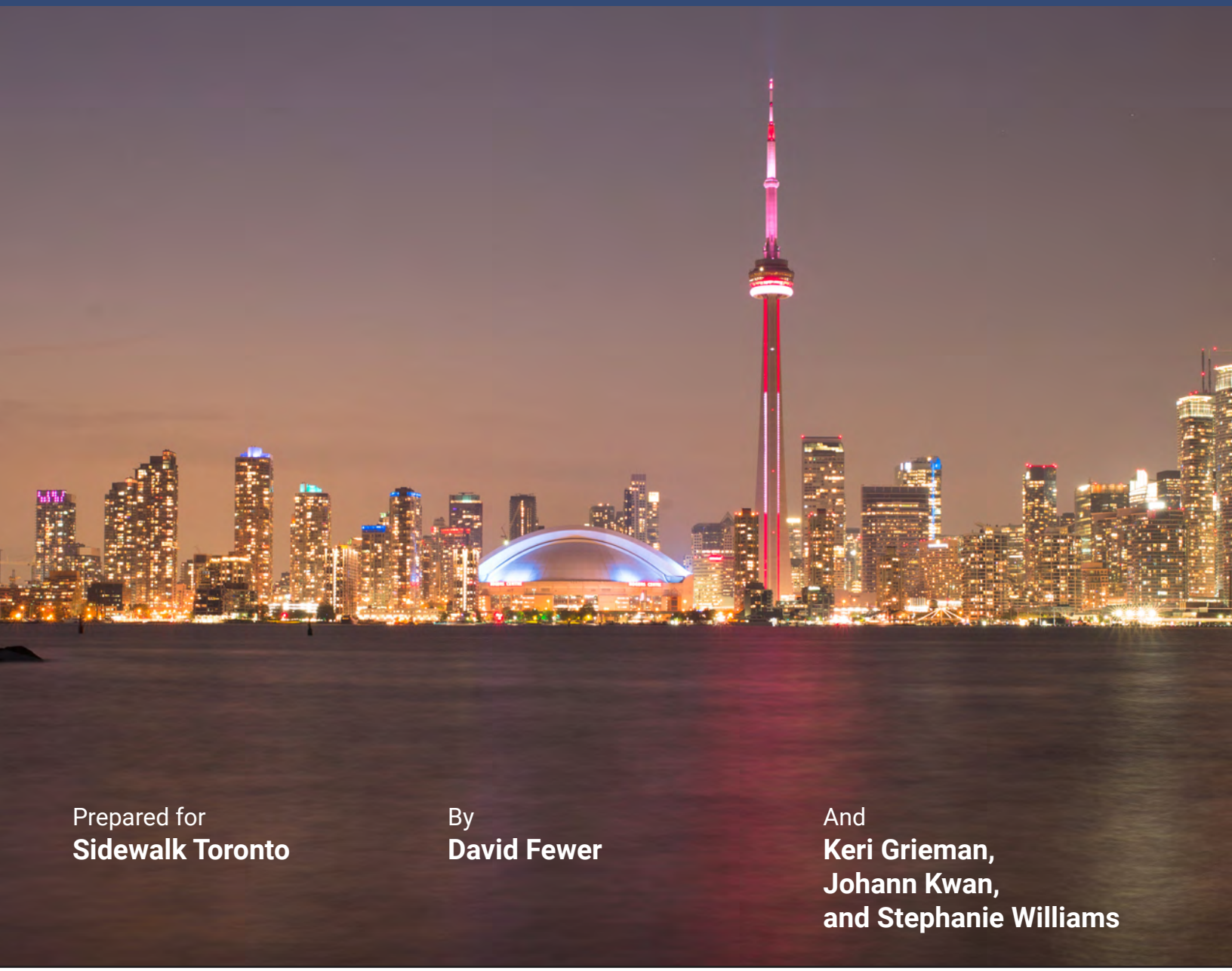
BIKE COUNTING

Privacy implications



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Sidewalk Toronto

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The Samuelson-Glushko Canadian Internet Policy and Public Interest Clinic (CIPPIC) is a legal clinic based at the Centre for Law, Technology & Society (CLTS) at the University of Ottawa, Faculty of Law. Its core mandate is to ensure that the public interest is accounted for in decision-making on issues that arise at the intersection of law and technology. It has the additional mandate of providing legal assistance to under-represented organizations and individuals on law and technology issues, as well as a teaching mandate focused on providing law students practical training in a law and technology setting.

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Introduction to the Project

Integration of transportation is an important part of every city, and none more so than the smart city. Transportation informs the way we design cities, the use we make of their space, and the capacity sections of the city may have. Cycling has long been popular with sports enthusiasts, but is beginning to come into its own as a method of urban transportation - not only is it environmentally friendly and good exercise, it is cheap, space-efficient, and of minimal impact to rideable surfaces.[1]

Cycle counting by cities encompasses the tracking of cyclists' road usage, numbers, collisions, and more with the intent of both responding to and improving usage of bicycle areas. This sort of large-scale data collection is perfectly suited to the smart city - one that adapts and designs itself to the most efficient and wide-scale use of its inhabitants. When that data is open and shared, populations become more aware of the transportation possibilities and investments in their area - such as the bicycle community Bike Ottawa's creation of a bicycle routing map based on the City of Ottawa's open data portal.

Data collection must inherently be sensitive to the privacy needs of citizens. Throughout this report, we will touch on some of the concerns raised by bicycle counting, the applicable laws, and how cities are dealing with them.

Uses of bicycle counting

Bicycle counting is useful for a variety of objectives. Frequent municipal uses include assessing spatio-temporal travel patterns,[2] road and traffic conditions,[3] and user density of cycle-specific paths;[4] informing city planning;[5] and testing out new allocations of road space.[6] In many cities, bicycle counting is used to generate and query a bicycle plan, as part of a larger urban mobility plan. Ottawa, for example,

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[1] Queensland Government Department of Transport and Main Roads, "Cycling Benefits" (26 June 2018), online: <https://www.tmr.qld.gov.au/Travel-and-transport/Cycling/Benefits.aspx>.
[2] Amy Smith et al, "Crowdsourcing Pedestrian and Cyclist Activity Data" (2015) Pedestrian and Bicycle Information Center, White Paper Series at, ii.
[3] Delphine Christin et al, "A survey on privacy in mobile participatory sensing applications" (2011) 84 Journal of Systems and Software at 1928 at 1931.
[4] Interview of Samuel Roberts, Transportation Planner for the City of Ottawa by David Fewer and Keri Grieman, (14 November 2018).
[5] *Ibid.*
[6] *Ibid.*

has a cycling plan as part of the transportation master plan, and evisions that cycling will achieve up to a five percent mode share for city transportation.[7] While the cities interviewed did all collect their own data, many cities supplement their own data collection with purchasing data from private companies such as Strava.[8] Others will engage with private entities such as bike-sharing companies for their users' suggestions, such as where residents have requested new bike stations in their communities.[9]

Smart cities and open data

While there are often shared means and values between the two, smart cities and open smart cities are not necessarily synonymous. Smart cities tend to be defined along the lines of technologies that collect and or analyze large amounts of data in order to more efficiently deliver city services or private projects. Open smart cities are cities that collect large amounts of data through various means, but the defining feature is that that data and systems are made available to other parties. Smart cities can be those solely run by government entities on municipal projects, wherein the data is not necessarily shared, or to a lesser extent. Open smart cities may have many similar projects, but strive to maximize the effectiveness of data by allowing it to be used by all capable parties, within reasonable limits such as privacy protection.

An open smart city is a collaboration "to mobilize data and technologies when warranted in an ethical, accountable and transparent way to govern the city as a fair, viable and liveable commons and balance economic development, social progress, and environmental responsibility."[10] Much of the literature on open smart cities focuses on the need for transparency of public processes,[11] as well as making the data accessible and usable by non-government entities,[12] so that value can be

[7] *Ibid.*
[8] *Ibid.*
[9] Smith, *supra* at 15.
[10] Tracey P Lauriault, Rachel Bloom & Jean-Noé Landry, *Open Smart Cities Guide V1.0* (Open North, 2018) online: <https://docs.google.com/document/d/1528rqTjzKWwk4s2xKuPf7ZJg-tLlRK8WcMZQbicoGTM/edit#> accessed 9 November 2018, at 6.
[11] José A G de Pinho, "Investigando portais de governo eletrônico de estados no Brasil: muita tecnologia, pouca democracia" (2008) 42:3 Revista de Administração Pública 471; Tainah S Sales. & Ana L P Martins, "Planejamento, transparência, controle social e responsabilidade na administração pública após o advento da lei de responsabilidade fisca" (2014) 34:1 Nomos 241.
[12] Diego Lusa, Roberto Rabello, & Cristiano Cervi, "'Open Smart City View – An Architecture for Open Government Data Manipulation and Presentation at City Level' (Paper delivered at the 14th

generated in "popular participation, empowerment of citizens, development or improvement,"[13] to name a few benefits.

Custodianship over data is naturally important for open smart cities. Open North's Open Smart Cities Guide notes that:

> In an Open Smart City, data management is the norm and custody and control over data generated by smart technologies is held and exercised in their public interest. Data governance includes sovereignty, residency, open by default, security, individual and social privacy, and [granting] people authority over their personal data.[14]

While this creates elements of commonality in data control, such as the need for individuals to have sovereignty over their own data, it does highlight two different vectors for how data is treated. First, the public and private dichotomy: where the city collects information, data governance and management is generally clear; however, where a private or non-public entity collects the information, data may be treated differently depending on legislation in places, or private agreements entered into by that entity. Second, individuals must have authority over their own data, and be secure of their privacy. While there are different ways to achieve this in an open smart city, how data is collected is obviously an important element - if data is related to an identifiable individual,[15] it raises different concerns than if it cannot be linked to an identifiable individual. In terms of bike counting, this is typified by differing collection methods such as inductive loops, wherein the metals in the bicycle trigger a signal to 'count' that a bike has passed, versus recording that same area on video, and then blurring out individual's faces afterwards. While bike counting appears to trend towards more privacy-friendly smart city applications, it is nonetheless important to note that collection can incur its own data governance issues.

International Conference on WWW/INTERNET 2015 in Maynooth, Greater Dublin, Ireland, October 2015) at 3.

[13] *Ibid.*

[14] Lauriault, Bloom & Landry, *supra* at 6.

[15] Such as in the Personal Information Protection and Electronic Documents Act (PIPEDA), which notes that personal information includes any information about an identifiable individual.

Cycle counting technologies

Cycle counting can be done with a variety of different resources. Participatory or crowd-sourced data tends to be collected via cell-phone, such as through the fitness app Strava, which can collect information from the phone's embedded accelerometer, microphone, and GPS.[16] Bike-sharing programs will typically have a GPS device and sensory equipment built into or onto the bike itself, with users agreeing to their data being shared in the bike-sharing user agreement.[17] Some static counters will use thermal imaging,[18] sensors that detect light intensity changes,[19] or inductive loops that measure the change in the magnetic field when metal passes over them.[20] Video surveillance can be used, and can be either a static, permanent camera, or a less permanent removable camera that is capable of reporting counts of cyclists and also specifics on their activities.[21] New initiatives are also beginning to use Lidar, which, while similar to radar, uses pulses of light from a laser rather than electromagnetic waves.[22]

Eco-Counter[23]

Eco-Counter has been developing technology for counting people and bicycles on any type of outdoor terrain, from paved multi-use pathway to forest trail, for over 15 years. Headquartered in France with offices in Germany, China, and Canada, Eco-Counter supplies over ten thousand pieces of equipment in 53 countries

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[16] Christin, *supra*.
[17] Smith, *supra*.
[18] Mark P Philipsen et al, "Thermal Activity Surveillance System: Measuring Mountain Bike Trail Use" (2018) 1:8 Proceedings 739.
[19] Norbert Brändle, Ahme Nabil Belbachir, & Stephan Schraml, "SmartCountplus – Towards Automated Counting and Modelling of Non -Motorised Traffic with a Stand-Alone Sensor Device" (2010) REAL CORP 2010: Cities for Everyone. LIveable, Healthy, Prosperous 1261.
[20] Roberts, *supra.*
[21] Miovision "DataLink: Smart cities with data you can trust" (2018) online: <https://miovision.com/datalink/> accessed November 2018.
[22] Blue City Technology, "Our Products" (2018) <https://www.bluecitytechnology.com/> accessed November 2018.
[23] Unless otherwise indicated, all information in this section is from the Interview of Jean-Francois Rheault, Eco-Counter North American Subsidiary Director, by Johann Kwan and Stephanie Williams (16 November 2018).

worldwide. In North America alone, Eco-Counter supplies over 800 organizations, and it can be found in 45 of 50 American states and in 9 of 10 Canadian provinces. Eco-Counter works with a variety of organizations: in the city of Ottawa alone, Eco-Counter works with the municipality, a recreation and parks program, and the National Capital Commission.

Eco-Counter offers a variety of counting products. Temporary counting products can be easily deployed for short-term studies and consist of pneumatic tubes that can also be combined with passive infrared sensors. Passive infrared is also a technology that can be used for permanent counting, using of an infrared sensor with a 10-year battery life that detects passing objects and classifies them as pedestrians or cyclists based on shape. Another permanent technology uses battery-powered inductive loops, with an accuracy of 97-99% for counting bicycles. Information collected from these products is typically collected at 15-minute intervals and shows the number of bicycles that have passed and the direction they are going.

There are also a variety of products that Eco-Counter offers to complement their counting technologies. One series of products offers real-time display of counter activity that is physically displayed alongside the counter itself. Another series of products, recognizing the high value of publicly available data, consists of the framework for a website where the public can view counts and trends in the data. The data offered and layout of the website itself is determined by the customer, who can also opt to design their own webpage using an application programming interface that Eco-Counter provides.

All data collected by Eco-Counter sensors is stored in servers in Roubaix, France, and is hosted by the French company OVH.[24] All data collected is owned by the customer, but Eco-Counter can use aggregated information, for example to compile their *Worldwide Cycling Index*.[25] Since Eco-Counter products only collect the number of passing bicycles and/or pedestrians and the direction they are traveling, no personal information is recorded, eliminating privacy concerns or the need to anonymize data. The only personal data collected by Eco-Counter is from the customers' workforce, including full name, and professional role, postal address,

[24] Eco-Counter, *Eco-Visio User's Guide*.
[25] Raphael Chapalain, "Eco-Counter Worldwide Cycling Index 2018: The Results!" (13 June 2018), Eco-Counter Blog (blog), online: <https://www.eco-compteur.com/blog/2018/06/13/eco-counter-worldwide-cycling-index-2018-results/>.

telephone number, and e-mail.[26] Eco-Counter protects this data under terms compliant with the European Union's General Data Protection Regulation.[27]

Privacy Concerns

Privacy is naturally a concern where the data of individuals is being collected, as that data can be used in many ways. Given the range of bicycle counting approaches, many different types of data can be collected - individuals' locations, photos and and videos, and unique routes, not to mention inherently sensitive information such as biometric data. Photos and videos produce obvious personal information, such as where an individual was at an exact time, but there are other issues. Tracing an individual's appearance at subsequent photo or video stops is a potential form of surveillance over a large distance. Tracking individual routes can reveal not only what route a person takes, but their stops along the way, and the timing of those stops. This can reveal that person's schedule and habits, as well as potentially private or obviously identifying characteristics - perhaps they belong to a support group for substances at a particular address, or work for a small shop with only one or two employees. This sort of data can produce distinctive information on "private life, habits, acts, and relations."[28]

Data stored with insufficient safeguards can be accessed by others, and information that was not initially attributable to an identifiable individual can be made so in combination with other data. Consider a grainy video from a traffic camera that shows a person wearing a uniquely patterned coat - that person might be identifiable in combination with route data taken from an app if they were the only cyclist there at the time, and with video or still shots from other locations to form a cohesive narrative of where they may have traveled.

Countermeasures may be taken to protect the privacy of those counted, and sensor uses can be tailored to user preferences where more sensitive data such as biometric data is collected.[29] Some countermeasures include anonymous task distribution; anonymous and privacy-preserving data reporting; pseudonymity; spatial cloaking; data perturbation wherein the sensing device "intentionally perturbs the sensor samples by adding artificial noise to the data"; hiding sensitive

[26] Eco-Counter, *General Terms and Conditions of Sale,* s 11.2.
[27] *Ibid* at s 11.
[28] Christin, *supra* at 1932.
[29] *Ibid* at 1936.

locations; data aggregation; privacy-aware data processing; review, deletion, storage and retention of data processes; and access control and audit of data.[30] A range of complexity may be used in addressing concerns - one study, finding geomasking inadequate, used k-anonymity, wherein “each release of data must be such that every combination of values of [attributes whose publication needs to be restricted] can be indistinctly matched to at least k individuals,” providing an accurate heat map with a minimum pre-defined number of users.[31] Other privacy protection measures include the design of the sensors themselves - one counting method is to use low-resolution recordings so that individuals cannot be recognized or identified;[32] to use thermal, which senses few if any identifiable characteristics;[33] and using sensor elements that respond to changes in relative light intensity, creating three-dimensional depth interpretation without sacrificing individual privacy.[34]

Individual Cities

San Francisco, Portland, Ottawa, and Montreal were chosen for their different maturity levels in their bicycle counting programs.

San Francisco[35]

According to their 2013-2018 Strategic Plan, the San Francisco Municipal Transportation Agency (SFMTA) has a mission to "connect San Francisco through a safe, equitable, and sustainable transportation system."[36] As part of this, the SFMTA maintains a network of permanent automated bicycle counters embedded into the pavement supplied by Eco-Counter. Testing on Eco-Counter's offerings by the SFMTA began at the end of 2013 into early 2014, during which time they tested

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[30] *Ibid* at 1936-1941.
[31] Juha Oksanen et al, “ Methods for deriving and calibrating privacy-preserving heat maps from mobile sports tracking application data” (2015) 48 Journal of Transport Geography 135 at 137.
[32] M Nilsson et al, “Reduced Search Space for Rapid Bicycle Detection” (2013) International Conference on Pattern Recognition Applications and Methods at 2.
[33] Philipsen, *supra*.
[34] Brändle, *supra* at 1261.
[35] Unless otherwise indicated, all information in this section is from the Interview of Tori Winters, Transportation Planner by Johann Kwan, (24 October 2018).
[36] https://www.sfmta.com/sites/default/files/reports-and-documents/2018/04/sfmta_strategic_plan.pdf , 2

both Eco-Counter's inductive loop systems and infrared detection systems. After testing, the SFMTA decided not to use infrared counters for a number of reasons: they found that they had difficulty distinguishing clustered bicycles; between different types of traffic such as scooters and skateboards; and that they were unsuited to the prevailing climate of San Francisco (e.g. fog). They now use a network of 75 induction loop counters throughout the city supplemented with an annual manual counting program. Due to issues like construction and equipment failure, it is estimated that 73 of their counters are consistently working at any one time.

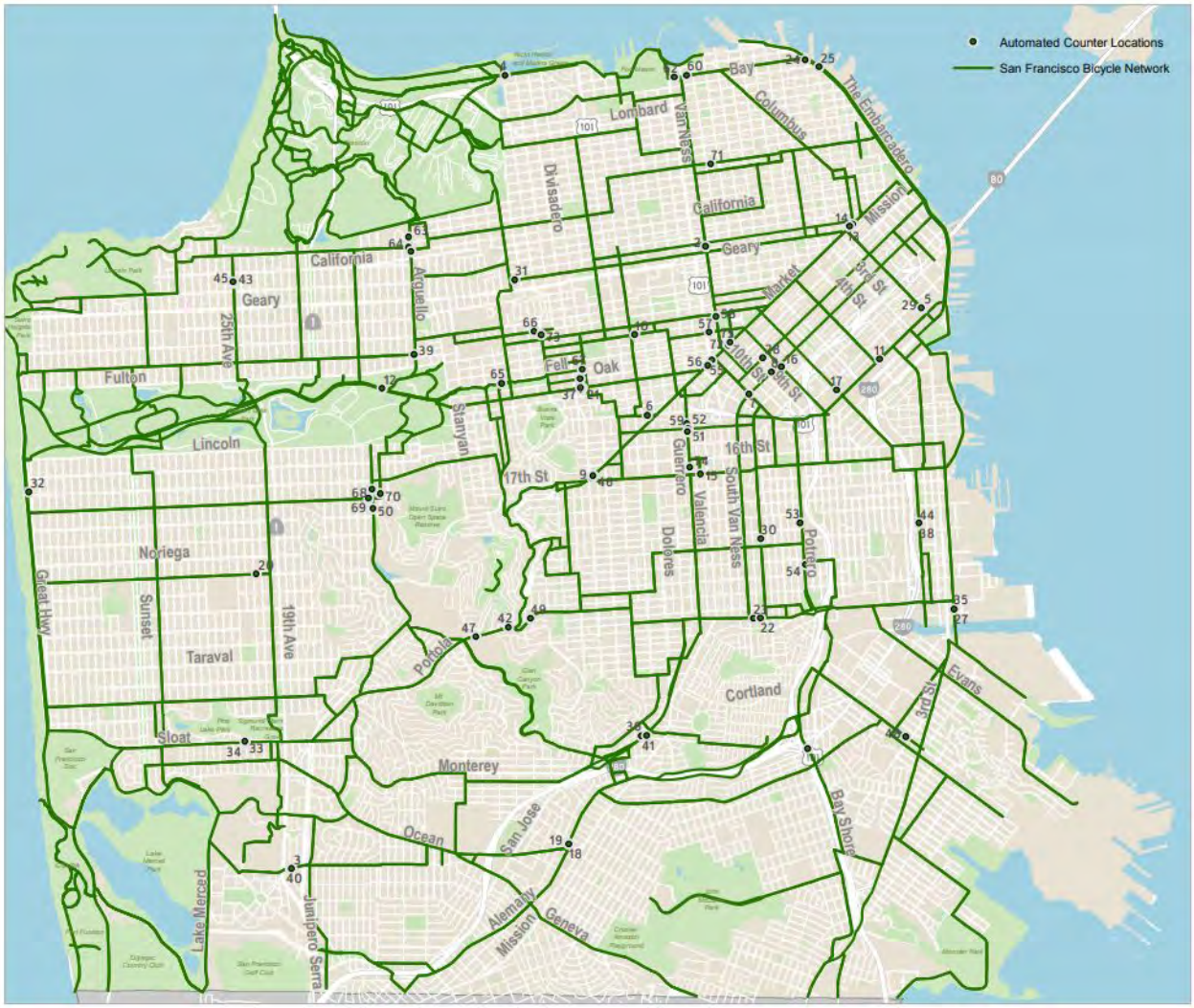
The SFMTA found that the induction loop counters suited their purposes best as they could be calibrated to only count bicycles without also counting scooters and skateboards; they could run 24 hours a day for 365 days a year; and generated a good dataset without being overly invasive. These counters collect an array of data: (1) latitude and longitude for each counter; (2) direction of travel for a single bicycle on certain one-log counters; (3) inbound and outbound information where there are two counters and directionality cannot be logged. As previously noted, this data is sent to Eco-Counter's servers in chunks down to 15 minutes, which represents the finest granularity achievable with this technology. After the information, in which the SFMTA retains legal possession and control, is sent to Eco-Counter's servers in Roubaix, France, the SFMTA is able to retrieve this information through an API and deploy the information for their uses.

The SFMTA has yet to subject this data to big data analysis or to apply computerized models to connect the data from different counters or American Community Survey data.[37] Up till now, it has been using the localized data on the scale of one or two blocks to determine trends as well as using the data to determine whether infrastructure changes have measurable effects. They rely on their annual manual counts to normalize the data and provide context to the automated counts for information such as helmet usage and how many people are on each bicycle.

The locations of these counters are provided to the public on an up-to-date map on the SFMTA's website *(fig.1)*.[38] Rather than using EcoCounter's own online display

[37] The American Community Survey is an ongoing survey by the US Census bureau.
[38] San Francisco Municipal Transportation Agency "Automated Bike Counter Locations" (October 2018) online: <https://www.sfmta.com/sites/default/files/reports-and-documents/2018/10/automatedbikecounterlocations_29oct2018.pdf> accessed November 2018.

offerings, the SFMTA pulls the data from EcoCounter's servers and displays them to the public on an annual basis through graphical "dashboards" showing volume usage, bicycle volumes, hourly counts, and most recently installed counters *(fig.2)*.[39] They are also exploring ways to increase the frequency with which they update these dashboards.[40]



(fig. 1) SFMTA's map of automated bicycle counter locations.[41]

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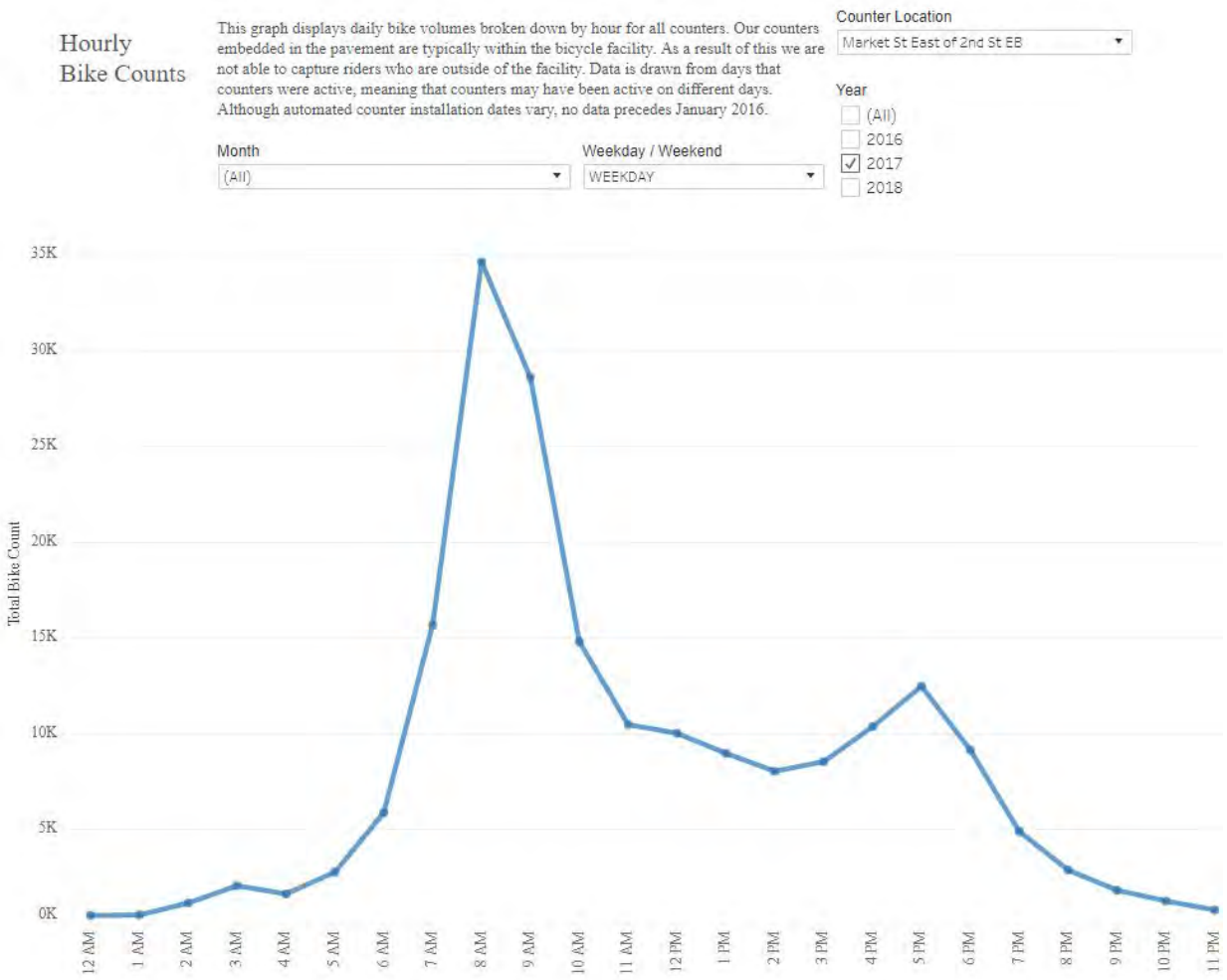
[39] San Francisco Municipal Transportation Agency "How Many People Are Biking? View various metrics for the number of people biking in San Francisco" (2013-2018), online: <https://www.sfmta.com/getting-around/bike/bicycle-ridership-data/how-many-people-are-biking> accessed November 2018.

[40] San Francisco Municipal Transportation Agency "Bike Metrics: Explore our bicycle ridership volumes through annual summaries, daily & weekly ridership volumes and ridership broken down by census tract" (2013-2018), online: <https://www.sfmta.com/bicycle-ridership-data-1> accessed November 2018.

[41] San Francisco Municipal Transport Authority, "Automated Bike Counter Locations," October 12, 2018, online:



(fig. 2) SFMTA's dashboard for Hourly Bike Counts.[42]

The SFMTA has no current plans to expand the number of bicycle counters in their inventory as they have reached a sustainable number for their program budget. As the SFMTA's automated bicycle counters were deployed in batches, their counters are not dispersed evenly throughout the city. For the most part, they are deployed along one major North-South axis down Van Ness Avenue to South Van Ness and down South into the Mission. While this gives them a fair idea of bicycle traffic along that thoroughfare and of bicycle traffic crossing East-West across that axis, they are looking at redistributing their counter network rather than putting more counters in place to gain better insight into bicycle traffic in San Francisco.

<"https://www.sfmta.com/sites/default/files/reports-and-documents/2018/10/automatedbikecounterlocations_29oct2018.pdf">

[42] San Francisco Municipal Transport Authority, "Hourly Bike Counts Dashboard," December 8, 2017 online: <"https://www.sfmta.com/reports/hourly-bike-counts-dashboard">.

The SFMTA does eventually plan to subject the data collected to more advanced modelling, but are mindful of the privacy concerns that can be triggered by amalgamating different datasets into one cohesive picture. They are looking to the example set by the San Francisco Department of Public Health in achieving the city's objective of zero traffic deaths by 2024 as part of the multi-national Vision Zero project. In compiling police collision data and hospital data to list accident hotspots and high injury corridors, they routinely redact all personal information, and often take a high-level approach to generalize information that they find too specific (e.g. a specific intersection location).[43]

Portland[44]

The City of Portland is bisected by the Wiliamette River, with numerous bridges enabling transit across the city. As such, Portland's automated bicycle counting program is primarily centered around counting bicycle traffic across these bridges. Portland employs seven permanently installed counters, four of which are surface pneumatic hose sensors sourced from Eco-Counter. The balance are surface-embedded piezoelectric sensors that detect bicycle wheels embedded in concrete bikeways from Roadsys.

These fixed locations are supplemented with temporary JAMAR Cycles Plus pneumatic tube counters that are placed in general traffic (along with motor vehicles) and used for periods up to a week, after which the pneumatic tubes wear out. The City of Portland also has an annual manual bicycle count.[45]

As with the sensors deployed in the other cities we surveyed, these sensors tracked locational data, time of input, and direction. The temporary JAMAR sensors also track speed, and are able to distinguish between bicycles and motor vehicles by wheelbase and number of axles.[46]

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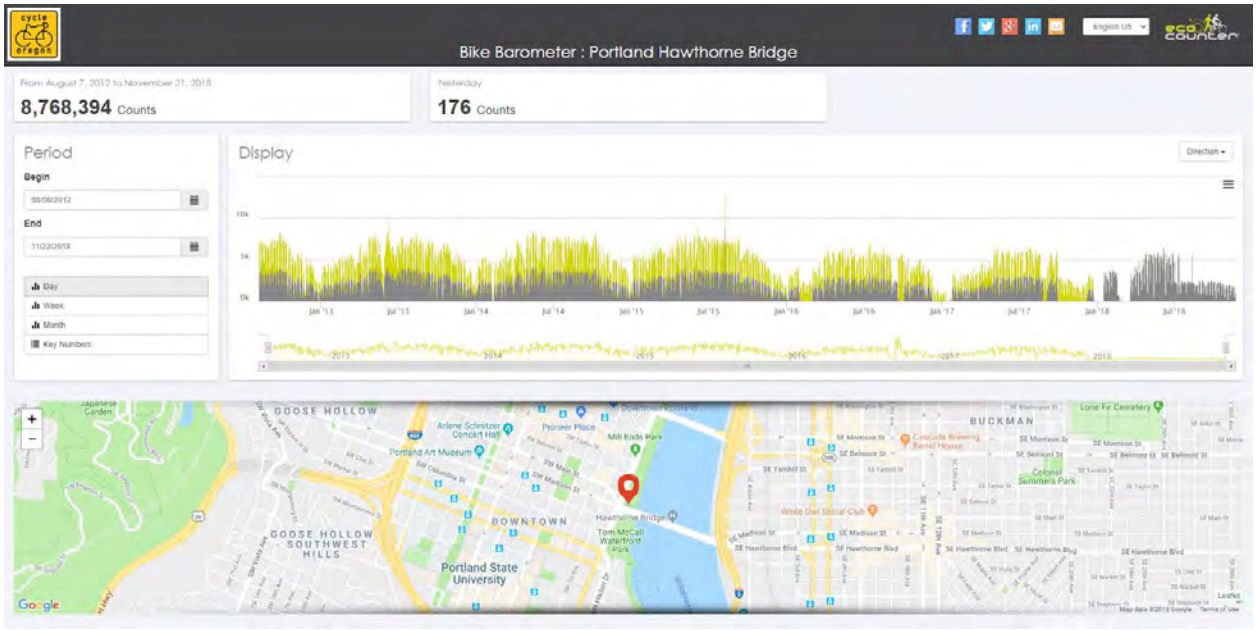
[43] *Ibid.*
[44] Unless otherwise indicated, all information in this section is from the Interview of Roger Geller, Bicycle Co-ordinator, Portland Bureau of Transportation, and Tom Jenson, Traffic Data, by Johann Kwan (26 October 2018).
[45] Portland Bureau of Transportation, "Bicycle Counts" (2018) online: <https://www.portlandoregon.gov/transportation/44671> accessed November 2018
[46] *Ibid.*

The storage of data varies depending on the technologies used. In the case of the permanent counters, data is stored on centralized servers provided by the vendors, and retrieved by the City. The City retains legal possession of the data. In the case of the temporary sensors, the data is manually downloaded and added to the local geodatabase. They have not subjected this data to big data modelling.

All of the data acquired is publicly available either by request. The City of Portland further leverages the ability to visualize and make publicly available the data acquired from their Eco Counter sensors placed at the Hawthorne[47] and Tilikum Crossing[48] bridges through Eco Counter's Eco-Visio platform *(fig.3)*.



(fig.3) The "bike barometer" tracking bicycle counts across the Hawthorne Bridge.[49]

At their current stage of development, the City of Portland's Bicycle Coordinator, Roger Geller, thinks that expansion of their automated bicycle counting program is likely. Mr. Geller expressed an interest in expanding automated counting on greenway trail networks to measure seasonal and weather variations of bicycle traffic. While there are as yet no concrete plans for expansion, the automated bicycle counting program has aided the City of Portland both on a macro and micro

[47] Cycle Oregon, "Bike Barometer: Portland Hawthorne Bridge" (2018) online: <http://portland-hawthorne-bridge.visio-tools.com> accessed November 2018.
[48] TriMet, "Bike Barometer: Portland Tilikum Crossing" online: <http://portland-tilikum-crossing.visio-tools.com> accessed November 2018.
[49] Cycle Oregon, "Bike Barometer: Portland Hawthorne Bridge" (2018) online: <http://portland-hawthorne-bridge.visio-tools.com> accessed November 2018.

level. On a macro scale, the program has helped demonstrate that increased bicycle usage corresponds to investment into the bicycle network. On a micro scale, the program has informed intersection design in the form of modified signal timing and geographic design to adjust for cyclist demand.

Ottawa[50]

Ottawa has taken a very robust approach to facilitating cycling, and produces an updated cycling plan every five years as part of its larger transportation master plan, with the aim of achieving a 5% mode-share for cycling.[51] The City of Ottawa engages in bicycle counting through manual counts, inductive loops, infrared products for both pedestrians and cyclists, algorithm-enabled cameras, and through the purchase of data through fitness apps such as Strava. There are a number of permanent counting stations which collect data year round, with more limited manual counts in the winter. Current equipment manufacturers include Eco-Counter and Miovision, and the city is currently trialing equipment from Blue City Technology Inc. Eco-counter produces inductive loops and infrared cameras, while Miovision specializes in algorithm-enabled cameras that allow the camera to "see" the intersection and recognize traffic types and record their actions.[52] Blue City Technology uses lidar. Data is used extensively for planning purposes: to show long-term trends and use difference where an intervention has been made, to direct investments, and to demonstrate to both the public and decision makers the extent of facilities use.

Ottawa has contracted Eco-counter to maintain the count database via the eco-visio web portal. Data is also stored in computer boxes at collection points, and with local copies of data in Ottawa. Data is curated by the city and then published through an open data portal, with corrections simulated to counting errors such as if the loop is damaged by construction. Open data is also produced for individual areas, such as the Laurier avenue bicycle web-page where the bicycle count and daily numbers can be accessed by the public. In terms of legal possession of data,

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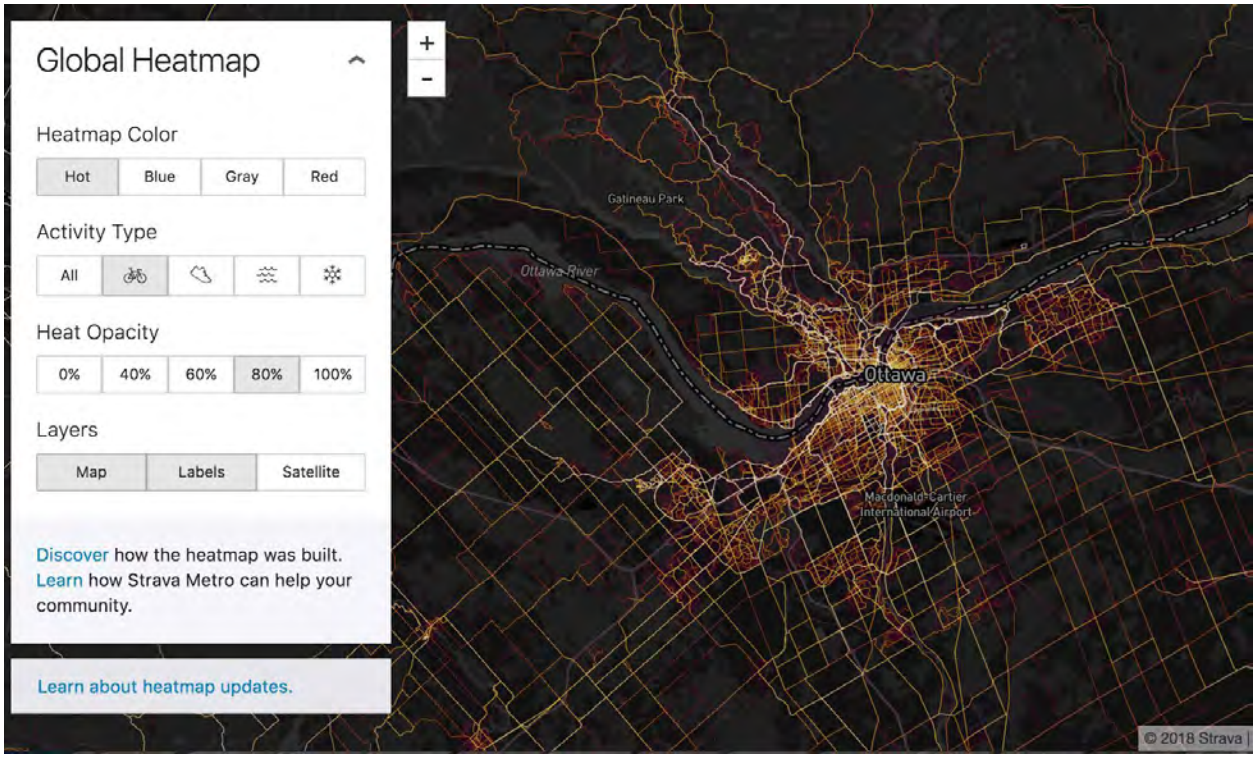
[50] Unless otherwise indicated, all information in this section is from the Interview of Samuel Roberts, Transportation Planner for the City of Ottawa, by David Fewer and Keri Grieman (14 November 2018).
[51] City of Ottawa, "Ottawa Cycling Plan" (November 2013) online: <https://documents.ottawa.ca/sites/default/files/documents/ocp2013_report_en.pdf> accessed November 2018
[52] Miovision, "Multimodal Detection" (2018) online: <https://miovision.com/solutions/multimodal-detection/> accessed November 2018

all Eco-counter equipment used is owned by the City, and so data is the property of the city. Data purchased from companies such as Strava is used under license for the period of the contract, but remains legally owned by Strava.

In terms of privacy interests, Ottawa maintains compliance with the *Municipal Freedom of Information and Protection of Privacy Act*, and its own internal data management policies. Most methods employed by the city provide information in a way that is difficult to attribute to identifiable persons, such as inductive loops and infrared cameras. The city also conducted a 'snapshot' survey of 25,374 household's transportation habits, and follows accepted privacy practices on collection, storage and use of tis information.[53] Occasionally the City will run consultations, and ask for consent to send emails if the individual interviewed is interested in hearing more about the project.[54]
In purchasing information from companies such as Strava, which utilizes the GPS in user's phones, Ottawa has access to a 'heat map' that shows where riders are in numbers and regularity *fig.4)*.[55] Individuals accessing the data can see, for example, the number of people who use a particular bicycle lane, but not specific individual routes. Data is anonymized around people's homes, and while local streets are identifiable, ends of routes are not.[56]

[53] *Ibid*; "TRANS "TRANS: a joint transportation planning committee serving the national capital region" (2018) online: <http://www.ncr-trans-rcn.ca/surveys/o-d-survey/o-d-survey-2011/> accessed October 2018
[54] *Ibid.*
[55] Strava, "Global Heatmap" (2018) online: <https://www.strava.com/heatmap#12.00/-75.70730/45.38386/bluered/ride> accessed November 2018
[56] *Ibid.*



(fig. 4) - Ottawa - Strava Heat Map[57]

Further uses of the cycling data include determining the impacts of weather, and separating trends from variability of weather. Ottawa also plans to expand its use of the data to its regional transportation model, or 'TRANS' for for short.[58] The model is used to reproduce existing traffic use patterns, but also to produce information for project evaluation by predicting the effects of future projects on traffic use.[59] Additionally, for new cycling facilities, either inductive loops or Eco-counter products and infrastructure are included in the original build - such as the pedestrian bridge over the Rideau canal at 5th and Clegg. The City is currently considering other technologies to engage in bicycle counting, including potentially cycling apps for further information on origins and destinations.

[57] Strava, "Global Heatmap" (2018) <https://www.strava.com/heatmap#10.00/-75.81084/45.42664/hot/ride> accessed November 2018.
[58] TRANS, *supra*.
[59] *Ibid*.

Montreal

Montreal is a leading example in North America when it comes to cycling.[60] With 846 kilometers of cycling paths[61] and the number of cyclists increasing, the city has a vision of creating a safe, year-round, cycling-friendly city.[62] While it is unclear to what extent bicycle counting data has influenced actions the city has taken or plans to take to make the city safer and more accessible for cyclists, Montreal has been using these technologies for some time.

The city has been using bicycle counting technologies since at least 2008. Data collected from five bicycle counters between 2008 and 2010 was used in a study evaluating weather-related use of bicycles. This was also a period of heavy expansion of dedicated bicycle routes in Montreal.[63] By 2011, the city had doubled its bicycle counters, using 10 from the company Eco-Counter.[64] Information collected from these counters could be used to understand how the number of cyclists at particular locations in the city can change in relation to size and number of bicycle lanes either at that specific location or on alternate routes nearby.[65]

Currently, there are 23 locations in Montreal where Eco-Counter bicycle counting technologies are being used, some with physical display of the data alongside the counter. The bicycle counters are most heavily used in and around the city centre. All data collected from these counters is displayed on a webpage easily accessible to the public.[66] There is a vision that the availability, especially public availability, of

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[60] Montréal, Members of the Comité visant à promouvoir la pratique du vélo, *Montreal, City of Cyclists – Cycling Master Plan: Safety, Efficiency, Audacity* (Montréal: Ville de Montréal) at 3 [City of Cyclists].
[61] Ville de Montréal, "Découvrir le plaisir de rouler", online: <http://ville.montreal.qc.ca/portal/page?_pageid=8957,99637650&_dad=portal&_schema=PORTAL> accessed November 2018.
[62] *City of Cyclists, supra* at 3.
[63] Monique Beaudin, "More people cycling, thanks to bike paths" *Montreal Gazette* (24 December 2010) online: <https://montrealgazette.com/news/local-news/more-people-cycling-thanks-to-bike-paths>.
[64] Alanah Heffez, "Bike Counters Find Cycling Trips Have Doubled on Laurier Ave" *Spacing Montreal* (22 September 2011) online: <http://spacing.ca/montreal/2011/09/22/bike-counters-find-cycling-trips-have-doubled-on-laurier-ave/>.
[65] *Ibid*.
[66] Eco-Counter, "Ville de Montreal" (2018) online: <http://www.eco-public.com/ParcPublic/?id=630#> accessed November 2018.

bicycle counting data will help provide better services as Montreal continues to strive to reach its goal of safe, four-season cycling.[67]

Local laws

San Francisco

San Francisco's bike counting activities are governed by Article 1 of the *California Constitution*,[68] the *Information Practices Act*,[69] the *California Public Records Act*,[70] and the *Sunshine Ordinance*,[71] and a variety of laws governing private-sector uses of information culminating in the *California Consumer Privacy Act of 2018*.[72]

Article 1, section 1 of the *California Constitution* explicitly protects every citizen's "inalienable right" to pursue and obtain privacy.[73] Section 3(b) protects the right of the people to "have the right of access to information concerning the conduct of the people's business, and, therefore, the meetings of public bodies and the writings of public officials and agencies shall be open to public scrutiny."[74]

These constitutional considerations are further expanded upon for information held by state and local governments in the *Information Practices Act* and the *California Public Records Act*.

The *Information Practices Act*, codified in the *California Civil Code* as § 1798, limits the use and disclosure of personal information held by California state and local governments, limiting the government from disclosing information about a person unless it is to the individual to whom the information pertains or with consent, subject to certain exceptions. Those exceptions include: for reasons of law enforcement; where required by state or federal law; where required by the

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[67] "Montreal announces new bike paths and "smart" counters for 2017-18" *Montreal Gazette* (9 June 2017) online: <https://montrealgazette.com/news/local-news/city-announces-bike-paths-for-2017-18>.
[68] CA Const art I.
[69] Cal Civ Code tit 1.8 §§ 1798-1798.78.
[70] Cal Gov Code tit 1 §§ 6250-6276.48.
[71] San Fran Adm Code § 67.
[72] *The California Consumer Privacy Act of 2018* tit 1.81.5 Cal Civ Code § 1798.100-1798.199.
[73] CA Const art I, § 1.
[74] CA Const art I, § 3(b).

California Public Records Act; or for the purposes of legitimate research where the information disclosed is not personally identifiable.

The *California Public Records Act*, 1968, codified in the *California Government Code* as §§ 6250-6276.48, is designed to ensure that "access to information concerning the conduct of the people's business is a fundamental and necessary right of every person in this state."[75] This law ensures that public records are open to public inspection. This is further expanded upon in San Francisco's municipal law by the *San Francisco Sunshine Ordinance,* which is Chapter 67 of the *San Francisco Administrative Code*.[76] This code further strengthens freedom of information within the city of San Francisco and ensures that public information is open to public review.

California law encompasses a variety of laws that apply to private-sector use of personal information, including: the *Online Privacy Protection Act*[77] which places several positive obligations on operators of commercial websites; a data breach notification law[78]; and the "Shine the Light" law[79] (*California Civil Code* § 1798.83) which requires companies to disclose to consumers what personal information has been shared to third parties. The state recently passed the *California Consumer Privacy Act*[80], giving citizens the right to know: "(1) The right of Californians to know what personal information is being collected about them. (2) The right of Californians to know whether their personal information is sold or disclosed and to whom. (3) The right of Californians to say no to the sale of personal information. (4) The right of Californians to access their personal information. (5) The right of Californians to equal service and price, even if they exercise their privacy rights."[81]

All this means that California has some of the strongest privacy legislation in North America. Commentators have frequently stipulated that the *California Consumer Privacy Act* may usher in other similar consumer focused legislation across the US modelled after the GDPR.[82]

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[75] Cal Gov Code tit 1 § 6250.
[76] San Fran Adm Code § 67.
[77] Cal BP Code §§ 22575-22579.
[78] Cal Civ Code tit 1.81 § 1798.82.
[79] Cal Civ Code tit 1.81 § 1798.83.
[80] *The California Consumer Privacy Act of 2018* tit 1.81.5 Cal Civ Code § 1798.100-1798.199.
[81] US, AB 375,*The California Consumer Privacy Act of 2018*, 2017-2018, Reg Sess, Cal, 2018, s 2(i).
[82] <online: "https://www.forbes.com/sites/forbestechcouncil/2018/08/20/how-will-californias-consumer-privacy-law-impact-the-data-privacy-landscape/">.

This has numerous implications for bicycle counting technologies. In the preamble of the *California Consumer Privacy Act*, the California legislature explicitly recognized that "the proliferation of personal information has limited Californians' ability to properly protect and safeguard their privacy. It is almost impossible to apply for a job, raise a child, drive a car, or make an appointment without sharing personal information. [...] As the role of technology and data in the every daily lives of consumers increases, there is an increase in the amount of personal information shared by consumers with businesses."[83] As bicycle counting methods develop and new technologies are used, the likelihood that personal information may be implicated grows. Both governmental organizations and private industry will have to take care to use, collect, and disclose the information collected with an eye to using personal information responsibly.

Portland

Portland is governed by the laws of the State of Oregon. State laws regarding the use of public information can be found in the *Oregon Revised Statutes*, at chapter 192. Information of a personal nature cannot be disclosed if public disclosure would constitute an unreasonable invasion of privacy, "unless the public interest by clear and convincing evidence requires disclosure in the particular instance."[84] Individuals may also submit a written request to a public body "not to disclose a specified public record indicating the home address, personal telephone number or electronic mail address of the individual" where the individual demonstrates that the personal safety of the individual or family member is in danger if the home address, personal telephone number, or e-mail address remains in the public.[85]

Oregon's laws governing privacy issues in the private sphere are found in Chapter 14 of the *Oregon Revised Statutes*, particularly Chapter 646 and 646A, with new laws going into effect on June 2, 2018.[86] These laws include provisions for protections against identity theft under the *Oregon Consumer Identity Theft Protection Act*[87] including provisions for data breach notification.[88] They also state that a person

[83] US, AB 375,*The California Consumer Privacy Act of 2018*, 2017-2018, Reg Sess, Cal, 2018, ss 2(c) & (d).
[84] Or Rev Stat § 192.355.
[85] Or Rev Stat § 192.368.
[86] Or Rev Stat §§ 606, 646A.
[87] Or Rev Stat § 646A.600-646A.628.
[88] Or Rev Stat § 646A.604.

"engages in an unlawful trade practice" if they do not adhere to the terms of their consumer agreements (e.g. privacy policy).[89]

Oregon's privacy laws, while not as robust as California's, clearly indicate that privacy is a right to be respected. Public bodies cannot disclose information that would be an unreasonable invasion of privacy, balanced against the public interest of disclosure. Private entities must adhere to their agreed-upon privacy policies. In the case of bicycle counting, this merits careful attention by governments employing bicycle counting technologies. Not only must they balance the interests of personal privacy with the public interest, but they must also be careful to ensure that private entities that they engage with have privacy-respecting policies in place.

Ottawa

Ontario is governed by the Freedom of Information and Protection of Privacy Act (FIPPA), the Municipal Freedom of Information and Protection of Privacy Act (MFIPPA), and the Personal Information Protection and Electronic Documents Act (PIPEDA).

FIPPA and MFIPPA protect individual privacy with respect to government institutions' collection, retention, use, disclosure, and disposal of personal information. FIPPA includes all ministries of the Ontario government and any agency, board, commission, corporation or other body noted as an "institution" under the regulations.[90] MFIPPA applies to all municipal corporations, "including a metropolitan, district or regional municipality, local boards and commissions. Both FIPPA and MFIPPA include direction on the use or disclosure of a record, and the definition of personal information to mean "recorded information about an identifiable individual."[91] This information does not need an individual's name attached to be personal information, and can include a physical description, photo, or video, and the individual's address.

There are three possible pre-conditions for personal information to be collected:

[89] Or Rev Stat § 646.607
[90] Government of Ontario, "Introduction of the Act" (27 June 2018) online: https://www.ontario.ca/document/freedom-information-and-privacy-manual/introduction-act) accessed November 2018.
[91] *Ibid.*

-the collection of personal information is expressly authorized by a statute. The authority to collect must be in a statute rather than in a regulation; or
-the information collected is used for the purposes of law enforcement; or
-the collection is necessary for the proper administration of a lawfully authorized activity (provincial institutions may have this activity authorized by statute, regulation or order- in-council; local governments by statute, regulation or by-law).[92]

Information collected is also limited to 'necessary' information.[93]

In other words, where the city collects information that is not about an identifiable individual, no authorization is needed. This is likely the case for infrared, light-based, and inductive loop collection, as long as they are in areas that could not be linked to a small pool of individuals. If, for example, there were an inductive loop at the end of a small cul-de-sac, then the information could be linked to a potentially small amount of individuals and thus narrowed to a single person, whereas an inductive loop on a bikeline downtown is unlikely to produce information attributable to an individual. Where broader collection methods are used, such as videos or photos, which do produce identifiable information the city must be authorized by statute, such as the 'Red Light Camera System Evidence' Regulation under the *Highway Traffic Act*.[94] The city must also limit information to what is 'necessary' to perform that task. This can include only counting the number of bicyclists, rather than the the type and destination, where the counting is being used to determine use on a particular road.

PIPEDA applies to federal works, undertakings, or businesses; and when there is commercial activity. In other words, PIPEDA would apply to private entities such as Strava who collect users information in the course of commercial activity, and when that information is subsequently sold. PIPEDA is relevant to the collection, use, and disclosure of personal information. Such commercial enterprises are required to get users informed consent for the collection, use, and disclosure of their information, as well as its subsequent sale. This is usually done through asking the users' consent through the app.

[92] *Ibid.*
[93] *Ibid.*
[94] Highway Traffic Act, R.S.O. 1990, c. H.8 277/99

Montreal

Quebec has both private and public sector privacy acts, both overseen by the Commission d'accèss à l'information du Québec. Quebec's public sector privacy legislation is the "Act respecting access to documents held by public bodies and the protection of personal information," which covers information collected, used, released, and kept by government departments and agencies, as well as municipal bodies.[95] No person has the right to collect personal information on behalf of a public body "if it is not necessary for the exercise of the rights and powers of the body or the implementation of a program under its management."[96] Public bodies themselves may collect personal information "if it is necessary for the exercise of the rights and powers or for the implementation of a program of a public body with which it cooperates to provide services or to pursue a common mission."[97] Information may only be used with a public body for the purposes for which it was collected.[98] Public bodies may use information for a purpose other than for which it was collected, with or without consent, if:

> (1) if the information is used for purposes consistent with the purposes for which it was collected;
> (2) if the information is clearly used for the benefit of the person to whom it relates; or
> (3) if the information is necessary for the application of an Act in Québec, whether or not the law explicitly provides for its use.[99]

This means that the municipality can collect information in connection with the implementation of a program under its purview, such as creating a city-wide cycling program, or improvement of traffic flow. The city can also use information for other purposes, as long as that information is consistent - if a bicycling count was done to assess the number of users for a particular path, it can also be used for extrapolating use on a new bridge, or to predict when maintenance should be done to the path.

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[95] Légis Quebec Official Source, "Act respecting Access to documents held by public bodies and the Protection of personal information" online: <http://legisquebec.gouv.qc.ca/en/ShowDoc/cs/A-2.1> accessed November 2018.
[96] *Ibid.*
[97] *Ibid.*
[98] *Ibid.*
[99] *Ibid.*

Quebec's private sector legislation is the "Act respecting the protection of personal information in the privacy sector," which is legislation deemed substantially similar to the federal PIPEDA legislation mentioned above, as applicable to federal entities and commercial activity. Companies engaging in commercial must seek consent to collect personal information.

Conclusions

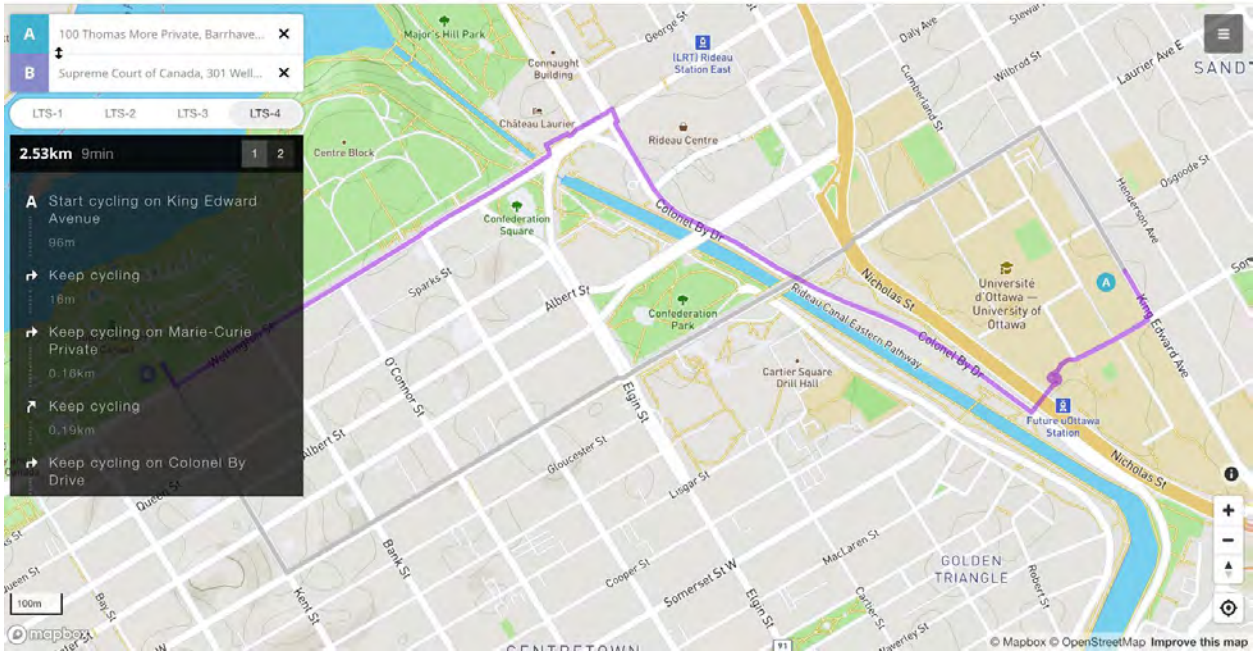
Bicycle counting technologies have the potential to greatly increase bicycle ridership and generate useful information for urban planning and quality-of-life improvements. These technologies vary in type and use, and include electromagnetic sensors, infrared, algorithm-enabled video, and light sensors. Their use is becoming more widespread throughout cities in North America, and is playing a greater role in the development of urban transportation strategies.

As personal information is likely to include any information about an identifiable person, this is likely to include information wherein an individual's path from, say, their particular address to their workplace. It is unlikely to include the number of users of a bicycle path. Accordingly, there are two ways that privacy legislation is likely to be engaged by bicycle counting technologies: where broader collection techniques are used, such as video, and where detailed user specifics are collected, such as their individual bicycle routes, or unique addresses. Additionally, it must be noted that the definition of personal information in Canada includes any information about an identifiable person, not simply information that identifies a person. This has the potential to include broader collection techniques, such as those that link a person to their neighbourhood and time of commute. Privacy laws also apply to use, disclosure, and storage, so there are potential risks to privacy after collection occurs.

All of the cities surveyed in this report took care to collect information that does not implicate personal information to the greatest extent possible, including techniques such as data fuzzing around endpoints that could be linked to individuals and collecting data that only counted bicycles by time and direction rather than specific route or personal identifiers.

Use in planning does not typically reveal personal information but cities must nonetheless be wary of revealing personal information by piecing together various data points. For example, San Francisco, which has a mature bicycle count program,

has been considering different ways to obfuscate personal information if they decide to apply sophisticated analysis methods to their data, including redacting all personal information as well as generalizing problematic intersections to wider areas. In providing its open data portal, Ottawa, curates its data to ensure that no identifiable data can be applied in combination with other sources. This sort of open data provision allows non-governmental groups both public and private to use the data in increasingly creative and interesting ways, such as Bike Ottawa's cycling routing app *(fig. 4)*.



(fig. 5) Bike Ottawa's Routing App[100]

Cities should also be careful where they purchase their data from. While city planners may be careful in collecting data with as minimal personal information as possible, such restraints may not always be observed by private companies. Additionally, different legislation applies to the collection of information by private companies as opposed to public entities. Though some jurisdictions such as California, Canada, and the EU have prominent private-sector privacy legislation, this may not be true for every jurisdiction.

As bicycle counting technologies become more prominent and more cities implement such technologies, it is worth noting that long-term planning saves

[100] Bike Ottawa "Routing Map" (2018) online: <https://maps.bikeottawa.ca/routing/> accessed November 2018.

headaches down the road. As many of these counting technologies can be built semi-permanently into physical infrastructure, the distribution and placement of bicycle counters across an a city is best done with long-term gain in mind. This applies not only to logistical concerns, but also to privacy. Planning around technologies that are privacy-respecting and with plans to preserve privacy rights through the use of the data that does not identify individuals will save time, money, and headaches in the long run.

Best practices

1. **Use technologies that limit the collection of personal information.** If personal information absolutely must be collected, it should be stripped away as soon as possible.
2. **Store data securely.** Data that does not initially identify individuals can do so in combination with other data.
3. **Limit data collection to only that which is needed.** Collection strategies such as bicycle numbers and heat maps rather than individual-specific routes avoid engaging more serious privacy concerns.
4. **Ensure that partners or contractors follow collection restrictions**. When purchasing data from private companies, ensure that they are upholding their own privacy obligations under relevant legislation.
5. **Notify individuals that data is being collected**. Where possible, notify individuals that data is being collected. This is a requirement for collection through personal devices such as apps, and advisable for external collection devices.
6. **Installing counting devices when creating a new space**. When creating new infrastructure that bicycles will use, including counting devices in the original build allows for better integration of use, saving installation costs and allowing for a greater range of device types.
7. **Hide or mask sensitive locations.** Fuzzing data of sensitive areas provides an additional layer of security for personal information.

Lessons learned

1. **Variety of counting technologies available**: bicycle counting technologies have evolved beyond manual counts to include a variety of methods. There are privacy friendly options available that use less invasive methods.
2. **Data used for extensive planning objectives**: bicycle counts form a part of broader transportation plans, and cities are actively promoting bicycling in transportation.
3. **Private companies supplying equipment**: Eco-Counter, Miovision, Roadsys, and JAMAR are all currently supplying counting devices to cities, with Blue City Technology Inc being trialed in Ottawa.
4. **Data hosted by private companies**: Data is often hosted by private companies, such as through the Eco-Counter data portal.
5. **Open data is a valuable city resource**: allowing non-government entities to access the data can result in a shared ecosystem of public resources.