprietary, and restricted technologies, data, and research. As a result, many of the activities and technologies valorized or promoted within Public Lab are "open" or "open source". The development of DIY aerial mapping technology, for example, was driven in large part by a need for aerial imagery that, in some cases, was already being collected by satellites, but was not being made easily accessible, or was otherwise restricted in its use. The Public Lab water monitoring prototype was developed because currently-available water monitoring technologies employ proprietary hardware, software, and encrypted data formats that do not allow for easy hardware

[45] A similar point is made by Mordechai Haklay in regard to the democratizing potentials of Volunteer Geographic Information (VGI) and Neogeography in general (Haklay 2013).

modification or data sharing. Much of the work done by those within the Public Lab community is focused on trying to identify data sets that are useful for advocacy and policy decisions, and render it available and accessible. However, the use of DIY aerial photography in Silwan shows that promoting “openness” and “transparency” is not always a simple intervention, as in a case in which the sharing of aerial imagery might have threatened the safety of the practitioners. When working with marginalized groups, especially in conflict areas, the promotion of collaborative principles with regard to tool development and the sharing of knowledge can be very difficult, even impossible to implement and sustain locally. In regard to the need for “openness” to be upheld as a fixed ideology (Nascimento et al. 2014, p. 22), the “appropriate flows” of information must be determined in each case while attending to its social and political context and sensitivities.

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