



Superpedestrian

ANALYSIS OF
PAVEMENT RIDING ON SHARED
E-SCOOTERS IN NOTTINGHAM

July 2023

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OVERVIEW

Superpedestrian is a leading micro-mobility company committed to providing the safest service in the cities we serve across Europe and the United States; including Nottingham in the UK. To achieve this, we collaborate with councils and local stakeholders in each city around key issues. Pavement riding although illegal in the UK is often cited as a concern by local stakeholders, especially for people with disabilities; including those who are vision impaired or blind.

To tackle this, we have developed an innovative proprietary technology called Pedestrian Defense **(PD)**, which specifically detects and records instances of pavement riding. In November 2022, we successfully introduced PD onto the streets of Nottingham. Since then, PD has been detecting and recording pavement riding in the city.

In this report, we present the pavement riding data we've collected in Nottingham, along with our analysis of why e-scooter riders engage in this behaviour. Our findings indicate that the majority of e-scooter trips take place on the road. We have also observed that inexperienced riders and a small minority of riders account for the vast majority of pavement riding incidents. We have conducted a survey with a sample of the top pavement riders to understand their concerns, and the main reasons behind their decision to ride on pavements.

PAVEMENT RIDING DETECTION TECHNOLOGY IN NOTTINGHAM

In November 2022, Superpedestrian rolled out 300 scooters equipped with PD technology into our Nottingham fleet. While these scooters may appear similar to others in our fleet, they incorporate advanced onboard technology capable of accurately detecting riding behaviour in real time. To ensure rider privacy, all the data that we collect from these scooters is anonymized and aggregated.

During the first month, we gathered baseline pavement riding data. Subsequently, in December 2022, we activated our system to alert riders via in-app educational notifications to instances of pavement riding. These notifications are designed to nudge behaviour change by notifying riders they were riding on the pavement. Additionally, they provide riders with educational information, emphasising why riding on the pavement is not permitted.

THE DATA: PAVEMENT RIDING IN NOTTINGHAM

Scope of Data Review

Over the past six months, we have thoroughly analysed all the data collected by our PD enabled scooters in Nottingham to get a picture of the trends of pavement riding in Nottingham. The following metrics provide an overview of our comprehensive approach:

- § Sample period: 23 Dec 2022 to 23 May 2023
- § Geographical coverage: 100% of city pavements mapped
- § Total rides: Our analysis covers 82,893 rides recorded within the specified timeframe
- § Unique riders: The data represents 19,562 individual riders who utilised our service
- § Daily rental availability: 281 PD-enabled scooters for rent daily (average) representing 33% of deployed scooters
- § Pavement riding detection threshold: Our system triggers when a rider exceeds one minute of aggregate pavement riding, allowing us to accurately identify instances of this behaviour

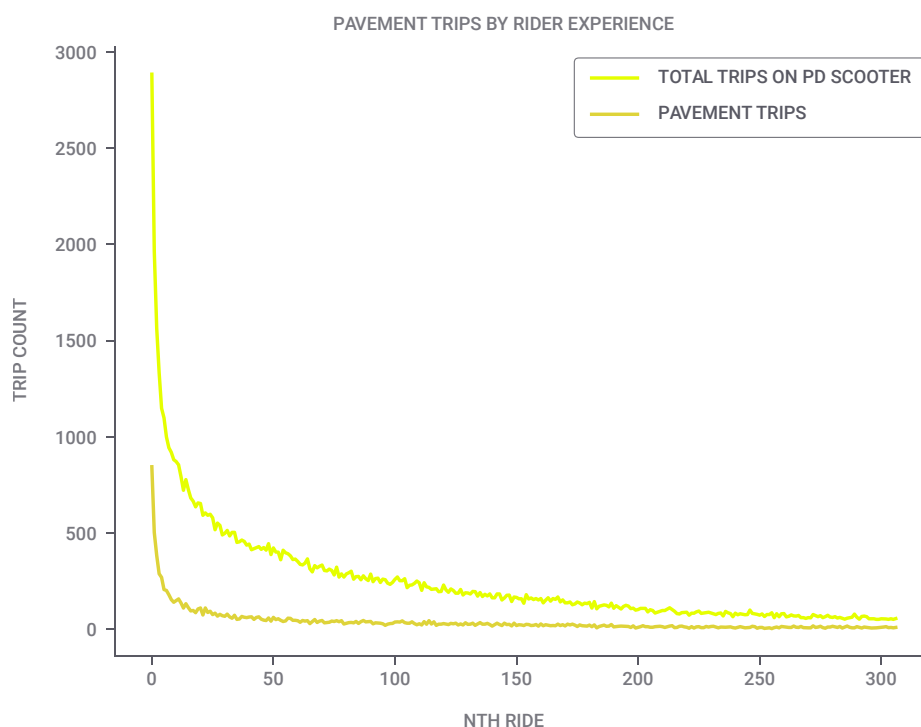
Data Analysis

Our analysis has concluded the following:

1. **Most trips are not on the pavement**

84.6% of all trips stayed on the road.

Experienced riders (> 10 rides) are far less likely to ride on the pavement than new riders.

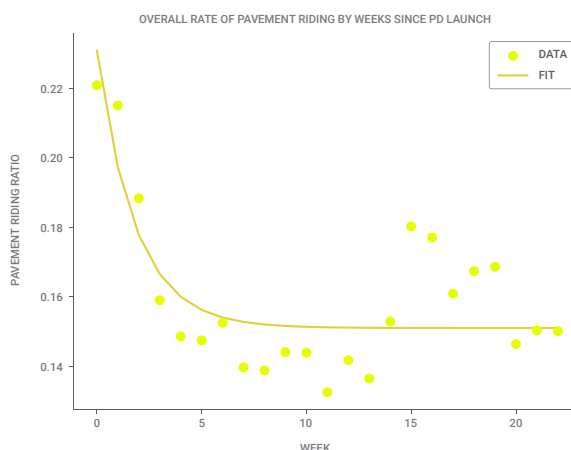


2. Fleet-wide, pavement riding reduced over the intervention period

Following the activation of pavement riding notifications, we observed a consistent decline in the overall rate of pavement riding, **decreasing by 4.62% per week**. The statistical analysis indicates a significant correlation ($R^2 = 0.66$, $p = 0.025$) between the introduction of the pavement riding notifications and the reduction in pavement riding incidents.

Our PD system identifies instances of pavement riding and triggers notifications for every rider engaged in this behaviour, specifically when they ride on the pavement for more than a minute aggregate during a single trip. In week 1, after implementing the notifications, **22%** of trips taken on PD scooters detected pavement riding behaviour. By week 26, this rate declined to **14%**, demonstrating a steady decrease over time.

These findings highlight the **effectiveness of our approach in promoting rider awareness and encouraging behaviour change**. By actively notifying the riders about their instances of pavement riding, we have witnessed a **significant reduction in such behaviour**, leading to improved safety and adherence to the correct riding rules in Nottingham.

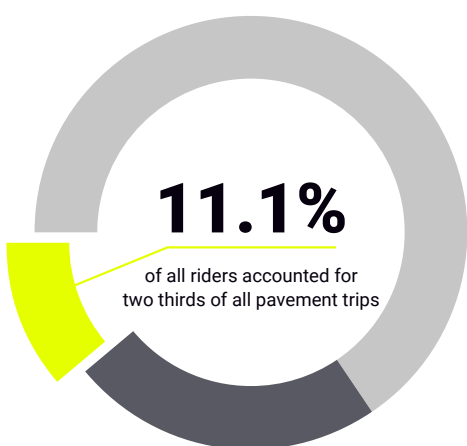


3. Pavement riding declines rapidly with experience

According to our analysis, a given rider is **14.43% less likely to ride on the pavement** each trip they take ($R^2 = 0.84$, $p = 0.025$). This finding suggests a strong correlation between rider experience and reduced pavement riding instances.

When examining first-time riders, we found that **28%** of first-time rides involved pavement riding. In contrast, experienced riders (more than ten rides) travelled on the pavement **~ 13%** of the time.

These statistics indicate that as riders gain more experience and receive pavement riding notifications, their likelihood of engaging in pavement riding decreases significantly. The data suggests that rider education and repeated exposure to our system's notifications play a role in promoting adherence to proper riding practices and minimising instances of pavement riding.



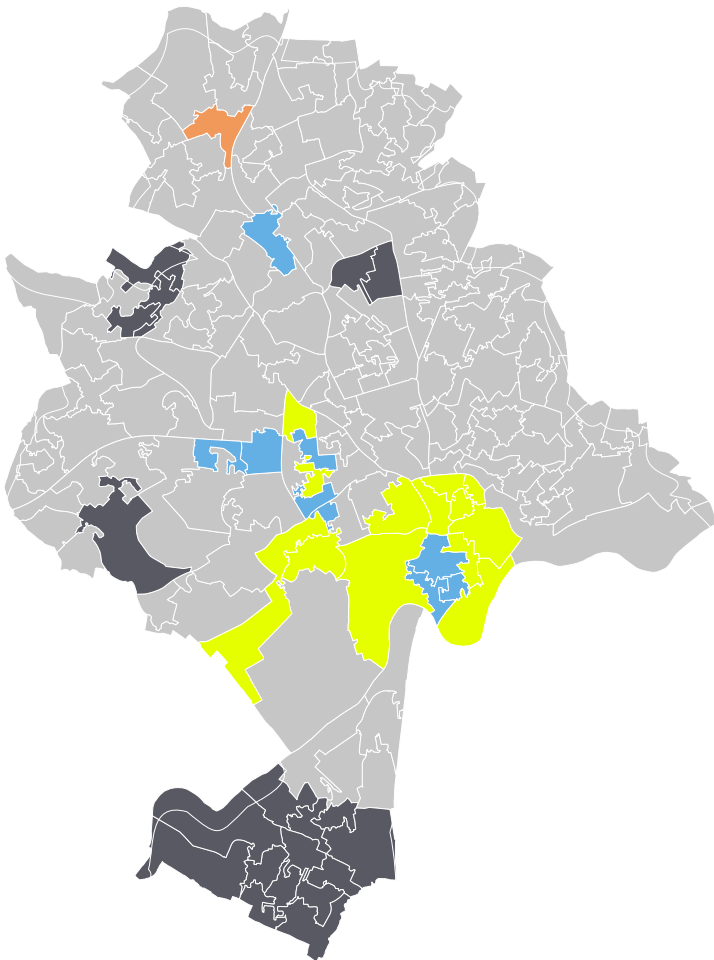
4. A few riders account for most pavement rides

The majority of our riders don't pavement ride – and our data shows that **65.3%** of riders have never ridden on the pavement. Additionally, **23.5%** of riders have only travelled on the pavement once. However, a subset of riders, amounting to **11.1%** of all riders persistently rode on the pavement two times or more - accounting for **66%** of all pavement trips.

Understanding that only a small fraction of riders (*one in ten*) consistently engage in pavement riding behaviour enables us to develop a targeted enforcement program to address this, to further minimise pavement riding in the city.

5. **Pavement Riding Hotspots (based on Volume of Trip Starts)**

Using our PD data, we have been able to identify the areas in Nottingham where we see most trips that involve pavement riding starting. This data helps us to see in general the areas where such trips start, but not identify precise streets where pavement riding is occurring. Nonetheless, it can help us to identify areas for interventions that can help to reduce the level of pavement riding in the city.



Moran Cluster Map: Pavement Trip Count

Methodology: The colored Lower Layer Super Output Area - specific geographic areas of the city are areas with a statistically significant ($p < 0.05$) cluster of high or low pavement trip rates, in terms of both absolute count and percent of trip starts.

● **High volume of pavement riding**

Our data shows us that most of the trips that involve high levels of pavement riding in Nottingham are starting in areas immediately around the city centre such as the Lenton and Dunkirk areas, known for their large student populations. We see that there are high levels of pavement riding during trips in the industrial area to the west of Lenton which connects to the city centre, suggesting this is a common route between these busy student areas and the city. We generally see high levels of pavement riding during trips in the large area between Victoria Centre in the north (including Broadmarsh and Station areas) to the Victoria embankment in the south, and from Dunkirk in the west to Island Quarter in the east - with the exception of north of the Meadows.

● **Moderately High outlier area**

It is worth mentioning we see an unusual spike in pavement riding in Bulwell town centre. This might indicate an infrastructure issue in this area, or a population of riders there to reach out to. This area would represent an excellent opportunity for targeted outreach to riders to address pavement riding.

● **Low volume of pavement riding**

In contrast with the area around it where we see high levels of pavement riding, to the north of the Meadows there are low levels of trips involving pavement riding. There are also low levels of trips involving pavement riding east of Wollaton and in the very east of Lenton, and in a pocket in Old Basford.

● **Very Low volume of pavement riding**

There are very few people having trips where they ride on the pavement - and indeed very few riders in general - in the following areas: Clifton, west of Wollaton Park, Broxtowe, Cinderhill and north of New Basford. Those areas require the least amount of attention in terms of pavement riding interventions.

This data can help inform a more targeted approach to addressing pavement riding, reaching riders directly where trips involving pavement riding are occurring, and potentially supporting local infrastructure decisions. Data is also viewable with more detail at bit.ly/443QTDj. We are producing a more detailed report on pavement riding hotspots for Nottingham City Council at the end of the year.

SURVEY RESULTS

WHY PAVEMENT RIDING OCCURS IN NOTTINGHAM

Our objective extended beyond merely quantifying the extent of pavement riding in Nottingham; we also sought to comprehend the underlying reasons behind this behaviour. To gain deeper insights, we identified the 300 riders who have ridden on the pavement most over the last six months. The range was broad with some of these riders riding on the pavement a handful of times, and others riding on the pavement over 30 times during that period.

In early June we conducted a targeted survey, reaching out to these riders individually. With this survey, our aim was to gather insights into the motivation and factors influencing the decision of Nottingham residents and other riders to ride on the pavement.

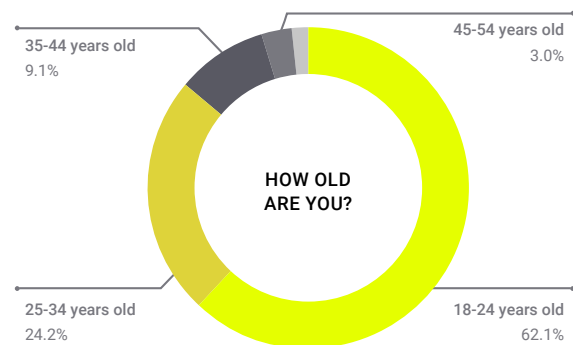
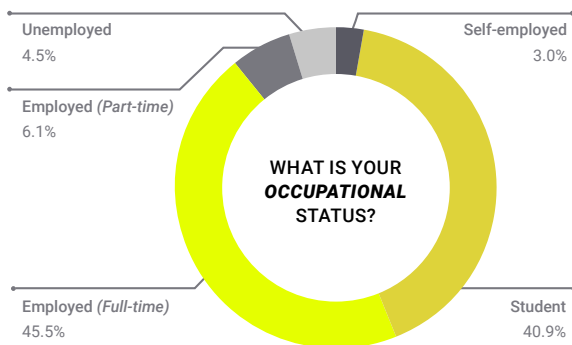
By directly engaging with this group, we have obtained valuable feedback regarding their choice to ride on the pavement. This data will enable us to further refine our strategy and develop more effective approaches to address the specific concerns and challenges faced by riders in Nottingham.

Survey Response Rate

The response rate to the survey was over 20%, which enables us to get a good picture of who is riding on the pavement most in Nottingham, and why. Data from this survey was anonymized and aggregated to protect rider privacy.

1. Demographic of pavement riders mirrors demographic of all riders

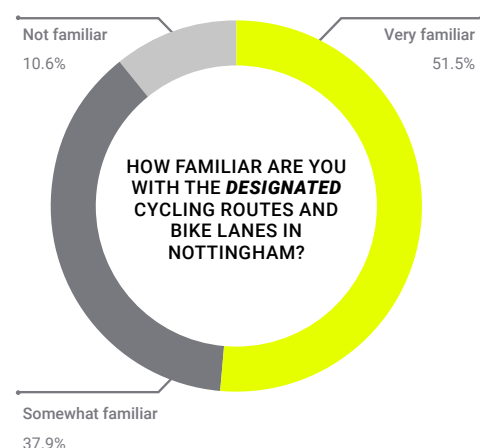
Most riders surveyed as the top pavement riders were male, and most were aged 18-34. This was broadly in keeping with the demographic for general ridership in Nottingham and indeed the UK in general - although we and other e-scooter operators are working to encourage more female riders and more older riders to avail of the benefits that shared e-scooters can provide. 45% of riders surveyed were in full time employment, with 40% indicating they were students.



2. Familiarity with cycle lanes may factor into pavement riding

More than half of the riders felt they were familiar with the bike lanes and designated cycle routes in Nottingham. However, almost 40% felt they were only somewhat familiar, with 10% indicating they weren't familiar at all.

This could indicate that further education and raising awareness among riders on the available cycling infrastructure in Nottingham could impact the level of pavement riding.

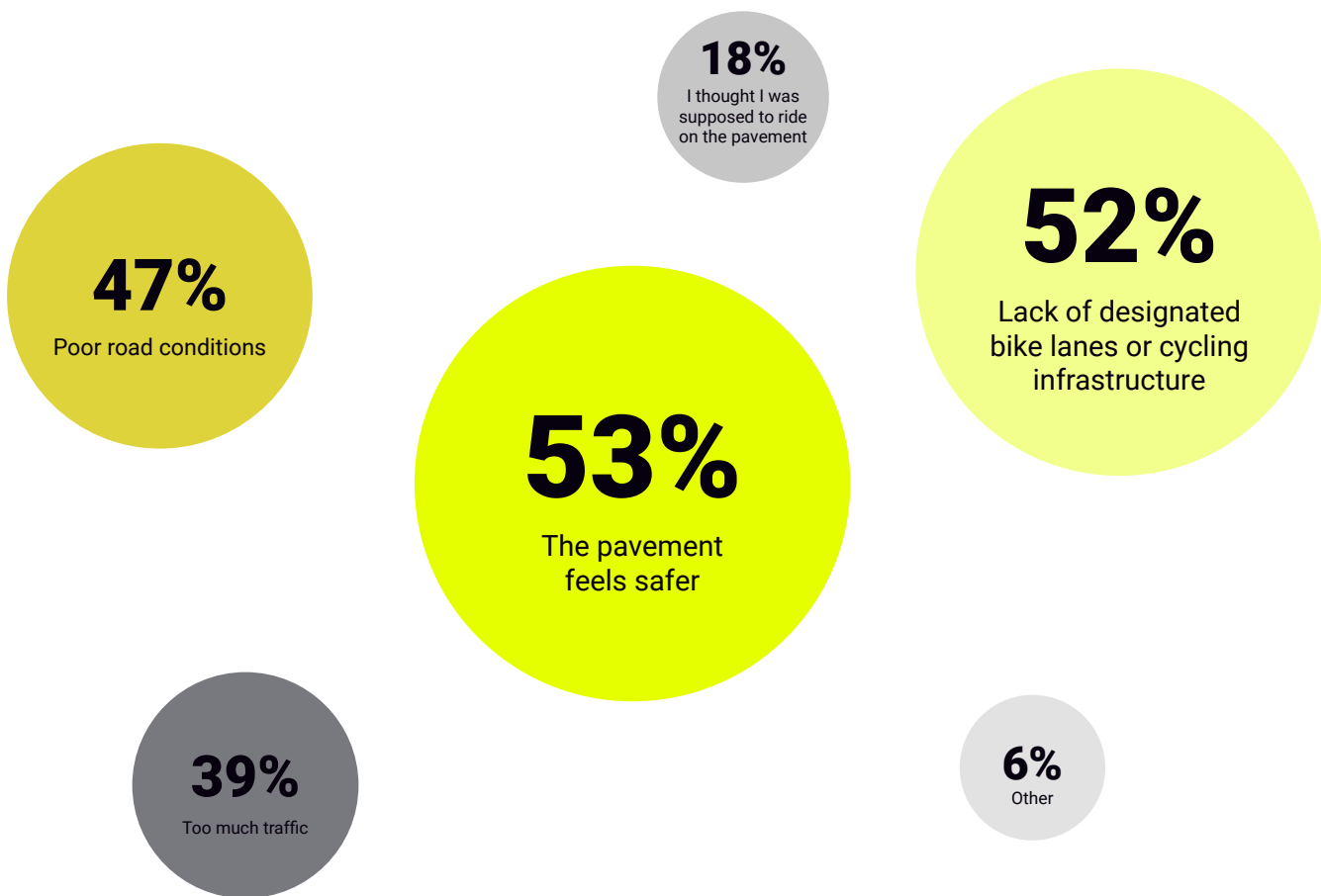


3. **Infrastructure and safety concerns are the top reasons for pavement riding**

Riders were asked to indicate all the reasons they ride on the pavement from a list:

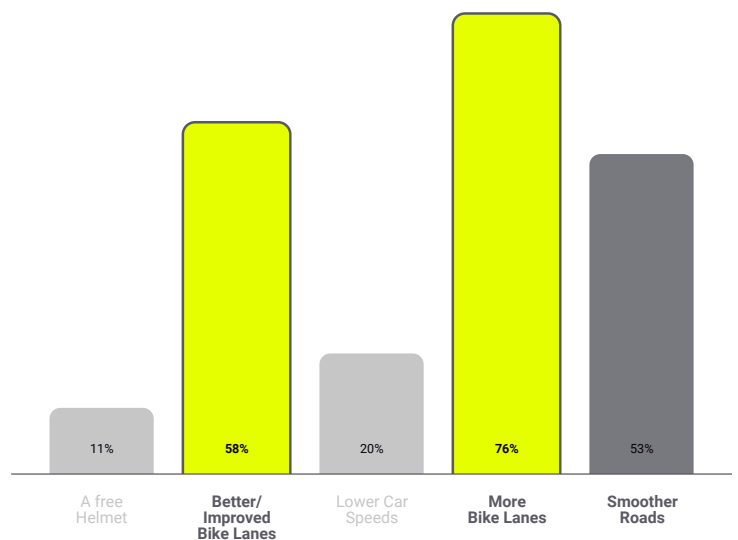
A majority of riders cited that they felt safer riding on the pavement. Lack of designated cycling infrastructure was highlighted as a key reason that caused riders to choose to ride on the pavement rather than the road, as well as poor road conditions.

When given an open opportunity to say more, a few riders indicated the speed of e-scooters versus faster cars was a factor in causing them to ride on the pavement. Availability of road space was also mentioned.



4. **Infrastructure improvements are the most common suggestions for preventing pavement riding**

When asked what improvements would make them more likely to ride on the road - riders overwhelmingly (76%) cited that **more bike lanes** would encourage them to ride on the road. Uneven road surface was also identified with 53% of riders indicating **smoother roads** would make them more likely to ride on the road.



5. **Riders deem pavement riding necessary during heavy traffic**

In an open-ended answer section, when asked about the specific situations where riders felt riding on the pavement was necessary **23% of riders referred to traffic as being a major factor.**

Other factors included poor road conditions (such as potholes) and specific locations.

Selected rider answers to the question "What are the specific areas or situations where you feel riding on the pavement is necessary?" are:

- § "For parking zones, roads being blocked off, potholes and getting out of the way of emergency services"
- § "If I ever ride on the pavement it's due to heavy traffic and cars overtaking me very close and at speed, it sometimes feels very unsafe on the road travelling at half the speed of cars."
- § "Cycling routes missing, massive traffic"

"When there is heavy traffic and there is no bike lane"

Some riders mentioned locations they found **particularly challenging**, with a few broadly citing the City Centre and NG7 in the north of the city. A number of riders called out particular roads:



6. **Riders have safety concerns about cars and driver behaviour**

We also asked an open-answer question about challenges or concerns with road riding that lead to pavement riding. Many answers were in the affirmative that riders had concerns with road riding, and one particular point in many answers really stood out - with **32%** of respondents voluntarily citing driver behaviour as a major concern.

Rider answers for the question "Have you encountered any challenges or concerns when riding on the road that led you to ride on the pavement?" included:

"Cars driving too close and not allowing room as they drive by"

- § "...cars beeping behind me, getting threatened by drivers for being too slow"
- § "Cars seems to go towards you trying to make you leave the road"
- § "Cars have no consideration for you"
- § "Cars trying to overtake put me in danger"
- § "Drivers not paying attention, drivers pressuring riders to move faster"



Conclusion and Next Steps

To date, our understanding of the extent of pavement riding by e-scooter riders in Nottingham has primarily relied on anecdotal evidence rather than solid figures. By undertaking the comprehensive task of mapping the pavements of the entire city in Nottingham, and deploying Superpedestrian's PD-enabled scooters as a significant portion of the fleet, we have been able to bring a more scientific approach to understanding, and addressing, this issue.

Through this concerted effort, we now have a solid evidence base in Nottingham that allows us to precisely determine the prevalence of pavement riding in the city. Furthermore, our survey of pavement riders has provided valuable insights into some of the underlying reasons behind this behaviour. Armed with this knowledge, we can design a more effective approach to reducing the level of pavement riding in Nottingham.

The data we have gathered will enable us to work in partnership with Nottingham City Council to implement bespoke measures such as a tailored rider education programme - addressing the areas and ridership where we know pavement riding is prevalent. Additionally, for those riders who are regularly and consistently riding on the pavement all the time, we plan to implement a three strikes system for dealing with serial pavement riders in Nottingham later this year, ensuring accountability and reinforcing the importance of adhering to proper riding practices and respecting traffic rules.

We will continue to track progress in tackling pavement riding in Nottingham, and we will produce an update on these findings next year.

Acknowledgements

Superpedestrian would like to thank Nottingham City Council for their support and collaboration in launching our PD system in Nottingham, enabling this to be the first city in Europe where we were able to use this technology to gather detailed insights around pavement riding. **In particular, we thank the Transport Strategy Team for their support.**



APPENDIX A

Superpedestrian

Superpedestrian was spun out of Massachusetts Institute of Technology (MIT) in 2013 with the mission to develop the world's smartest and safest light electric vehicle fleets. In 2020, Superpedestrian debuted its shared scooter, heralded as "The Volvo of e-Scooters" for its patented Vehicle Intelligence platform that actively prevents costly mechanical and electrical hazards that beset other e-scooter operators. Superpedestrian has become a world-leader in transportation robotics and human-scale mobility, holding over 40 patents in autonomous failure protection for vehicles, automated maintenance software, fleet optimization, and vehicle context awareness. In 2022, Superpedestrian was named one of Fast Company's Most Innovative Companies in Transportation. Superpedestrian operates shared scooter programs across Europe and the United States, including in Nottingham in the UK.

What is Pedestrian Defense?

Pedestrian Defense is Superpedestrian's proprietary technology that uses a dual band satellite position system, onboard sensors and onboard geofencing to enable us to understand where the vehicle is at any point in time and how the rider is behaving (e.g. whether they are riding on the pavement):

1. DUAL-BAND SATELLITE SYSTEM

Superpedestrian's dual-band satellite positioning system (GNSS) minimizes location error as compared to conventional positioning solutions, as occurs in cities with high structures such as tall buildings or trees.

This dual-band positioning system integrates location data from 5 different satellite constellations (GPS, Galileo, BDS, GLONASS, and QZSS).

3. ONBOARD GEOFENCING

Our superior geofencing accuracy is well regarded in the industry as the fastest system available with a 99.93% enforcement success rate applying geofence area commands in 0.7 seconds on average, regardless of connectivity issues and/or vehicle speed.



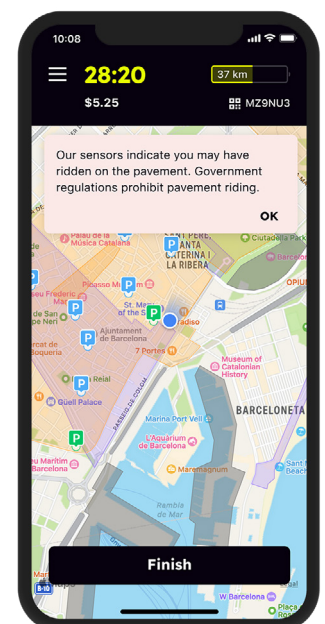
2. ONBOARD SENSORS

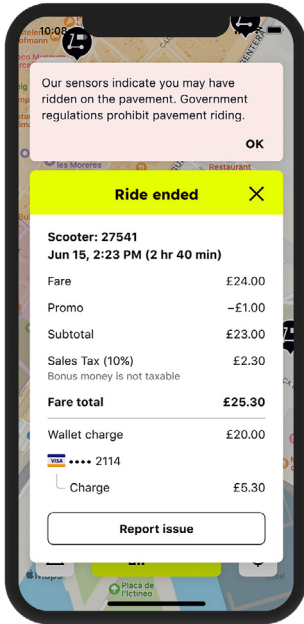
Pedestrian Defense uses a "dead reckoning" solution that supplements satellite positioning using onboard wheel and scooter orientation sensors to calculate the scooter's position when satellite coverage is unavailable or sub-optimal. Dual-band GNSS and sensor systems improve positioning to centimeter-level accuracy.

How does it work?

The system uses an AI trained algorithm to learn what pavement riding looks like, and we tailor the PD algorithm uniquely to each city where we deploy this technology. Our system recognises pavement riding and assigns a confidence level of how certain it is that it has identified pavement riding. The threshold we use for the PD system for pavement riding is more than one minute aggregate pavement riding (this doesn't need to be continuous). We have chosen this threshold as it is at this level that our system has the maximum level of confidence that it has accurately identified periodic pavement riding.

Pedestrian Defense enables us to implement a range of interventions when the system detects unsafe rider behavior. This ranges from in-app notifications after the ride, all the way to intervening with the power to the vehicle itself in subsequent rides. Superpedestrian's approach is to use the lowest level of intervention - through post ride notifications - to nudge and reform riding behavior. It is our philosophy that we do not want to interrupt a rider during a ride for safety reasons.





By utilising post ride notifications, we believe we can work with cities to tailor intervention through specific rider education as an effective means to reduce pavement riding. From our experience with this technology in the US, we find that most riders want to follow the rules, and when they are reminded about the dangers of pavement riding, they are likely to change their behavior.

After a period of data collecting using the PD scooters in Nottingham on the baseline level of pavement riding in Nottingham, we switched on rider notifications in December 2022. The rider notifications in Nottingham read: "Our sensors indicate you may have ridden on the pavement/footpath. Government regulations prohibit pavement riding"



APPENDIX B

Rider Survey

Email

How old are you?

- Under 18 years old
- 18-24 years old
- 25-34 years old
- 35-44 years old
- 45-54 years old
- 55-64 years old
- 65 years or older

What is your gender?

- Male
- Female
- Non-Binary
- Prefer not to say
- Other:

What is your occupational status?

- Student
- Employed (Full-time)
- Employed (Part-time)
- Self-employed
- Unemployed
- Retired
- Other:

What are the main reasons you choose to ride on the pavement instead of the road? (select all that apply)

- I thought I was supposed to ride on the pavement
- Lack of designated bike lanes or cycling infrastructure
- The pavement feels safer
- Poor road conditions
- Too much traffic
- Other:

How familiar are you with the designated cycling routes and bike lanes in Nottingham?

- Very familiar - I have good knowledge of the designated cycling routes and bike lanes.
- Somewhat familiar - I know about some of the designated cycling routes and bike lanes.
- Not familiar - I have limited knowledge of the designated cycling routes and bike lanes.
- Not familiar at all - I was unaware that Nottingham had designated cycling routes and bike lanes.

What are the specific areas or situations where you feel riding on the pavement is necessary?

Have you encountered any challenges or concerns when riding on the road that led you to ride on the pavement?

What improvements or changes would make you more likely to ride on the road instead of the pavement?

- More bike lanes
- Better/Improved bike lanes
- Smoother Roads
- A free helmet
- Lower car speeds
- Other: