WECOUNT

WeCount: Citizens Observing UrbaN Transport

Deliverable 4.3: Final Summative Case Study Report

Report for:
European Commission
Research Executive Agency (**REA)**

Date: September 2021

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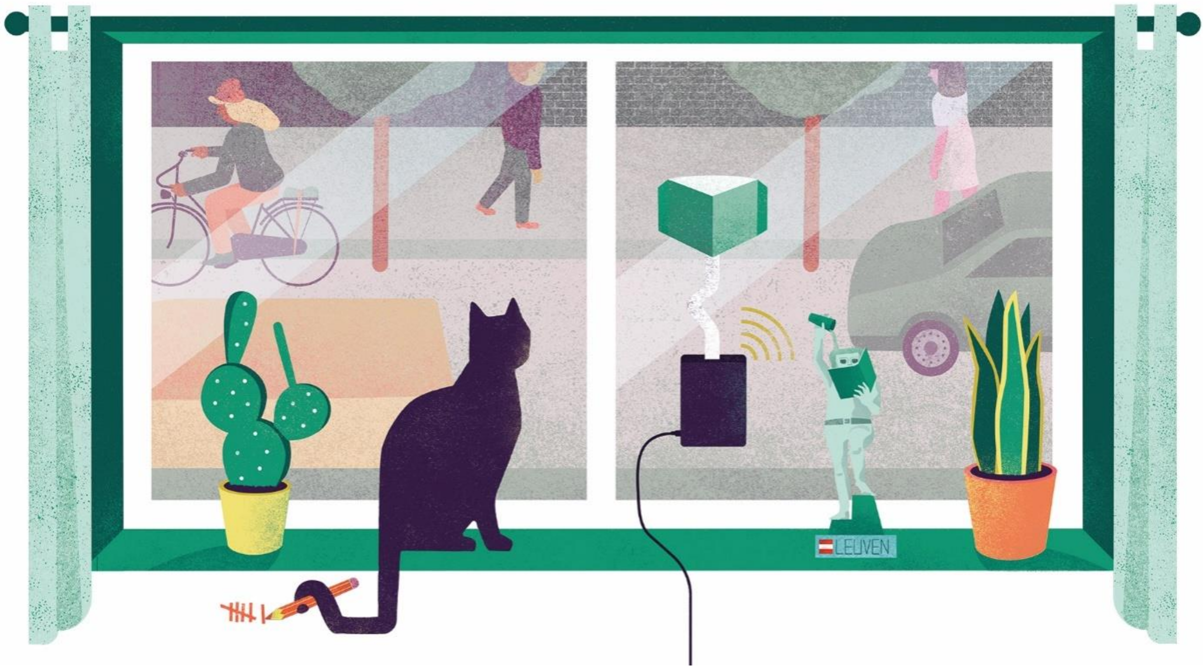

The WeCount Project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 872743

Document Details

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Creation Date	June 2021
Date of Last Revision	September 2021
Description	D4.3 Final Summative Project: Report: summarizing overarching conclusions of the citizen science activities, guidelines building, installation and data analysis

Version History

Version	Updated By	Date	Changes / Comments
1.0	Anja Bagon	23/07/21	Outline
1.1	Lucija Ažman Momirski	20/08/21	Added content for Ljubljana
2.0	Kris Vanherle, Giovanni Maccani, Enda Hayes, Anna Molter	10/09/2021	Added partner contributions
2.1	Lucija Ažman Momirski, Tomaž Berčič, Jon Šinkovec, Anja Bagon	21/09/2021	Draft version
3.0	Lucija Ažman Momirski	30/09/2021	Completed

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1 Introduction

WeCount, Citizens Observing Urban Transport, is a Horizon 2020 funded project that is part of a Science with and for Society (SwafS) call (H2020-SwafS-2018-2020). WeCount is a Citizen Science project working in five cities in Europe to empower citizens to take a leading role in producing data, evidence, and knowledge around mobility in their own neighborhoods and at the street level. The project applies participatory Citizen Science methods to collaboratively develop and deploy innovative, low-cost, automated traffic counting sensors (e.g., Telraam) and multi-stakeholder engagement mechanisms in five case studies in Leuven (BE), Madrid and Barcelona (ES), Cardiff (UK), Dublin (IE) and Ljubljana (SI). The five cases followed a similar execution path, with Leuven & Madrid (and Barcelona) leading off and serving as a test case for the remaining three cases. Following this approach, WeCount aims to quantify local road traffic (cars, trucks, active modes, and speed), produce scientific knowledge in the field of mobility and pollution, and co-design informed solutions to address a variety of road transport challenges. In addition, the project provides cost-effective data for local authorities on a much larger temporal and spatial scale than would be possible with traditional traffic counts, opening new opportunities for transportation policy and research.

This deliverable represents the third version of the document reporting activities conducted as part of WeCount's Work Package 4 (WP4): Use Cases: 5 Citizen Science Activities. This WP is the central component of the WeCount project. The main goal of the WP is to implement citizen science activities (WP2) and sensor arrays (WP3) across five case studies and explore how they can contribute to solving a variety of societal problems related to transportation that are important to citizens. This WP builds on previous Citizen Science activities (e.g., the Telraam pilot in Leuven) and scales to other cases in terms of scope (e.g., linking with other low-cost sensors from iSCAPE), size (more sensors per case), and geographic location (five cities in Europe).

The deliverable brings the summative case study report for all five case studies, Leuven, Madrid/Barcelona, Cardiff, Dublin and Ljubljana and summarizes the actions related to guidelines building, installation analysis, data analysis and participatory data analysis by citizens.

Guidelines building: The goal of all use cases in this project is to bring about real policy change as a direct result of Citizen Science activities. It is not enough to simply collect data and expect policy makers to solve the problems that citizens raise through Citizen Science activities. Specific guidance and relentless efforts are needed to ensure that policy impact is accomplished. Partners explored with citizens what information from the data should be relevant/priority/sensitive for policy makers. This activity is a mix of educating and empowering participating citizens in terms of what is likely to trigger a policy response. One of the possible end results is regularly organised consultative groups consisting of both citizens and local authorities to shape policy. Such a consultation platform ensures that it raises citizens' concerns and creates policy that is supported from the bottom up.

Installation analysis: The project teams worked with the participants to learn the pros and cons of the Telraam sensor installation process. This involves mutual learning both on the part of the citizens, what can be learned from the installation process, and for the project teams to better understand what kind of installation process is relevant and adapted for the citizens. This activity consists of a mix of techniques to engage participants (surveys, workshops, guides, videos, etc.).

Data analysis and awareness paragraph focuses on extracting useful information from the data, beyond the simple dashboard in the platform to understand potential data-anomalies and to improve understanding for better data interpretation. This subtask is primarily desk research work for the project team data specialist on data processing and interpretation, though we do intend to work with participants on the raw data directly as well.

Participatory data analysis by citizens: The main objective is to involve pilot case participants and data specialists outside the project in working with the data and conducting analyses they find interesting. This subtask uses a variety of tools to achieve this goal. These can vary in ambition depending on the group of participants (e.g. schools); inventorying potential data analyses and publishing them on the data platform using the API; publishing 'data stories' with links to the original dataset on which the data stories are built, with the aim of inviting participants and external specialists to work with the data themselves. The activities vary depending on the age of the participants.

2 Guidelines building

2.1 Leuven

Based on the contacts that we had with counters in Leuven and surroundings, the questions we have received, we learned there was a need for more support to do more with the Telraam data: more analysis, more context, more action. To finetune these questions and needs we set up a first TelraamLab with several counters. We get to know them better, their motivation to start with Telraam, and their needs for more support. Also based on this first TelraamLab, we defined 5 personas, to group the different needs.

A persona is a description of a fictitious user of your product, tool, or the like. Personas are used for design processes to develop products and tools that meets the users' needs and goals. The choice for using Personas in the tool design process is based, among other things, on the research paper of the pilot study "Real or Imaginary: The effectiveness of using personas in product design", Frank Long: 'This pilot study produced objective evidence to support the key claims made by Cooper, Pruitt et al. for using personas in the product design process. Personas strengthen the focus on the end user, their tasks, goals and motivation. Personas make the needs of the end-user more explicit and thereby can direct decision-making within design teams more towards those needs' . Since its inception in the 1990s, the persona-method has evolved from a method for developing IT systems to its use in many other contexts, including product development, marketing, communication planning and service design .

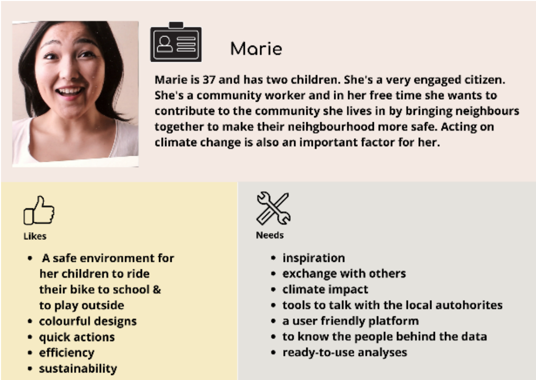

Figure 1: Personas.

Using these personas, we set up 2 more TelraamLabs (workshops). Based on the first session, we found out that there was a need for a community platform, to network, to learn, and to inspire each other. We asked in the second TelraamLab to create a box, which represents the Telraam Community Platform. The participants worked with cardboard boxes and craft materials to make clear what should be in a Telraam community platform. These boxes we used then as a basis to come to several building blocks for a Community Platform.

During the 3rd and final TelraamLab, we developed and discussed the building blocks of this Telraam Community Platform more in depth, so we had a clear view of goals and content of every building block.

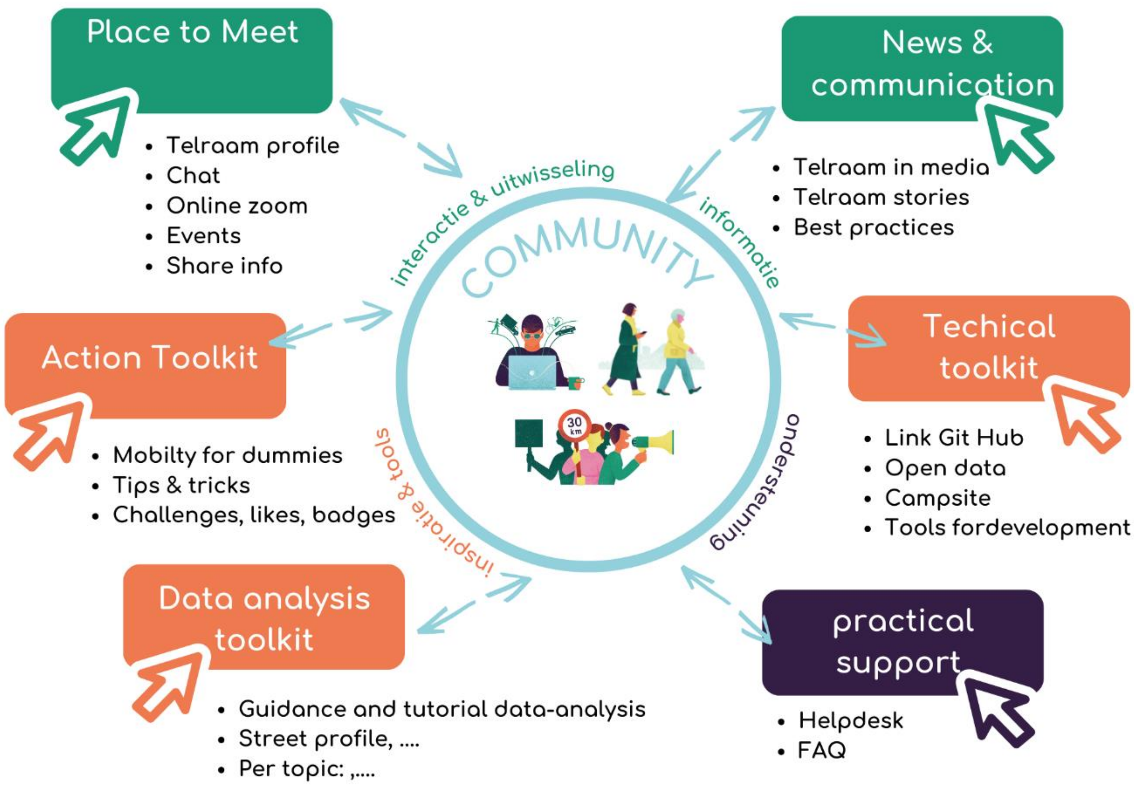

Figure 2: Building blocks.

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2.2 Madrid

Consistent with the citizen science nature of this project, traffic related issues have been explored, investigated and outlined starting from how local residents perceive and experience them. This process consisted of multiple interactions over time between the project team and situated communities of citizens across Barcelona and Madrid. During this period, relevant actors across the quadruple helix were gradually emerging and were subsequently targeted and engaged. This process allowed further narrowing down the matter of concern (traffic) across six axes: safety, speed compliance, air quality, noise pollution, livability of the area, and other traffic-related policies.

In summary, at the end of these first participatory problem formulation and co-design phases, the most important outcomes with respect to scoping the case studies in Barcelona and Madrid were:

- The WeCount local narrative has been articulated further for both cities and specific narratives were co-developed with the different participants. This enabled pursuing the so-called train-the-trainer approach whereby citizens are empowered to contribute to their own agenda and address the specific mobility concern that affect them as well as the relevant policies for these concerns.
- Traffic-related matters of concern experienced and perceived by local citizens have been explored, identified, and mapped across the city's districts, time of the day, and month in the year.
- Participants have gained awareness about citizen science, key issues, topics, and current trends related to urban (sustainable) mobility, and technical knowledge about Internet of Things paradigm, low-cost environmental sensors, image processing techniques, data visualization, and more generally about low-cost computing hardware (Raspberry Pi) and data processing complying with the sometimes complex legal, regulatory, and ethical landscape.
- The various communities of participants were aware of expectations and commitments required for the successful implementation of the case study.
- Establishment of air pollution as the main traffic and mobility-related issue to be investigated and tackled during the case study, according with participants' inputs.

With respect to the latter, i.e. in order to complement traffic and air quality measuring, we incorporated within the initiative Vigilante del Aire[1], promoted by *Ibercivis* Foundation, the Spanish ministry of Science and Innovation, and the *Instituto Pirenaico de Ecologia*.Overall, the action consisted of distributing 1,000 strawberry plants that participants had to place on their balconies or windows for approximately 3.5 months (i.e. from the beginning of October until mid-December). During this period, contaminating particles deposited on the plant's leaves. At the end, participants needed to cut three leaves from their plant and send them to the lab that is currently conducting the bio-magnetic measurements. Results are available at: https://vigilantesdelaire.ibercivis.es/informe-cientifico-vigilantes-del-aire-2021/.

Overall, the Madrid and Barcelona WeCount network counts:

- 735 members.
- 90 users, i.e. members that host the Telraam sensor.
- Approximately 1,000 people that host the air quality biosensor[2].

[1] https://vigilantesdelaire.ibercivis.es/

[2] it is noted that approximately 75% of people hosting a Telraam sensor also host the biosensor.

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2.3 Cardiff

Telraam sensors were used by Cardiff citizens with an interest in a wide variety of transport related issues including concerns about public transport, active travel, congestion and air pollution, road safety and the general liveability of their local area. In most cases these concerns were largely anecdotal, as they did not have quantitative data to support their arguments and activities. WeCount Cardiff provided the mechanisms to close these data and knowledge gaps. In total, we identified and contacted >100 organizations, networks, individuals and public sector bodies across the Cardiff area. Several other organisations contacted us after learning about the project through social media, national news or personal contacts, allowing us to reach local communities in various areas around the city and wider region. The WeCount Cardiff stakeholders can be broadly grouped into two categories: Community Groups & Civic Society and Public Sector Organisations.

Citizens were provided with Telraam sensors and generated data across a variety of sampling intervals, some sensors have been operating for 11 months whilst others were in use for up to a month at a time. Different citizens have different data needs and participatory tolerances, but all data generated allows others to understand traffic in their neighbourhood and help inform their own policy perspectives. We encouraged the citizens to think about their engagement on three scales:

1. "My Sensor, My Street" – at this scale the data is of interest to the participant and their neighbours. It allows the citizen to explore geographically specific issues that they might have and to take the lead in evaluating and communicating these issues supported by the WeCount data. Localised issues might include air pollution, noise, road safety etc

2. "My Sensor, My Community" – at this scale the individual is part of a wider network of data generators and community activists. Led by the community champions or community networks, the density of sensors allows the individuals to come together as a group to explore wider geographical issues e.g. rat running, time specific or origin-destination specific traffic volumes etc.

3. "My Sensor, My City" – at this scale, data users such as local authorities, consultants, academics and NGOs, can use the data to evaluate city wide challenges e.g. air pollution, speed compliance etc.

The WeCount Cardiff team took the role as enablers rather than leading analysts/advocates, to empower and facilitate the citizen led policy contributions. Two data workshops were held across Cardiff, bringing citizens from Roath, Grangetown, Canton and Riverside together to interrogate and analyse the data. Before these workshops, Community Champions were encouraged and coached to develop their own data stories using Telraam data, providing valuable case studies highlighting local issues. These workshops and data allow citizens to explore and critique data in an open and transparent way, whilst at the same time understanding the strengths, weaknesses and limitations that accompany such data analysis.

2.4 Dublin

There are several ongoing infrastructure developments in Dublin that created interest in the WeCount project. BusConnects is the National Transport Authority's programme to improve bus services in Irish cities, and it is currently re-designing the Dublin area bus network. Proposed plans for the Dublin area bus network were published in September 2020 and raised concerns in several neighbourhoods. For example, citizens living in the Phibsborough and Crumlin areas joined the WeCount project, because they were concerned about the BusConnects plans and wanted to collect traffic data to support their objections to the National Transport Authority.

Another ongoing infrastructure development is the Strand Road cycleway. This is the northern extension of the coastal mobility route, which is a newly built segregated cycle lane along the Dun Laoghaire coast. The coastal mobility route was implemented in 2020 and has received positive feedback from both local residents and local businesses. However, the Strand Road extension has been much more controversial, as it will involve the closure of a major car route into the city centre. Residents of the Sandymount area joined the WeCount project to collect baseline data on traffic patterns around Strand Road, and to monitor any changes if the cycleway is implemented.

Dublin City Council are currently implementing a policy that will reduce the speed limit on most roads to 30km/h. Other European cities (e.g. London, Edinburgh, Paris, Brussels), who have introduced widespread 30km/h speed limits, have seen a significant reduction in road traffic accidents and fatalities. The new policy has received strong public support during a recent consultation; however, it is currently unclear whether drivers are following the new speed limits. Several citizens joined the WeCount project to monitor car speeds, particularly in smaller streets, which are rarely monitored by law enforcement.

Several neighbourhood groups, e.g. Castleknock, Phibsborough, joined the WeCount project as they felt that their local area was dominated by through traffic from people commuting into Dublin. The through traffic resulted in a loss of local community and the high number of cars and trucks discouraged active travel, such as walking and cycling. Similarly, some neighbourhood groups, e.g. Ashtown, Mount Merrion, were concerned about traffic associated with ongoing construction. This included concerns about increased truck traffic due to the construction, as well as concerns about the road capacity after new buildings have been completed.

In addition, several districts of the SmartDublin initiative, e.g. smart Balbriggan, Smart Sandyford, were interested and got involved in the WeCount project. Smart Dublin is an initiative to bring together technology providers, academia and citizens to transform public services and enhance quality of life. Smart Dublin was founded by the four Dublin Local Authorities, and its goal is to future-proof the Dublin region by trailing and scaling innovative solutions to a wide range of local challenges.

Finally, Dublin City Council's school zone project provided an opportunity to monitor traffic and air pollution near schools. The school zone project aims to introduce traffic calming measures around schools, to encourage active travel to school and to reduce idling outside schools. To monitor the effectiveness of these measures schools in Dublin got involved in the WeCount project and offered to host traffic sensors and simultaneously air pollution sensors.

2.5 Ljubljana

The Municipality of Ljubljana was particularly interested in counting electric scooters, as they are increasing rapidly in Ljubljana, and which often pose a danger to pedestrians and the drivers of electric scooters themselves due to the lack of regulations in this area. Also, the Slovenian government is currently preparing an amendment to the Transport Act that will also consider the increasing use of electric scooters in transport. The Municipality of Ljubljana has set up counters at certain points in the city to measure the number of cars, trucks, and cyclists. These are mostly located in the busiest areas of the city. However, the city does not have counters for pedestrians and electric scooters. Therefore, it was/is interested in a Telraam device to count these two road users and get data from the Telraam sensors, hoping to provide detailed statistics on electric scooters (it turned out that the sensor does not have this capability). Eight Telraam devices were installed at the windows of their buildings, which also enabled measuring locations not covered by other measuring devices. Specific guidelines and proposals were developed for the municipality to consider cycling policies for specific neighbourhoods.

The traffic counting network in Novo mesto was set up on the initiative of the local champion Luka Mali. The case study also involved technology enthusiasts from the Novo mesto region, who installed their own devices. The aim was to install the devices on municipal buildings, renovate the devices for connection to the LoRaWAN network and cooperate with the municipality on real traffic policy change.

The municipality of Domžale (Department of Spatial Planning) showed great interest in receiving data from the sensors, as they have traffic problems to solve. However, due to technical problems (the Telraam device cannot be installed outdoors, problems with WiFi connectivity), their interest was dampened. With the upgrade of the sensors, Domžale is a potential location that could allow for continuous involvement of local authorities in the whole process of cooperation, preparing the municipality to meet citizens' expectations and preparing citizens for a constructive dialogue with policy makers.

The LoReWan network for the municipality of Nova Gorica, elected European Capital of Culture 2025, is promoted by two institutions: The Community Things Network Nova Gorica and the Xiris Institute. Both institutions have made it their mission to provide the entire city of Nova Gorica with data connectivity for the Internet of Things by building the network through crowdsourcing from citizens and local businesses. A range of services will be offered to facilitate entry into the IoT world, collecting data from a few thousand sensors in large areas. In cooperation with the two institutions, the aim is to install as many Telraam sensors as possible in Nova Gorica in order to provide the Nova Gorica municipality with the most complete data possible to change transport policy.

At the end of November 2020, we were contacted by a concerned citizen from Spodnji Stari grad in the municipality of Krško. He learned about the WeCount project through an acquaintance who is involved in the project in the Novo mesto region. He expressed his wish to cooperate with us, but since there is no WeCount network in the Krško region, we did not confirm the cooperation at first. After he described to us all the problems that the residents of the settlement Sp. Stari grad have and the many appeals to the authorities to regulate the situation he has convinced us and we agreed to their participation in the study.

The through traffic in their settlement is extremely disturbing. Employees of the surrounding businesses use the road through the settlement as a shortcut. According to their observations, there is a traffic violation every 30 seconds, and even every 2 seconds during rush hour. The highest traffic congestion occurs during rush hours between 6:00 - 7:15 and 13:45 - 15:15. This is the road section with the highest number of violations per time unit in the municipality of Krško. With the opening of the nearby bridge, the traffic volume has increased even more.

Measures have already been taken in the settlement before WeCount to limit transit traffic, such as:

- Installation of traffic signs prohibiting transit through the settlement for all vehicles except for residents.
- Traffic controls by the police and the inter-municipal police service.

All measures worked only for a short time, after which the situation worsened. There is more through traffic through the settlement than ever before, the speed limits are not respected, so the situation has become alarming.

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After confirming a suitable view, the citizen obtained a Telraam device and installed it on one of the residential houses in the centre of the settlement. The obtained data were the basis for numerous requests for the settlement of traffic issues addressed to the Municipality and the Mayor of Krško, the Krško Police Station and the Krško Intermunicipal Inspectorate.

The following data has been highlighted:

- Up to 1000 vehicles pass through a settlement with 243 inhabitants during the day, which means an average of 1 vehicle per minute,
- The fact that between 200 and 300 trucks or delivery vans pass through the settlement per day is striking, which represents a complete transit traffic that is prohibited in Spodnji Stari grad. Transit traffic is also intense when the working population is at work.
- The data collected show that 30% of drivers exceed the maximum speed limit (40 km/h), which is also above 70 km/h.

Recently we received a feedback from Krško: Despite all evidence and indications of an untenable situation, the current state of affairs has not changed significantly, the Krško police station has only increased the controls, which according to the citizens is still insufficient. Mr Lapuh assured us that they will continue to monitor the traffic in the settlement of Spodnji Stari grad and will continue to put pressure on the decision makers. If there is interest in further installations of the Telraam device, we also promised them our help for the future.

For the impact story we recorded a promotional video with a presentation of three different counters stories.

Figure 3: YouTube WeCount Ljubljana impact story screenshot.

3 Installation analysis

3.1 Leuven

The sensor installation process in Leuven has been described in length in D4.1. Due to technical and non-technical challenges (i.e. Covid-19), the installation of the sensor by citizens has been a continuous focus point in the Leuven pilot case.

As Leuven was one of the 2 pilots to start sensor deployment, we can now, close to the end of the project, make an assessment of the retention of the installed sensor. Table below summarizes the amount of users (i.e. participants that have a sensor) in the last half year, at the end of the main deployment phase.

	mar '21	Jun '21	sep '21
TOTAL users	**249**	**297**	**316**
UP	*88*	*119*	*114*
UP & DOWN	*36*	*23*	*19*
DOWN	*61*	*71*	*86*
not started install	*37*	*57*	*68*
install not complete	*27*	*27*	*29*
share non-install	26%	28%	31%
share active of installed	67%	67%	61%
share up & down of installed	19%	11%	9%

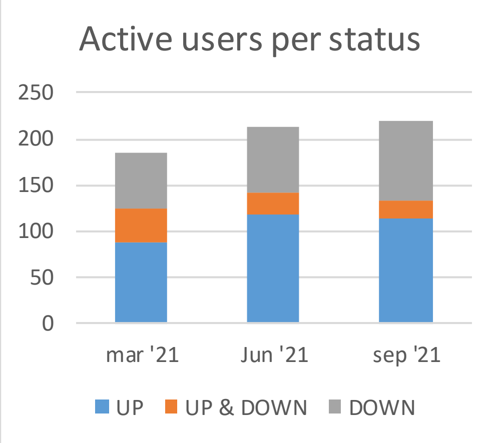

Table 1: Analysis of Telraam-users in Leuven.

Even though the bulk of the sensor deployment was completed in early '21, more users have joined the pilot later on and either procured their own hardware or took over the sensor from other users. The final Heverlee network (26 users) was added in March '21.

As of September '21, a total of 219 Telraam sensors have at some point collected data in Leuven: 114 are still active, 19 are intermittently active and 86 are not collecting data at this point. A total of 97 users has never collected data. This includes a mix of users that did not receive a sensor but registered as a Telraam user (e.g. to acquire access to the API) and participants that were not successful in installing the sensor. Sensor hardware has in most cases been recollected and distributed to other participants.

During the period March-June, in WP3 the focus was on improving the software reliability. This is visible also in the sensor retention and the share of sensors that only intermittently were active ("up & down"), dropping from 19% to just 9%. A significant improvement, but the issues has not fully been resolved.

If users were able to install, most have remained active, even as the pilot case was fully completed in June '21 as the (local) pilot was finalized with the data workshop. There have been subsequent activities still that keep engagement of the participants and we are continuing to supply technical support for participants that stay active. Retention is consistent at about 2/3 of the participants, bearing in mind that some new users are in fact taking over the sensor equipment from existing users that quit the project for a variety of reason (e.g. moving, house renovation, etc.) and non-active users have not all registered an account to have a sensor.

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3.2 Madrid

In total, 90 participants across Madrid and Barcelona have received the sensor and registered as Users on the Telraam platform. Of these, 69 could successfully complete the installation process and had their sensors active for a certain period. To support this process, the team in IFC has produced two key resources: (1) a printed step-by-step installation guide that participants received, together with the sensor; in particular, we developed two versions of this (i.e., one per each version of the software). The guide consists of a 12 pages booklet comprising detailed descriptions supported by images about the actual installation process. The process has been broken down into 16 basic, elementary, steps; (2) An 8-minutes long spoken video (in Spanish) with a clear visual explanation of the overall process[3], especially for older adults and for those with limited digital skills. This process across Barcelona and Madrid highlighted several lessons learned with respect to the installation and user experience perspective, which, consistent with the exploratory nature of the case study (i.e., it was implemented in the first phase together with the one in Leuven), informed the remaining case studies:

- Often the Telraam sensors fall from the windows, especially if they are facing south. To address this issue, the participants that followed received two extra double-sided tapes.
- Placing the sensor in the upper side of the window (e.g. to overcome obstacles such as a balcony or an air conditioning external unit) has been problematic. The suggestion was made for longer power cables needed to avoid using impractical extensions.
- The camera keeps moving, and this has been observed as particularly critical when windows have curtains. TML has addressed this issue for future participants by adding a new feature on the platform where they can check the positioning of their cameras daily.
- The sensor doesn't work when wi-fi networks are encrypted or need additional access credentials. This inhibits schools, other public or private institutions, and those relying on public wi-fi to host a sensor.
- Some participants manifested the perception that their wi-fi speed has been significantly lower since they installed the sensor (due to COVID, most participants were working from home).
- Participants manifested the interest in also distinguishing between bicycles, scooters, and motorbikes. Participants were interested also in electric scooters, which in their opinion, are causing several safety-related issues in the city following their rapid diffusion in Spain.
- Conducting an online workshop to install the sensor with participants has been found impractical. However, the resources provided, specifically the step-by-step printed installation guide, were found to be useful and enough for most participants to be able to install the sensor independently.
- Connected to the previous point, we observed that some participants experienced issues in installing their sensors. These were mainly older adults (one person required a visit at his home for installing the sensor) and those that do not speak or understand English (at this stage, most steps in the registration process and during the installation were either in Dutch or in English). Therefore, we developed a longer, spoken, step-by-step installation video tutorial in Spanish to assist these participants.
- Providing more informal channels of communication between participants and with the WeCount team has proven to be overwhelming for both parties. Therefore, we decided not to use social networks for this, grounded and detailed, continuous engagement.

In addition, lessons learned are proposed from this stage taking a wider, engagement related perspective. These are summarised below:

- In Spain, engagement by theme (e.g., mobility and noise, mobility and air quality, mobility and speed compliance, mobility, and road safety etc.) was found to be more effective than engaging people by

[3] https://www.youtube.com/watch?v=l8XKh6BcJF8&t=2s

neighbourhood or geographical area. Different community champions perceive different mobility-related issues, and some existing communities are already active in specific domains (e.g. air quality, working with schools and interested in road safety around it).

- "One strategy fits all" is not likely to be suitable. This was particularly relevant with respect to timing. For example, some participants work with schools, and manifested interest to start the measurements in the area from September / October 2020.
- Given some data quality issues, we learned that it is of paramount importance to manage expectations of participating citizens. We advocate for a considerable amount of time to be spent with them as the more people understand the technology (e.g., that is low cost, under development etc.), the more they appreciate the value of being engaged in its experimentation.
- While some communication and engagement effort were dedicated at this stage to include participants from low socio-economic backgrounds, we observed that most of them could not participate because of different reasons such as: do not own a smartphone and a laptop; use their mobile connection as their "home internet"; often live on ground floors or in very tall buildings.

3.3 Cardiff

Cardiff case study citizens were provided with Telraam sensors following web-form sign-up. Citizens were tasked with assembling and registering their own sensors after face-to-face delivery. Instructions were provided verbally on delivery and citizens given the opportunity to ask questions, raise concerns, elaborate on their motivations etc. This face-to-face engagement with the WeCount Cardiff Project team was considered very helpful as it created a meaningful connection between the citizens and the project. Additionally, detailed Assembly, Registration and Installation instructions were provided with the Telraam sensor and through online FAQs and helpdesk support.

Despite detailed instructions many participants encountered difficulties when assembling and installing the sensor. Step 16 in the installation guide showed instructions on where to find further help, and on how to contact the Telraam helpdesk (https://telraam.zendesk.com/hc/en-us). Some participants followed these instructions, while others contacted us directly via email when encountering problems. Below is a list difficulties reported to us. Participants did not encounter all these problems during a single installation, but different participants may encounter one or more of these problems. The most common problems encountered were 'no image showing' and the 'Telraam sensor stopping counting'.

Issue	Description	Solution
Camera Cable not working	the set-up pages do not show an image just a white square where the image should be.	Provided the participant with a longer camera cable
Need to update the SD Card	SD Card needs updating but no port to update it on a Mac	Participant exchanged sensor for one with an up to date SD card
Sensor stops counting	Provided guidance via FAQs	On occasion this works, on other occasions a replacement sensor was provided. Telraam system administrator provided support
Picture not showing/No image available	Image is not showing on their mobile phone during installation	Provided links to the FAQ
Telraam not counting HGVs	The Telraam data wasn't accounting for	Explained to the participant that

Issue	Description	Solution
	HGVs	Telraam requires several weeks of calibration before HGV measurement occurs
Sensor not visible on the dashboard	The participant couldn't identify if their sensor was visible on the dashboard, but wasn't working	An offer was made to attend a live workshop to discuss the issues with Telraam system administrators and a new sensor was also provided
camera displaying as viewing wrong side of road	The road segment was incorrect and was on the wrong side of the road	An update was made by Telraam system administrators that allowed for a segment switch and subsequent data migration
Challenge finding the wifi	Participant could not find the wifi	Provided a link to the appropriate FAQ.
Sensor does not send data	The sensor stopped sending data	Participant restarted the device a few times and the problem resolved itself

Table 2: Lists common issues reported by participants.

In a small number of cases we were not able to resolve the challenges faced by participants through the FAQs or through support provided by the Telraam system administrators. In these instances, participants exchanged their sensor, or specific components, for a working device. The two most common challenges faced by participants was that the street image was not showing or visible during installation and that the Telraam stopped counting. For the former of the two challenges, there is likely to be two sources of the problem, a language bug which prevents completion of the installation process, or an issue with the flashing of the SD Card. In addition to support via e-mail, a technical support session was offered to participants via video call. This session was organised and hosted by Telraam and participants could directly explore their challenges with the technical support staff. All participants who attended these sessions were either able to resolve their issue or were provided with a replacement sensor. Despite these challenges, many participants were able to assemble their sensors and generate valuable data without support from the WeCount Cardiff Team or from the helpdesk itself. Reducing the number of challenges noted above will provide a more accessible and user tool for citizens in any further deployment opportunities.

3.4 Dublin

Participants in the Dublin Case study encountered a number of problems during the set up of the traffic counters. They reported these problems via the Telraam helpdesk, by emailing the Dublin Case study email address (wecount@ucd.ie) or by emailing a member of the study team directly. In addition to problems during the set up, participants also contacted us when they thought that the counter was not working correctly, e.g. when the counter was not showing counts night. The table below summarises the main issues reported.

Issue	Description	Proposed solution
No feedback during installation	Users did not know if the sensor has connected to the Telraam server at the end of the installation.	Ideally, there should be a message on the app, once the connection has been established. Alternatively, the server could send an automated email to the user triggered by the handshake with the sensor.

Telraam WiFi does not appear on phone	When the sensor is plugged in 'Telraam' does not appear in the WiFi list.	Troubleshooting flow chart or checklist
Sensors stop counting when it gets dark	Users were worried because the sensor stopped counting after 18:00 and before 8:00.	More information on website
Sensors are not counting heavy vehicles	Users are worried because the sensor counts 0 heavy vehicles.	More information on website
Sensor counts seem wrong	User does not think the counts made by the sensor are accurate, e.g. too many bikes, not enough cars.	More information on website
Wrong MAC address was entered	Network administrator noticed that the first part of the MAC address did not identify as a Raspberry Pi device.	This could be checked when the user enters the MAC address and a warning could be displayed.
Sensor stops counting and set up needs to repeated	The sensor stops counting and the user needs to set it up again via their phone. This happens multiple times	More information on website about faulty power supplies.
Sensor does not send data	After multiple checks and tests, the sensor still does not send data	Unknown
Sensor not counting anymore	The sensor stops counting.	Unknown
Map screen freezes when selecting segments	User cannot zoom and/or select segment.	Unknown
No software on SD card	User could not see Telraam WiFi, but was familiar with Raspberry Pi and therefore noticed that the SD card was blank.	Troubleshooting flow chart

Table 3: Summary of the main issues reported.

During the WeCount project we developed a number of materials for future installations:

- Step-by-step guide for installation in Dublin, which based on the guide developed by the Barcelona/Madrid case study;
- Trouble-shooting steps for participants who experienced problems during installation, in particular guidance on how to check which devices are connected to the router;
- Materials and presentations for online workshops.

In addition to developing materials ourselves, we also received helpful feedback from participants. This included feedback from an IT specialist with in depth knowledge of Raspberry Pi devices.

3.5 Ljubljana

In the Ljubljana case study, we encountered various problems during the installation process of the device, which are described in more detail in report D4.2. We must point out that most of the sensors were installed without any problems, and if they appeared, we solved them together with the participants either via e-mail, telephone conversations or face to face. The most common problems that plagued the study participants are described below.

Technical and User Experience related issues

- Telraam sensors often fall off windows, especially when placed on the window facing south. To remedy this problem, participants were subsequently given two additional double-sided tapes.
- Placement of the sensor at the top of the window (e.g., to overcome obstacles such as a balcony or outdoor air conditioning unit) proved problematic. It was suggested to use longer power cables to avoid impractical extensions, but the problems with the power supply needed for the sensor to function properly occurred. The second problem encountered with the installation of the sensor is the mounting of the housing, as it cannot stand on the windowsill, but must be attached directly to the window glass with double-sided tape, which loosens over time. Another solution that has worked better is to use Velcro to attach the sensor housing.
- The camera housing is constantly moving, which has proven to be especially critical when the windows have curtains. It usually then falls off or changes the view, resulting in incorrect and erratic data. TML has solved this problem for future subscribers by adding a new feature to the platform that allows them to check the positioning of their cameras daily.
- The sensor does not work when Wi-Fi networks are encrypted or require additional credentials. This hinders schools, other public or private institutions, and those that rely on public Wi-Fi to host a sensor.
- It could take several weeks for the sensor to begin counting heavy vehicles.
- Participants expressed interest in also distinguishing between bicycles, scooters, and motorcycles.
- Engagement by topic and engagement by neighbourhood or geographic area were both equally unsuccessful.
- The installation process seemed simple for the most part for those with some English and technical knowledge. The steps requiring the sensor to be connected to the WLAN via the participants' smartphones were found to be difficult.

Based on installation analysis, the project team has left some useful content for future installations:

- Video content about the installation of the Telraam sensor and the registration process, available for everyone on YouTube. Three videos were published (5.5.2021).
- Analysis of recruitment strategies and methods.
- Instructions for conducting online workshops, including presentations.
- A complete guide to extending the case study to other districts and cities.

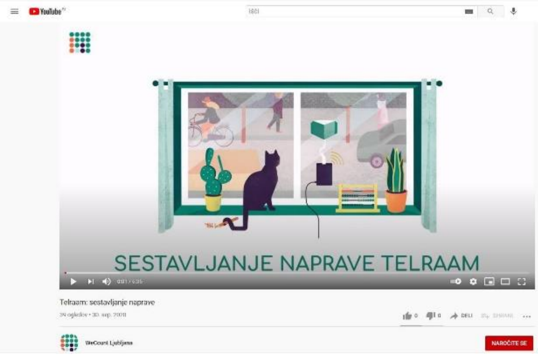

Figure 4: The YouTube account was created to share useful videos on assembling and setting up the Telraamdevice.

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4 Data analysis

4.1 Leuven

In terms of data-analysis, the scope of the Leuven case is to use Telraam-data for the assessment of the impact of interventions in the traffic circulation on traffic volumes. As discussed in D4.1, the assessment is heavily dependent on the timing of the interventions itself, organized by the city of Leuven.

Figure 5: Area of interest of the intervention in the Burchtstraat, Leuven and sites with available Telraam-data

Timing of these interventions was scheduled for early '21 but timing has slipped due to Covid-19. As such, only for a few examples a meaningful analysis was done, as demonstrated with the example of the Burchtstraat discussed in length in D4.1.

There is little further analysis to add, so we recap on the analysis approach from the Burchtstraat, as it will serve as a template for future analysis in Leuven.

Data with Telraam-sensors was collected several months before the intervention. The intervention itself is the installation of an automatic numberplate recognition (ANPR) camera, to verify only local residents are using the road.

As the impacted street is used extensively for cut-through traffic, there is a risk of displacing rat-running to adjacent streets, in particular Wilsele borough (North) and the city centre (South). The topic is of high concern with local citizens and citizen advocacy groups have raised their concerns. One of the cases investigated in the participatory data analysis (see further) was dealing with this case as well.

We found traffic volume post-intervention decreased a lot on the Burchtstraat, dropping from a daily total of 5000-6000 to about 2000 passenger cars. An increase in bike traffic was observed as well, which is likely linked to the improved weather in the 2nd part of February.

Similar analysis was done on adjacent streets, to verify if the traffic was indeed displaced to the main ring road (desirable outcome) or if it initiated rat running through the city centre and Wilsele borough ((undesirable outcome). We found minor increases in adjacent streets, concluding the intervention was successful.

The analysis was shared with the local authority and was used extensively in citizen information campaign to demonstrate the effectiveness of the intervention. The city authority has expressed it will continue to use Telraam data for the assessment of future interventions.

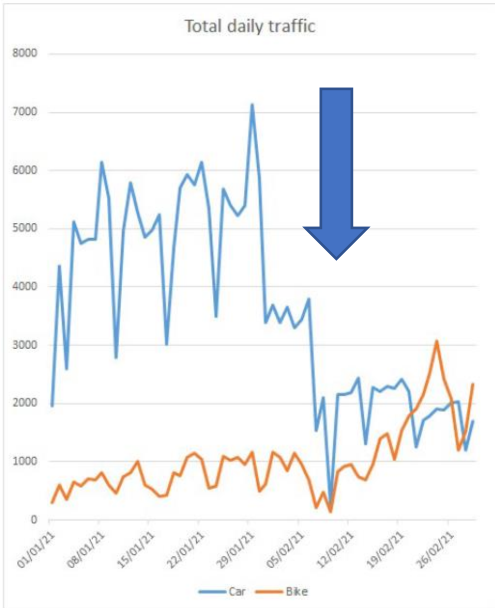

Figure 6: Trend of absolute daily traffic volumes for car (blue) and bikes (orange).

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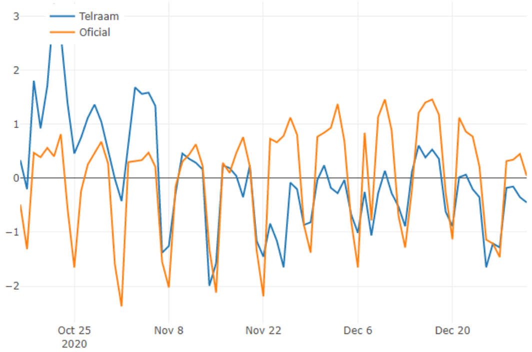
4.2 Madrid

According to the data generated by the system, of the 69 sensors installed, only 44 produced data of sufficient quality to be considered for the analysis step (i.e., 19 in Barcelona and 25 in Madrid). Of these 44 sensors, not all were always active. Rather, sensing activities were disrupted in some cases for various reasons. These included, for example, the sensor falling from the window, the sensor disconnecting from the wifi network, the camera module has moved and thus do not point at the street anymore, among other problems experienced.

In terms of actual analysis, the data processing and visualisations ingrained in the Telraam platform were used as the natural starting point. In addition, we performed and presented more sophisticated data analysis results obtained through: (1) downloading and analysing the Telraam data; (2) comparing and crossing Telraam data with official traffic and mobility data from Barcelona and Madrid (see left side of figure below); and (3) Crossing Telraam data with other open datasets with a specific focus on air pollution data to accommodate the focus of the case study as co-designed with participating citizens (see right side of figure below).



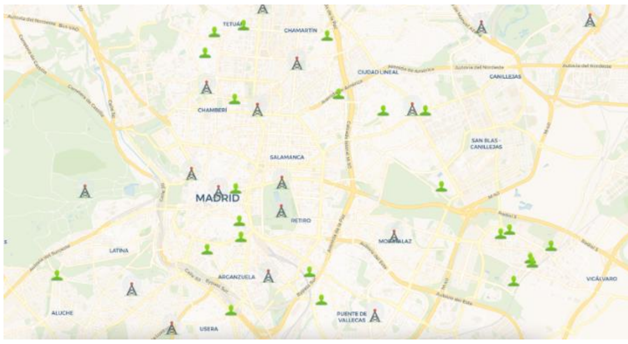


Table 4: Telraam and official traffic data.
Figure 7: Telraam and official air quality stations.

These results have been presented, discussed and interpreted together with participants in dedicated online workshops; to this end two data analysis and awareness online workshops were carried out, for Madrid and Barcelona respectively.

Overall results are published for both Madrid and Barcelona on the local WeCount website and will be actively disseminated for the remaining WeCount funded period and beyond.

Madrid analysis report: https://www.wecountmovilidad.eu/es/resultados-madrid
Barcelona analysis report: https://www.wecountmovilidad.eu/es/resultados-barcelona

In particular, in addition to the features and data visualised onto the platform, the analysis focused on[4]:

1. Descriptive analysis including sensed objects over time (number and type by month day and hour), boxplot diagram of daily objects and speed levels.
2. Comparison with official mobility data including correlation analysis and visualisation. The coefficient calculated for both cities were[5]:

[4] For full details see Deliverable 4.1

[5] It is reminded that the Pearson correlation coefficient ranges between -1 and 1, whereby -1 represents a situation of perfect anti-correlation, 1 of perfect correlation, and 0 of no association between the two variables.

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- Madrid's correlation coefficient: 0.45 (conf. interval 95% between 0.25 and 0.61; p value < 0.0001).
- Barcelona's correlation coefficient: 0.48 (conf. interval 95% between 0.28 and 0.63; p value < 0.0001).

  In both cases the correlation coefficients are similar and representative of a moderate correlation between the two variables, thus demonstrating the effectiveness of the Telraam sensors.

3. Telraam and air pollution data and related correlation analysis. Although approximate and affected by the low number of sensors as well as by the non-optimal positioning of the air quality monitoring stations (compared to the localization of participants), some interesting findings emerged. Overall, with this correlation model, results show that 42.6% and 49.8% of the variability of air pollution levels is linked with the traffic counting vehicles from the Telraam sensors in Madrid and Barcelona respectively.

4.3 Cardiff

Data generated through WeCount has provided a significant opportunity to explore local challenges in diverse settings across Cardiff. To date, 98 sensors have been deployed, generating over 300,000 hours of data. The first sensor, deployed in October, 2020 has collated over 8000 hours of data on its own.

These data have been collected across a range of road types, from the very quiet roads, e.g. Somerset Street, Grangetown (Figure xx) to those experiencing very high traffic volumes, e.g. Shirley Road, Roath (Figure xx).

Figure 8: Somerset Street, Grangetown (left), Shirley Road, Roath (right)

Whilst citizens right across Cardiff have participated in WeCount, four areas were evident in the distribution. These were Roath, Canton, Riverside and Grangetown, representing a broad range of socioeconomic and demographic landscapes in Cardiff. The WeCount Cardiff Project Team supported but allowed the citizen scientists to explore the data from their own concerns and motivations. Some examples of data analysis and interpretation from the citizens are provided here. Traffic flows on roads in Cardiff varied spatially and temporally during the study. For example. Somerset street, a narrow residentially street in the north of Grangetown, averaged ~100 vehicle movements a day, whilst streets such as Landsdowne Road and Shirley Street, both key arteries for traffic movements into the City, average between 6,000 and 11,000 movements a day.

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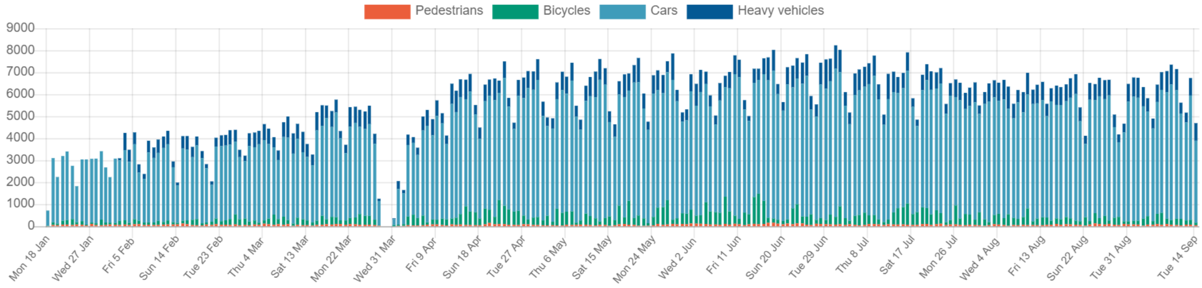

Table 5: Shirley Road Telraam traffic count (Traffic count, X axis, measurement date, Y axis).

Temporally, traffic volumes have changed significantly over time, particularly with the introduction of restrictions associated with pandemic lockdowns. In Wales, these persisted to varying degrees of restriction for the duration of the case study, with the more significant restrictions of this calendar year introduced at the beginning of 2021, with ongoing relaxation throughout. This is evident in the data from some of the busier streets in Cardiff, however the signal is either significantly weaker or not visible in quieter streets. This might imply that incremental traffic increases are associated with an increase in commuting along the main arteries into and out of the city. The relationship between lockdown restriction and traffic volume is shown in Table 6.

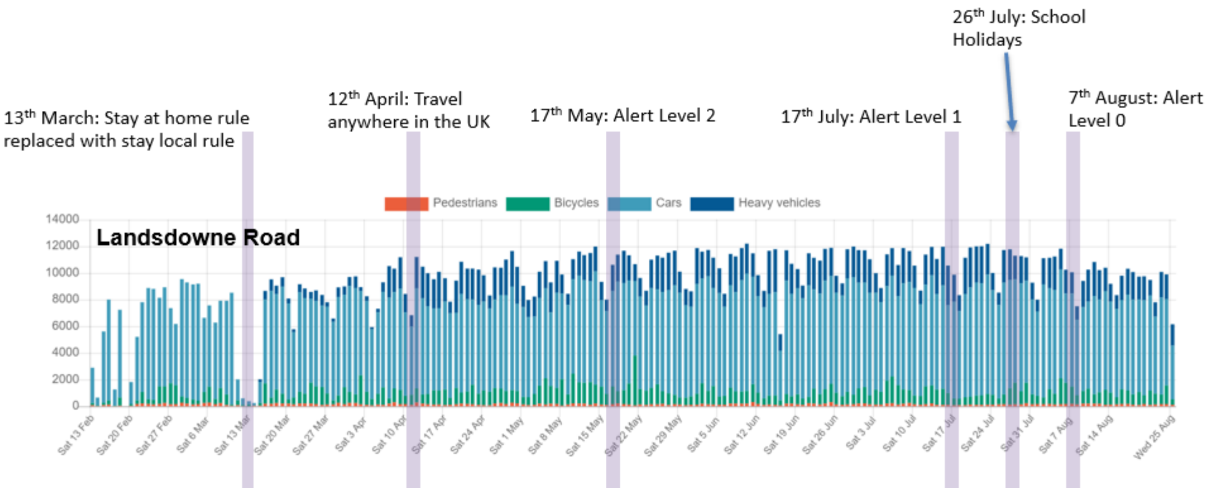

Table 6: Lockdown restrictions and their impact on traffic movements along Landsdowne Road, Canton.

In addition to the spatio-temporal data, traffic speeds are also powerful in demonstrating compliance or not with local speed limits. In addition to traffic counts the Telraam platform and API also provides hourly speed measurements in 10km/h intervals. One of the primary issues experienced in using Telraam in the UK is that our speed limits are mph not kmph which means the data has to be adjusted, or that speeds recorded in speed bands clearly in excess of the speed limit are considered. As shown in Table 7, below, designed by a WeCount Cardiff participant, traffic speeds on their street regularly exceeded the 20mph speed limit, using a conservative cut-off for the data.

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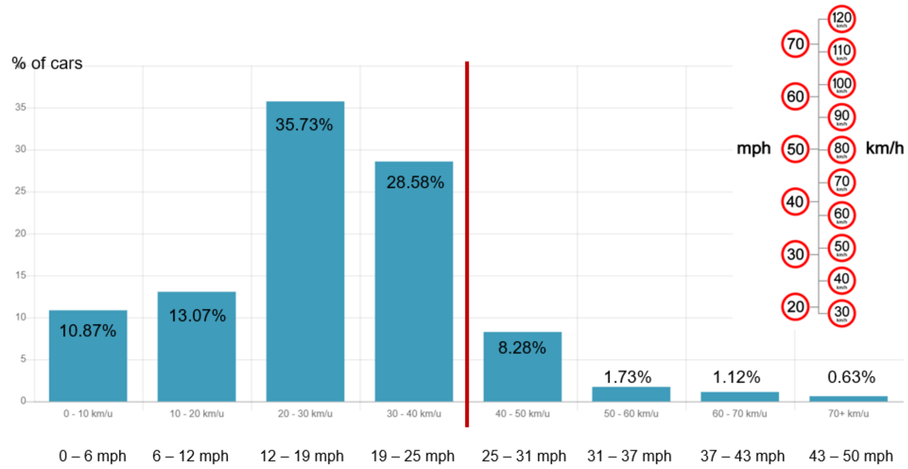

Table 7: Car Speeds on King's Road. Riverside.

In this instance, these data translate to, on average, 88 cars exceeding the speed limit on the road per day, 27 cars exceeding the speed limit by 10mph and five cars traveling at more than double the speed limit. These examples show the power of using Telraam at a local level, providing unprecedented access into high volumes of traffic data otherwise inaccessible without significant financial outlay, democratising access to community generated data. The data platforms are accessible and provide opportunities to explore aggregated data further, through associated API tools, facilitating complex analyses, whilst also providing high level, but valuable insight into specific segments at a resolution understandable by the lay person.

4.4 Dublin

The project team used the workbooks developed for the participatory data analysis (see 5.4) as a starting point. These workbooks contain the initial steps required for data analysis, such as downloading the data via the API, data cleaning, data aggregation, descriptive statistics. However, these workbooks are designed for analysing one street segment, therefore further work is required to extend them to multiple segments. As this data analysis is carried out at a larger scale additional considerations are required for the time period to be analysed. This will need to take into account the calibration periods of the traffic sensors and the various lockdowns in Dublin throughout the project. In addition, the larger scale analysis will need to take into consideration the spatial and temporal autocorrelation within the data, which may require specific methods for the analysis.

A preliminary descriptive analysis of speed limit exceedances on 75 street segments is shown in the Figures below.

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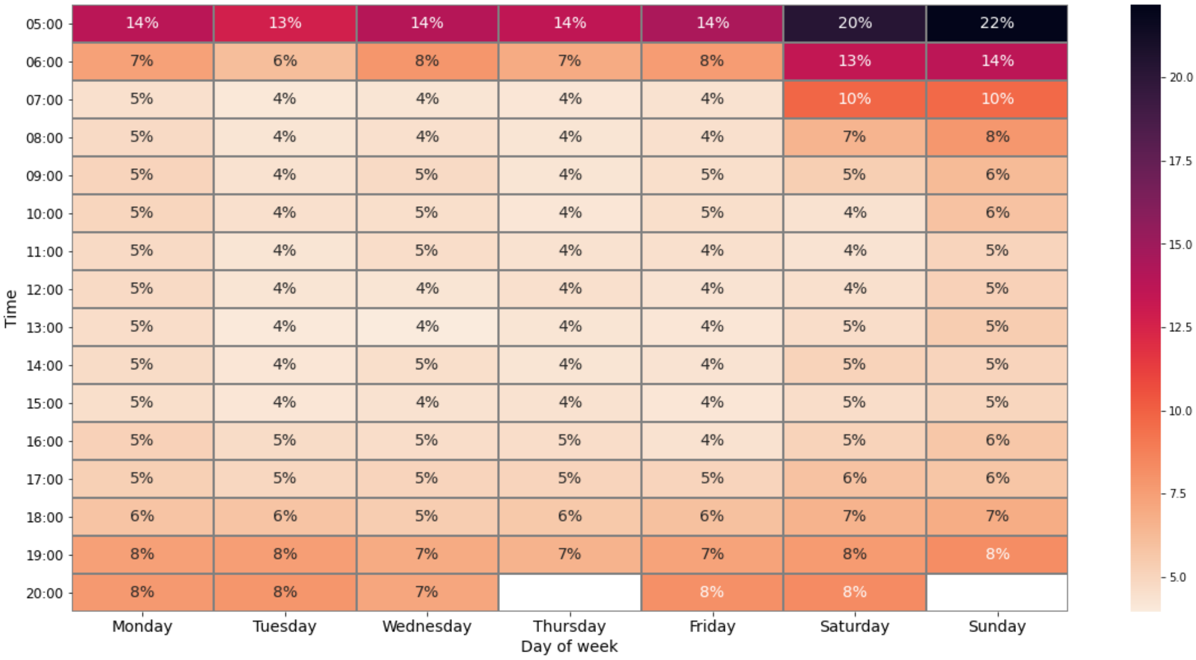

Table 8: Matrix plot showing the average percentage of cars exceeding 50km/h from 1st May 2021 to 1st August 2021 by time of day and weekday.

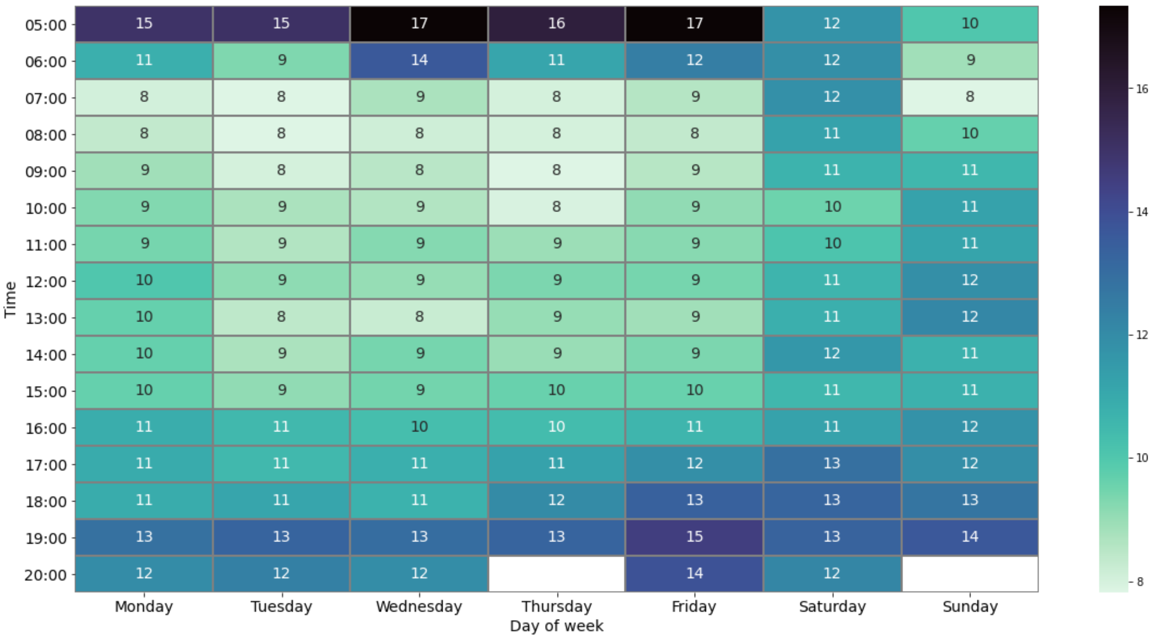

Table 9: Matrix plot showing the average number of cars exceeding 50km/h from 1st May 2021 to 1st August 2021 by time of day and weekday.

4.5 Ljubljana

The project team focused on data analysis (the process of categorising and summarising data) to get answers to exposed research questions (e.g. what is the average number of pedestrians, bicycles, cars and big vehicles in six months on a weekday). Data interpretation is the process of reviewing data to help assign meaning to data, reach relevant conclusions and help people understand numerical data that has been collected and analysed. Data collected in raw form can be difficult for lay people to understand, so analysts need to break down the information collected so that others can understand it. Graphical representation of information

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and data was done through visual elements such as charts, graphs and maps, and the data visualisation tools provided an accessible way to see and understand trends and patterns in the data (e.g. Table 10: Simplified representation of data; Table 11, 12, 13: Scientific representation of data).

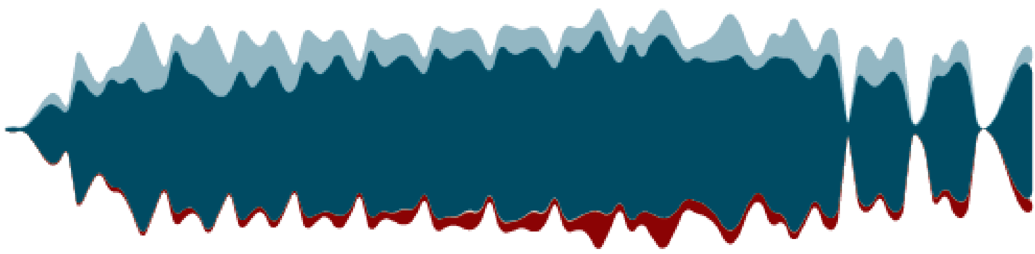

Table 10: Zoisova street in Ljubljana: flow of the traffic - number of all counted pedestrians, bicycles, cars, and big vehicles in six months per hour.

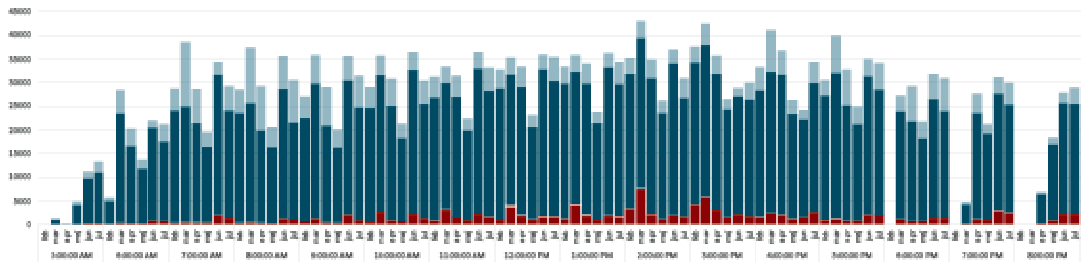

Table 11: Zoisova street in Ljubljana: number of counted pedestrians, bicycles, cars, and big vehicles in six months per hour, all the traffic.

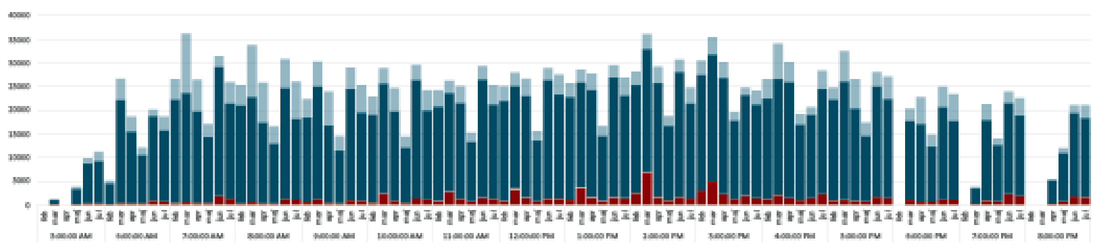

Table 12: Zoisova street in Ljubljana: number of counted pedestrians, bicycles, cars, and big vehicles in six months per hour all the traffic.

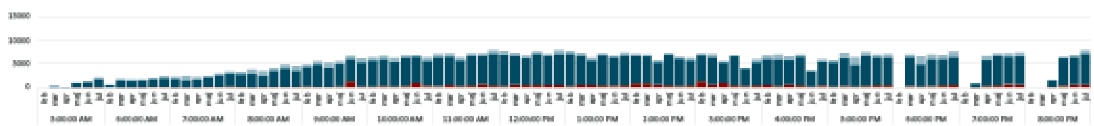

Table 13: Zoisova street in Ljubljana: number of counted pedestrians, bicycles, cars, and big vehicles in six months per hour during weekends.

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5 Participatory Data Analysis by citizens

5.1 Leuven

In this section, we zoom into the participatory data analysis, specifically the data workshop that was conducted in June ’21. The approach and results of the data workshop have not been considered in D4.1 as the data workshop was delayed several times due to Covid-19 restrictions and the preference to wait for a relaxation of measures to allow for a face-to-face workshop.

The data workshop was held on 29 June and attended by some 25 participants. After an extensive measuring period, all Telraam sensors in Leuven and sub-municipalities have collected a huge amount of data. All those traffic counts help to get an objective picture of the traffic in and around the city. It is with this wealth of information that twenty Leuven counters got to work during a workshop in Hal 5.

The participants themselves selected 4 cases to analyse further during an interactive data analysis workshop. They took a closer look at the works in the Grensstraat and the impact on the surrounding streets in Kessel-Lo. Using the Telraam data, they could compare the situation before and after the works. Another group focused on speed measurements with Telraam in Leuven, more specifically in the residential streets. And the traffic filter on Burchtstraat was also discussed.

Another case investigated was the Van Monsstraat, a residential and looping street in the center of Leuven. The Telraam data show that it is busy all day with an average of 300 cars per hour and peaks of up to 350 in the evening rush hour. Saturday is the busiest day of the week for this street. According to Telraam's measurements, the impact of the works on Vaartstraat or the Saturday traffic-free Bondgenotenlaan are clearly causing extra traffic and buses on this busy axis. Improving the situation is not easy, according to residents and Telraam counters. Working with the city, citizens are making plans that seek a balance and use Telraam as basic evidence to feed the discussions.

In another case, the counters went to work with Telraam's speed measurements. One participant made an analysis that deliberately looks at speeding in a different way. To better reflect the perceived feeling of insecurity, he takes a different approach. Namely: What is the probability that you, as a road user, will encounter a "speeding driver" on a particular street? In this way, the otherwise marginal percentage of speeding immediately gives a completely different perspective.

The tool developed by the participants is available as a stand-alone web-page:

Leuven's alderman for mobility David Dessers listened to the residents' suggestions. "These two hundred Telramen provide us as a city with a wealth of information. Information that we use when making all kinds of mobility decisions. For example, we will certainly include these analyses in our mobility plans for the boroughs," responded Alderman for Mobility David Dessers. "As a city, we are also pleased that so many people from Leuven have committed themselves to mapping out the traffic and then thinking about solutions together. Thanks to Telraam, residents are involved in our plans for sustainable mobility and the liveable and traffic-safe city we strive for. It is also great that this tool, which was developed in Leuven, is gradually conquering Europe."

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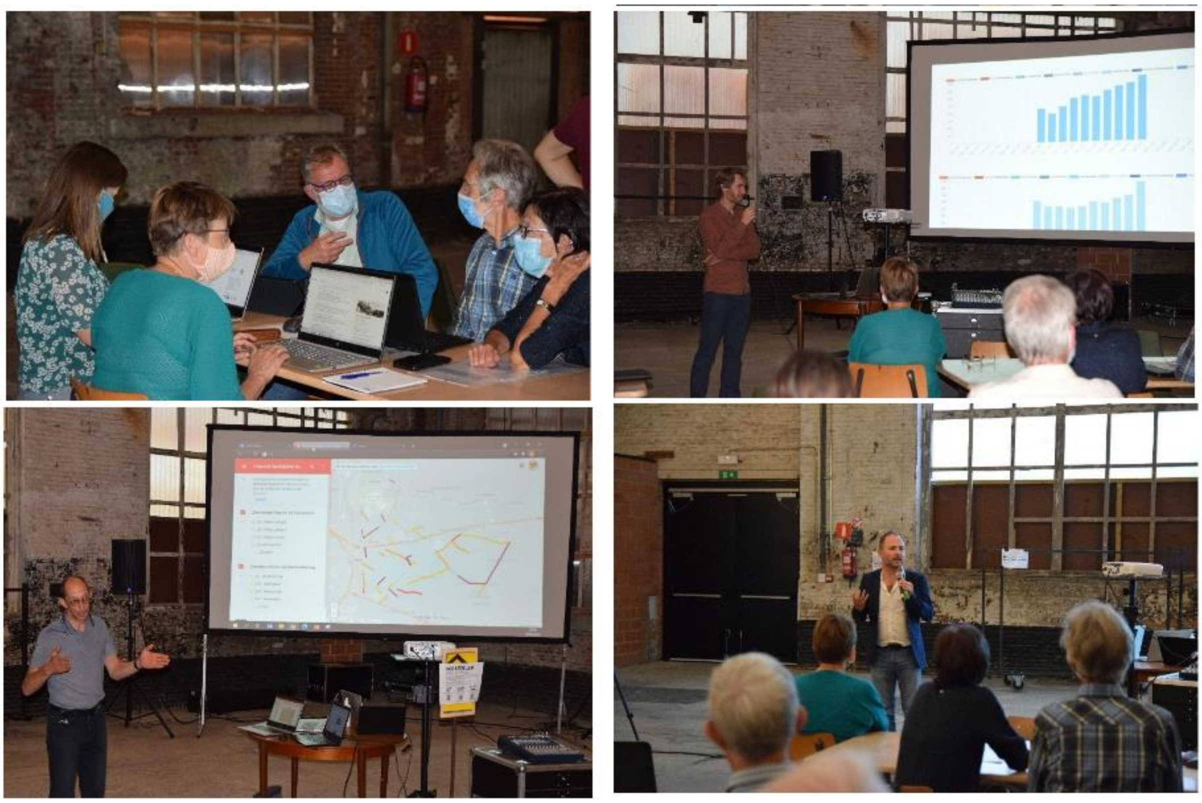

Figure 9: Impressions of the Leuven data workshop.

5.2 Madrid

The analyses undertaken by the research team summarised above were used as the main input to the participatory data analysis workshops conducted in the two cities. These workshops were structured in a way to enable citizens to conduct analysis on their own sensor (those that did not receive it were assigned one) with some games and exercises as well as to compare the data from the sensors and their perceptions and experiences emerged during the initial phases of the case study.

The main scope of this analysis phase has been to facilitate and enable actions based on both the experience and the findings of the case study. In this way, we distinguish between three types of actions towards reaching policy makers, which are tackled separately below. These are:

- Actions and future activities co-designed together with participants at the participatory data analysis and awareness workshops. Here they proposed new courses of action from the results of and the experience in the case study and three categories of actions have been proposed by participants, discussed, and agreed upon. These were then distributed through a survey to allow participants to choose which to finally implement. According to the results of this online voting, a final event has been organised simultaneously in Barcelona and Madrid in the form of a pop-up interventions in those streets where sensors were placed and where citizens agreed to lead the action. It consisted of analogue-based visualisations of some of the results of the specific street. It also included interactions with local citizens that contributed to the data in addition to being presented the results of the case study. The action was the final event in the case study in both cities and all participants (as well as all key stakeholders engaged during the project were invited. The action was fully co-created with the participating citizens as they: (1) co-created three options for the final action and event; (2) democratically chose the one to implement; (3) actively participated in the co-design of the materials (i.e., magnetic boards, pins, graphics, locations etc.); and (4) in some cases assembled the kits (see examples in figure below) and led the action itself.

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Figure 10: WeCount final action in Madrid and Barcelona.

- Actions we, as case study leaders, undertook and plan to carry out to connect with the policy domain and to transfer the knowledge and findings to relevant stakeholders. These have been carried out through the engagement with key stakeholders in the policy domain in Barcelona (the Citizen Science Office within the city council) and Madrid (the MediaLab Prado) throughout the case study. Dedicated events have been organised including a policy masterclass in Barcelona.
- Actions carried out independently by WeCount communities to pursue their own interests and, sometimes, existing agendas. These consisted of independent actions to translate the WeCount data into policy proposals by some of the participants involved. In this way, these represent important impacts of WeCount in Spain as, also according to the objectives outlined in the proposal, it demonstrates that communities have been empowered to address their own, situated and culturally specific concerns, thus advancing their own agenda. For example, the local community at *Ros de Olano* (a small street in Barcelona) independently interacted with Barcelona City Council and, through showcasing the evidence collected in their street from the WeCount Telraam sensors, managed to have a change in the speed limit for this street, which was decreased to 10km/h (see related news published on the community's Twitter account in the figure below).

Figure 11: Community Fumuts Ros de Olano - evidence of change

5.3 Cardiff

Cardiff Case Study citizen scientists undertook a wide array of data analyses using the Telraam data. As a consequence of the pandemic, workshops were moved online and over 40 participants in total attended two data workshops. Four examples of these were presented as local case studies during the two data workshops, as follows:

- Roath: Local Traffic and speeding along Shirley Road;
- Canton: Traffic volumes and local council challenges;
- Riverside: Healthy communities;
- Grangetown: Rat running.

Each workshop had four distinct sections, as follows:

- Define and Constrain. This section focused on refreshing an understanding of the project, it's aims and objectives and the strengths and weaknesses of low-cost sensors. It would also educate attendees who had not encountered WeCount previously. At the end of this section, attendees would understand the purpose of WeCount, the parameters and the limits on the interpretation of the data and understand the focus of the workshop.
- Roath's WeCount data in the context of lockdown and a specific case study of Shirley Road.
- A consideration of air pollution particularly considering the impact of Covid19 restrictions.
- A roundtable discussion with participants on:
    - any other data they would have an interest in seeing on the WeCount dashboard
    - how could the data help with local priorities and activities.

In each of these examples, the Cardiff WeCount team worked with Local Champions to help shape their presentations, explain ways of interrogating data and providing ongoing support before and during the workshops as and when it was needed. We considered the approach of allowing local residents to communicate their local traffic and neighbourhood challenges to other citizens as an integral part of the project. Whilst the WeCount Cardiff team could understand the data, the local meaning and impact of the data are best presented by those with the local context and knowledge associated with the daily nuances of their particular streets and neighbourhoods. In some instances, as shown in Figure 13, citizens undertook their own observations and compared their data against those collected using the Telraam sensor, providing an additional layer of understanding to both the sensor and their local context.

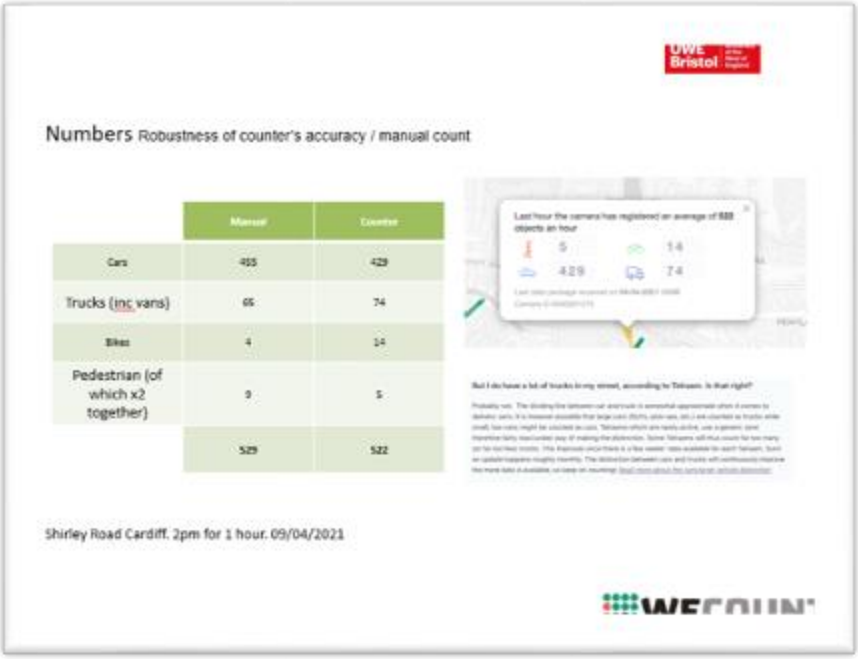

Figure 12: Manual traffic count vs Telraam traffic count on Shirley Road, Roath.

Social media engagement before, during and after the workshops was encouraging, with each workshop being Live-Tweeted throughout, providing some access to those who were either not able to attend the workshop or who could only digest snippets of the event in real-time.

Beyond the confines of the data workshops, citizens routinely share and discuss their data via social media, generating online discussion within their communities on the meaning of the data, its value and potential impacts. As shown in Figure 14, citizens assessed the impact of Play Streets, clearly linking the data generated by WeCount with priority policy areas.

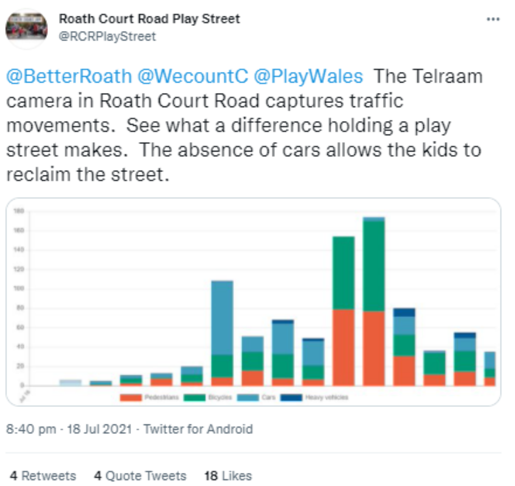

Figure 13: Telraam data used by citizens to evaluate play streets.

Citizens also used the opportunity to discuss WeCount data in their local context. As shown in Figure 15, a local resident, through motivations generated by WeCount, considered the relationship between parked cars, space and costs, demonstrating that WeCount not only enables conversations of specific considerations of data generated through this study, but also aligned perspectives such as climate.

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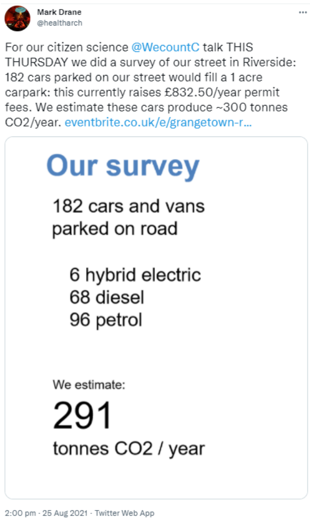
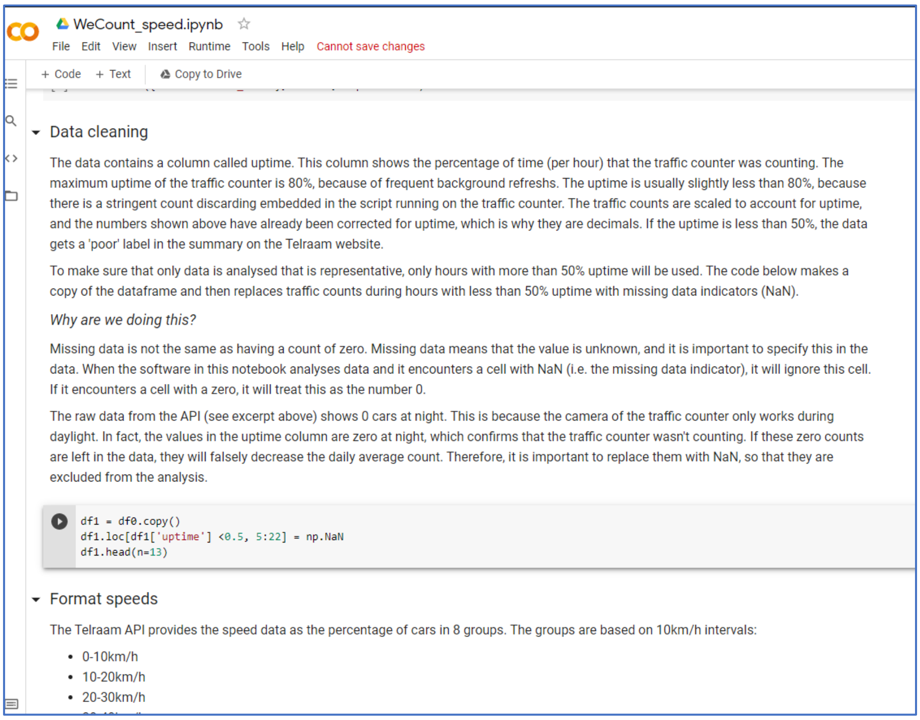


Figure 14: Street survey of parked cars, space and cost by local resident.

These examples demonstrate the value of easily accessible and communicable data in both the passive marketing of Telraam and of its impact in community discourse and policy assessment. Ongoing interaction is expected beyond the lifetime of this project as citizens continue to use their Telraam sensors to inform themselves and their communities of local changes.

5.4 Dublin

The project team aimed to make the data analysis as inclusive as possible. WeCount participants in Dublin had a wide range of data analysis skills, from complete beginners to data professionals. The project team developed online workbooks (via Google Colab), which allow participants to download traffic data from Telraam's API and to analyse three topics: speed exceedances, comparing two time periods, comparing two locations. The workbooks require minimal user inputs (API token, time periods, street segment ID), which means they are suitable for people without any experience in data analysis. However, the workbooks also show the code to carry out the analysis, which citizens with experience in data analysis could use as a starting point for further analyses. In addition to the code and the resulting graphs/summaries, the workbooks also explain different steps in the data analysis process, for example data cleaning, grouping prior to analysis. This provides a learning and skills development aspect to the participatory data analysis, and goes beyond merely producing some summary outputs from the analysis.



WeCount_speed.ipynb

File Edit View Insert Runtime Tools Help Cannot save changes

+ Code + Text Copy to Drive

Data cleaning

The data contains a column called uptime. This column shows the percentage of time (per hour) that the traffic counter was counting. The maximum uptime of the traffic counter is 80%, because of frequent background refreshs. The uptime is usually slightly less than 80%, because there is a stringent count discarding embedded in the script running on the traffic counter. The traffic counts are scaled to account for uptime, and the numbers shown above have already been corrected for uptime, which is why they are decimals. If the uptime is less than 50%, the data gets a 'poor' label in the summary on the Telraam website.

To make sure that only data is analysed that is representative, only hours with more than 50% uptime will be used. The code below makes a copy of the dataframe and then replaces traffic counts during hours with less than 50% uptime with missing data indicators (NaN).

Why are we doing this?

Missing data is not the same as having a count of zero. Missing data means that the value is unknown, and it is important to specify this in the data. When the software in this notebook analyses data and it encounters a cell with NaN (i.e. the missing data indicator), it will ignore this cell. If it encounters a cell with a zero, it will treat this as the number 0.

The raw data from the API (see excerpt above) shows 0 cars at night. This is because the camera of the traffic counter only works during daylight. In fact, the values in the uptime column are zero at night, which confirms that the traffic counter wasn't counting. If these zero counts are left in the data, they will falsely decrease the daily average count. Therefore, it is important to replace them with NaN, so that they are excluded from the analysis.

```
df1 = df0.copy()
df1.loc[df1['uptime'] <0.5, 5:22] = np.NaN
df1.head(n=13)
```

Format speeds

The Telraam API provides the speed data as the percentage of cars in 8 groups. The groups are based on 10km/h intervals:

- 0-10km/h
- 10-20km/h
- 20-30km/h

Figure 15: Excerpt of speed exceedance analysis workbook.

The workshop received positive feedback from participants, with some participants immediately putting the workbooks to use and sharing their results (see Figure below). Another positive aspect was participants asking if further workbooks could be developed, for example to correlate traffic with weather data or air quality data.

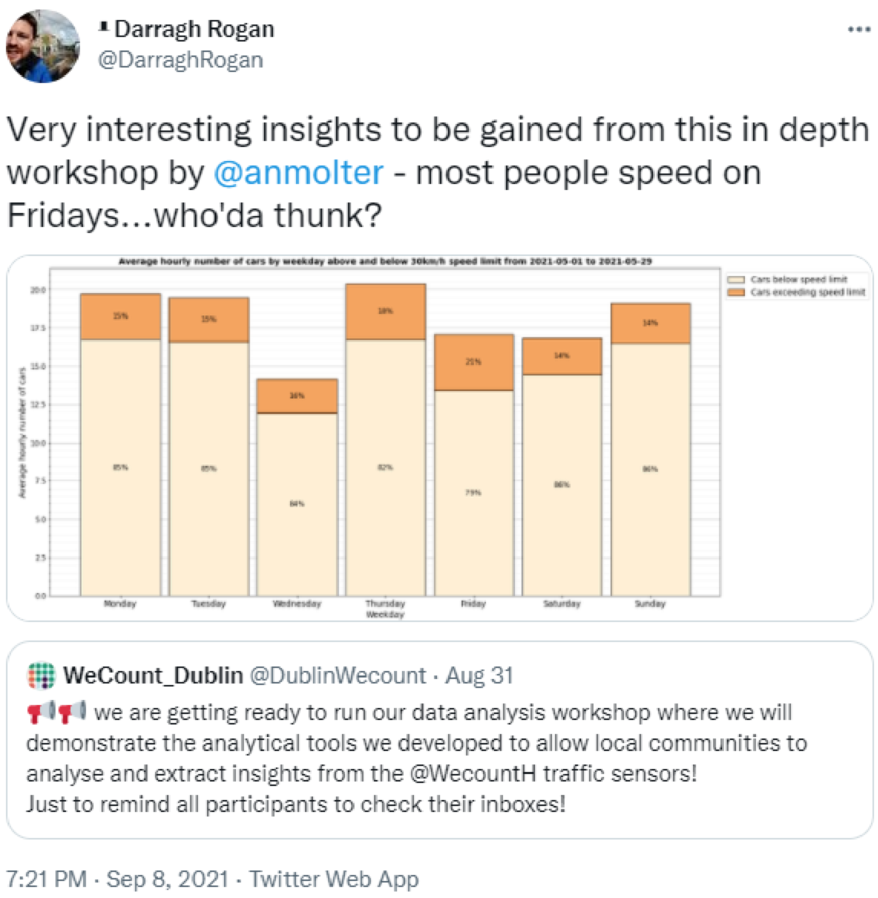


Figure 16: Tweet following Dublin data workshop.

5.5 Ljubljana

The activities with university students/urban residents/citizens in the form of design thinking and co-creation workshop aimed to engage young citizen scientists. The activities focused on urban planning students who were engaged in a process of design thinking in a very interactive and hands-on session to come up with new ideas for new street layouts, with deliberate attention to providing enough space to cycling.

In the pilot case of Ljubljana, due to the low participation and lack of interest of participants in the online workshops throughout the project period, the project team also decided to present the traffic count data in a way that would be visible not only to the project participants, but also to the wider population. Looking for the most appropriate way, we decided to present the most interesting and also most worrying traffic count data through advertisements on digital screens installed in public buses. We chose this type of presentation because it appeals to different demographic groups and reaches an average of 4,500,000 passengers per month on 180 buses in the city of Ljubljana and its surroundings. On the digital screens we showed data collected from five different locations in the city of Ljubljana.

The project team encourages all project participants and all residents of Ljubljana to send their reactions to the highlighted data via the project media (Facebook, Twitter).

Another data analysis and awareness raising workshop with interested research participants will be organised at the end of September 2021.

Figure 17: Did you know? On Zaloška street: 1,500 cyclists per day.
Figure 18: Did you know? On Dunajska cesta: 1600 cyclists per day.

Figure 19: Did you know? On Litijska cesta: 820 freight vehicles per day.
Figure 20: Did you know? On Zoisova cesta:13000 vehicles per day.

Figure 21: Did you know? On Dalmatinova ulica: 1650 cyclists per day.

Figure 22: Bus add 1,2

6 Summary of overarching conclusions

The partners developed different and individual approaches to empower citizens and reach policy makers. In Leuven, they were able to use 'personas' to build a community platform to network, learn and inspire the city's residents. In Madrid and Barcelona, the partners used what is known as a 'train-the-trainer' approach, which empowers citizens to contribute to their own agenda and engage with the specific mobility issues that affect them and the relevant policies for these issues. The distribution of 1,000 strawberry plants provided participants with an easy and accessible approach that was both humorous and effective. In Cardiff, the partners took the approach of empowering citizens at three levels: street, community and city, and their role was that of an enabler rather than a leading analyst/advocate. The Dublin team extended citizen participation in several neighbourhoods, in different developments in the city and in different transport events. In Ljubljana, networks were extended throughout Slovenia to reach interested citizens and policy makers at different levels.

In terms of the installation process, there were more similarities between the case studies based on the guide developed in the Barcelona/Madrid case study: (printed) step-by-step installation guides that participants received, dividing the process into several basic, elementary steps; videos on the installation of the Telraam sensor and the registration process, available to everyone on YouTube; troubleshooting steps for participants who encountered problems during the installation, in particular a guide on how to check which devices are connected to the router; guides on how to extend the case study to other districts and cities. All this was accompanied by individual counselling for the participants. However, the focus was also on improving the reliability of the software, with subsequent activities to maintain the engagement of participants who remain alive and in need of technical support. During the installation process, it became clear that engagement by theme (e.g. mobility and noise, mobility and air quality, mobility and speed compliance, mobility and road safety, etc.) is more effective than engagement by neighbourhood or geographical area, and that 'one strategy fits all' is unlikely to be applicable. It is also of utmost importance to manage the expectations of participating citizens and it is essential to spend a lot of time with them, because the more people understand the technology (e.g. because it is low-cost, still under development, etc.), the more they appreciate the value of participating in its testing.

The data processing and analysis was partly described in the two previous reports (D4.1 and D4.2). In general, the data provided a good opportunity to explore local challenges in different settings. Workbooks were created containing the initial steps for data analysis, such as downloading data via the API, data cleaning, data aggregation and descriptive statistics. These workbooks are designed for the analysis of one street segment and can serve as a template for future analyses, such as in the Burchtstraat in Leuven. In Madrid and Barcelona, a comparison with official mobility data including correlation analysis and visualisation was possible. The spatial and temporal variation of the datasets reflected the introduction of restrictions related to pandemic closures, infrastructure repairs and changes in main traffic directions. Traffic speeds data provide meaningful evidence of compliance or non-compliance with local speed limits. Data collected in raw form can be difficult for lay people to understand, so analysts need to break down the information collected so that others can understand it. Graphical representation of information and data was done through visual elements such as charts, graphs and maps, and data visualisation tools provided an accessible way to identify and understand trends and patterns in the data.

All case study teams involved participants in the analysis, who were very active: Some selected cases to be further analysed in an interactive data analysis workshop, developed analysis tools, thought about solutions, proposed new courses of action based on the case study findings and experiences, and communicated their local traffic and neighbourhood problems with other citizens. Some WeCount participants had a wide range of data analysis skills, others did not, and others were able to come up with new ideas for new street layouts, with deliberate attention to creating enough space for specific road users.

Case studies / **Actions**	**Leuven**	**Barcelona/ Madrid**	**Cardiff**	**Dublin**	**Ljubljana**
Guidelines building	Real policy change by Telraam Lab with 'personas'; codesigning Telraam Community Platform with citizens.	Real policy change by train-the-trainer approach: citizens are empowered to contribute to their own agenda and address the specific mobility concern that affect them as well as the relevant policies for these concerns.	Real policy change by empowering and facilitating the citizen led policy contributions through workshops on different scales.	Real policy change through extended citizen participation in different geographical units, for different spatial interventions, during different events.	Real policy change by extending networks throughout Slovenia in other cities: citizens using the data for representing difficult traffic situations.
Installation analysis (the pros and cons of the Telraam sensor installation process)	The pros: The reliability of the software has been improved; technical support continues. The cons: Software has not been resolved completely; some users had difficulty in installing the sensor.	The pros: A printed step-by-step installation guide, video with a with a clear visual explanation of the overall installation process; use of social networks for constant installation support. The cons: Minor technical problems occured (installation on south-facing windows, cables too short, etc.); difficulties connecting to Wi-Fi in public buildings, schools, etc.	The pros: Face-to-face approach has proven to be the most efficient; technical support sessions offered to participants via video call. The cons: Minor technical problems occurred (cables too short, sensors had to be replaced, the street image was not showing or visible during installation, the Telraam sensor stopped counting. etc.)	The pros: The installation help was offered by Telraam helpdesk and by direct emails to the team; Step-by-step installation guide to check which devices are connected to the router. The cons: Some solutions for technical issues were not found.	The pros: Video content about the installation of the Telraam sensor and the registration process. The cons: Minor technical problems occurred (cables too short, sensors had to be replaced, etc.), difficulties connecting to Wi-Fi in public buildings, schools, etc.

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Data analysis (extracting useful information)	Developed a template analysis approach for future analysis in Leuven; assessing the impact of interventions in the traffic circulation on traffic volumes.	Comparison with official mobility data including correlation analysis demonstrating the effectiveness of the Telraam sensors.	Traffic flows on roads in Cardiff varied spatially and temporally during the study; the introduction of restrictions associated with pandemic lockdowns was obvious. Traffic speeds data demonstrate compliance or not with local speed limits.	Workbooks contain the initial steps required for data analysis; they are designed for analysing one street segment, therefore further work is required to extend them to multiple segments. Example: Matrix plot showing the average percentage of cars exceeding 50km/h.	Graphical representation of information through visual elements; the data visualisation tools provided an accessible way to see and understand trends and patterns in the data (simplified representation v. scientific representation).
Participatory data analysis by citizens (participants working with the data and conducting analyses)	The participants themselves selected cases to analyse them further during an interactive data analysis workshop; participants chose different approaches for analyses; municipality representatives participated in the workshops and will include participatory data analyses in the mobility plans.	Citizens to conduct analysis on their own sensor; three types of actions towards reaching policy makers: citizens proposed new courses of action from the results of and the experience in the case study; steps to connect with the policy domain and to transfer the knowledge and findings to relevant stakeholders; independent actions of citizens to translate the WeCount data into policy proposals.	The approach of allowing local residents to communicate their local traffic and neighbourhood challenges to other citizens was integral part of the participatory data analysis. Citizens undertook their own observations and compared their data against those collected using the Telraam sensor. Citizens routinely share and discuss their data via social media, generating online discussion.	WeCount participants in Dublin had a wide range of data analysis skills, from complete beginners to data professionals. With online workbooks the participants could analyse three topics: speed exceedances, comparing two time periods, comparing two locations.	Participants with urban design skills came up with new ideas for new street layouts, with deliberate attention to providing enough space to cycling. *Did you know* advertisements on digital screens installed in public buses to support citizens to become involved in data analysis.

Table 14 14: Overview of achieved results in the citizen science activities, guidelines building, installation and data analysis.

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Appendix 1: List of figures and tables

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