Behnam Dayyan
supervisor **Ioannis Chatzigiannakis**
co-supervisor **Viktor Malakuczi**

TechSafe Ride

Enhancing Safety in Shared E-Scooter Mobility (Smart System for User Behavior Analysis)

SAPIENZA
UNIVERSITÀ DI ROMA

Master of Science in
PRODUCT AND SERVICE DESIGN
a.y. 2022-2023

Final Work

Student
Behnam Dayyan
dayyan.1954580@studenti.uniroma1.it

Supervisor
Ioannis Chatzigiannakis
Co-Supervisor
Viktor Malakuczi

a.y. 2022-2023
Behnam Dayyan - TechSafe Ride
Master of Science in PRODUCT AND SERVICE DESIGN
SAPIENZA
UNIVERSITÀ DI ROMA

Master of Science in
Product and Service Design
a.y. 2022-2023

Faculty of Architecture

Title:
TechSafe Ride
Enhancing Safety in Shared E-Scooter Mobility (Smart system for user behavior Analysis)

Student:
Behnam Dayyan

Supervisor:
Ioannis Chatzigiannakis

Co-Supervisor:
Viktor Malakuczi

CONTENTS

PART ONE
RESEARCH

01
Introduction

Streets aren't solely reserved for cars anymore. They've transformed into a mixture of options for getting around, such as bikes, e-scooters, and personal devices. These micro-mobility choices offer people a convenient new way to travel within their neighborhoods. The significance of these small-scale mobility solutions for cities lies in their ability to promote eco-friendly and sustainable transportation. They've also been effective in decreasing the reliance on private cars, especially for short trips.

My research focuses on examining major companies providing shared electric micro-mobility services. I studied this within Italy, with a particular emphasis on Rome, and evaluated companies that are offering these shared e-mobility options in a sustainable manner.

I examined these companies from various perspectives: their environmental contributions, safety records, and innovative approaches. I also looked into the distinctive qualities of each company. Moreover, I explored the vulnerabilities of these shared micro-mobility services, including past accident statistics. From my findings, I developed three ideas aimed at reducing the occurrence of accidents, with one of these ideas showing particular promise.

My research delves into the safety aspects of shared electric micro-mobility in Italy. I analyzed real-world cases and statistical data to gain insights into the risks and challenges associated with these novel transportation methods. I gathered insights by reviewing official reports, articles, and documents, and conducted interviews and surveys with both users and non-users of these services. This comprehensive approach allowed me to delve into various perspectives and gather a well-rounded understanding of the safety dynamics associated with shared electric micro-mobility in Italy. Through these interviews and surveys, I aimed to capture real-world experiences and opinions, ensuring that my research is deeply rooted in the practical aspects of these transportation options. This blend of qualitative and quantitative data acquisition further enriched the scope of my investigation, offering a comprehensive view of the challenges and opportunities tied to these evolving modes of urban transportation. Through this comprehensive approach, I identified critical safety issues. These encompass the need for improved road infrastructure to support these services, enhanced user education for safety, and strategies to monitor and promote safe user behavior during their journeys.

The implications of my research extend beyond Italy's borders. The insights I've gathered can be valuable for policymakers and stakeholders worldwide who are interested in promoting environmentally friendly and secure urban transportation. The combination of academic research, empirical data, and practical recommendations ensures that the journey toward safer and more sustainable urban mobility is well-informed and collaborative.

In summary, the evolution of urban streets into diverse mobility hubs, including micro-mobility options like bicycles and e-scooters, presents an avenue for sustainable and convenient transportation. Through a comprehensive assessment of leading shared electric micro-mobility companies in Italy, this research highlights their environmental impact, safety measures, and innovation. By addressing vulnerabilities and proposing safety strategies based on past accidents and user feedback, this study offers insights applicable beyond borders. Policymakers and stakeholders globally can leverage these findings to promote safer, more eco-friendly urban transportation systems, fostering a future of enhanced mobility and sustainability.

01.1
Topic

For a more comprehensive understanding of the subject, it is essential to provide initial definitions of the following key terms:

Micromobilities: Referring to the utilization of lightweight vehicles, such as bicycles or scooters—particularly those powered by electricity—that are often available for short-term rental within urban environments. Operating at speeds typically below 25 km/h (15 mph), these vehicles are user-operated and differ from rickshaws. Examples of micromobility devices encompass bicycles, e-bikes, electric scooters, electric skateboards, shared bicycle fleets, and electric pedal-assisted (pedelec) bicycles.

"Electric-micro scooters," commonly known as e-scooters, represent a relatively nascent yet rapidly expanding mode of transportation across numerous European nations, particularly within larger cities. Based on our examination of 18 European countries, it can be inferred that e-scooters are legally permissible in the majority of these countries. This observation underscores their increasing acceptance and integration into urban transportation networks.

Safety of Electric Micro-mobilities: The Safety of Electric Micro-mobilities remains a paramount concern, particularly as the array of available products expands rapidly in terms of both popularity and diversity. This surge in innovative offerings necessitates an agile approach to adapting to the evolving landscape. Consequently, new safety standards are emerging to critically evaluate aspects such as battery safety, electrical systems, and charging mechanisms. Furthermore, a concerted drive to enhance the inherent safety of the hardware itself is essential to preempt potential accidents.

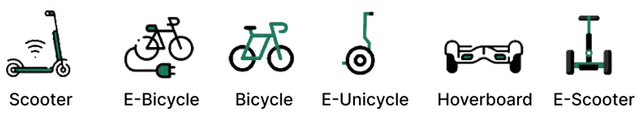
However, amidst the allure of convenience and the lithe nature characterizing these micro-mobility vehicles, it is essential to wholeheartedly acknowledge the latent risks they bear for users, pedestrians, and fellow road occupants. As a proactive measure, riders are not merely recommended, but indeed urged to don helmets and conduct meticulous inspections of the scooter's condition prior to embarking on their journey. This vigilant practice distinctly contributes to reducing the likelihood of untoward incidents, reinforcing the ethos of safety.

Moreover, one pivotal factor significantly contributing to accidents lies in the inconspicuous nature of these vehicles' near-silent operation. This auditory subtlety renders them virtually invisible to both other drivers and pedestrians, engendering a scenario that could potentially lead to inadvertent collisions.

In this context, the glaring lack of comprehensive training and education for riders assumes a critical role. Despite the transformative potential of micro-mobilities, a concerning gap exists in adequately equipping riders with the knowledge and skills necessary to navigate the urban landscape safely. This knowledge deficit is notably compounded by the fact that many users, enamored by the convenience and novelty of these modes of transportation, might underestimate the importance of formal training or adherence to safety guidelines. As a result, a considerable number of riders engage with these vehicles without proper understanding or awareness of road safety protocols, significantly escalating the inherent risks associated with micro-mobilities.

Equally significant is the necessity for vigilant monitoring of user behavior. The real-world utilization of micro-mobility vehicles demands a continuous assessment of how riders interact with these modes of transportation. Monitoring user behavior is instrumental in identifying risky patterns, as well as understanding common scenarios that could potentially lead to accidents. This data-driven insight can serve as a foundation for refining safety strategies and improving the overall design of micro-mobility systems. By tracking user behaviors, the research aims to create a proactive framework that minimizes potential hazards by instilling responsible riding practices and augmenting user awareness.

Micro-mobility refers to small, lightweight vehicles designed for short-distance travel. These vehicles are typically used for the "last mile" of a journey, connecting commuters from public transportation stations to their final destinations.



1.Riders using shared e-scooters in the main and historical center of Rome, including the area around the Colosseum.
2. Various types of vehicles fall under the category of micro-mobility

2

1

01.2
Electric Scooter History
Timeline of the Revolution

The accelerating integration of electric scooters into the fabric of urban life is not just altering the way we travel but is also weaving itself into the cultural and environmental tapestry of our cities. The sleek design and eco-friendly nature of these two-wheel wonders have transformed them from mere vehicles into symbols of a collective yearning for change, symbolizing a departure from the era dominated by noisy combustion engines.

What initially began as a practical response to environmental concerns has blossomed into a cultural phenomenon, marking a paradigm shift in the collective consciousness of urban residents. The almost silent purr of electric scooters encapsulates a shared desire for a quieter, cleaner, and more interconnected urban experience. This transformation is a testament to the idea that the evolution of transportation is not solely a result of technological progress but is intricately linked to the values and preferences of the people it serves.

In a world where cities grapple with limited space and escalating environmental challenges, electric scooters emerge as a solution harmonizing seamlessly with the contemporary ethos of sustainable living. The efficiency, cost-effectiveness, and environmental responsibility associated with electric scooters are propelling them from a niche concept to a mainstream choice. This silent revolution is not only reshaping the physical landscape of cities but is also challenging manufacturers and policymakers to adapt to this new era of urban mobility.

At the heart of this revolution is consumer demand, actively steering the course of innovation. The integration of electric scooters into daily routines underscores the idea that consumers are not passive recipients of technology but are active participants in shaping the future of urban mobility. This shift in perspective carries far-reaching implications, compelling manufacturers to prioritize sustainability, connectivity, and user experience in their designs. Technological advancements, particularly in battery efficiency, lightweight materials, and smart connectivity, have played a pivotal role in the evolution of electric scooters. What were once considered novelty vehicles have now become indispensable components of the urban transit ecosystem. The dynamic interplay between technological progress and consumer demand exemplifies a cycle of innovation, where breakthroughs in one sector propel transformative changes in another, consistently pushing the boundaries of what is conceivable.

As we peer into the future, the electric scooter narrative not only promises continued evolution but also hints at broader societal and infrastructural transformations. As electric scooters seamlessly integrate into urban life, city planners are compelled to reconsider infrastructure design, giving rise to dedicated lanes, charging stations, and a more interconnected urban environment. This ripple effect underscores the electric scooter's role not merely as a mode of transportation but as a catalyst for reimagining and reshaping urban spaces to accommodate and encourage sustainable alternatives.

In essence, the electric scooter transcends its utilitarian function as a means of transportation; it signifies a cultural and technological paradigm shift. It beckons us to envision a future where electric scooters actively contribute to a sustainable, interconnected urban ecosystem. As the narrative unfolds, electric scooters are poised to continue playing a pivotal role in shaping the way we move, live, and perceive the urban landscape, heralding a dynamic and transformative future for urban mobility.

Throughout this timeline, scooters evolved from manual, kick-powered models to motorized versions, and eventually to electric scooters that are widely used for short-distance transportation in urban environments. The adoption of e-scooter sharing systems represents a significant development in recent years, contributing to the growth of micro-mobility options in cities globally.

3.The photos depict the timeline from the invention of traditional scooters to the development of e-scooters today.

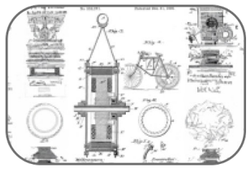
1817 — First velocipede invented by Karl Drais

1857 — First pedal-driven bicycles (called Pennyfarthing)

1886 — First chain-drive bicycles invented in Coventry, England

1887 — First pneumatic tire invented by John Dunlop

1895 — First battery-powered bicycle patented by Ogden Bolton



1915 — First motorized scooter released called Autoped

1936 — Cushman Auto Glide motorized scooter release with some success

1974 — Honda releases Kick'N Go, a three wheel kick scooter for children

1976 — Prototype for an E-Motorcycle scooter released called Papoose

1994 — The Kickbike is invented (a mix between a scooter and a bike)

2001 — The Segway is released

1996 — Wim Oubuter starts Micro Mobility, and reinvents modern kick scooters

2016 — The Xiaomi M365 is released, and Bird and Lime begin using it

2018 — The "scooter wars" are fought between ride-sharing companies, and also a lot of legal troubles for scooters appear

2021 — A golden age of electric scooters ensues, they are legal almost everywhere, affordable, and reliable

3

01.3 Overview

The Shared E-Scooter Industry in Italy has undergone rapid expansion in recent years, witnessing the entry of numerous operators offering their services across diverse cities. Among the notable players in the Italian e-scooter sharing landscape are Lime, Bird, Tier, Helbiz, Dott, and VOI. As of 2021, Rome emerges as the city with the highest volume of shared e-scooters accessible for public use, boasting an approximate fleet of 7,000 e-scooters from various operators. Following suit is Milan, where approximately 5,000 e-scooters are available. While cities such as Turin, Bologna, Florence, Naples, and Palermo have also embraced e-scooter sharing services, their e-scooter inventory remains comparatively lower than that of Rome and Milan.

A comprehensive study conducted by the European Cyclists' Federation in 2020 revealed that a staggering 74% of urban residents surveyed in Italy consider e-scooters a commendable alternative to traditional vehicles. Notably, this sentiment underscores a notable preference for e-scooters as an eco-friendly mode of transport. However, this study concurrently unveiled apprehensions regarding safety. Specifically, 66% of respondents expressed concerns about the potential risks posed by e-scooters, not just for riders but also pedestrians. An additional survey, conducted by Helbiz—an e-scooter sharing company—found that 90% of respondents in Italy believe e-scooters contribute positively to urban mobility. Impressively, 73% of participants considered e-scooters a more sustainable alternative to conventional cars.

However, a contrasting facet emerges through a study conducted by the Italian Consumer Association (Codacons) in 2019. Shockingly, only 11.6% of e-scooter riders in Rome adhered to the legal requirement of wearing helmets, exposing a significant lapse in safety compliance. Delving deeper into the behavior of e-scooter riders in Rome, this study underscored the glaring non-compliance with mandatory helmet usage. The majority of riders, despite legal mandates, chose not to wear helmets. This highlights a significant concern in enforcing safety regulations, particularly helmet usage, and underscores the need for stricter implementation to mitigate the prevalence of accidents and associated injuries.

Crucially, the percentage of e-scooter riders wearing helmets can vary significantly, contingent upon factors such as city dynamics and operator policies. Nevertheless, wearing helmets remains an imperative measure for safeguarding e-scooter riders' well-being, substantially diminishing the potential for head injuries in the event of accidents. Drawing upon data from the Italian Road Safety Observatory (OSR) in 2020, it emerges that car involvement in e-scooter fatalities accounted for 80% of such incidents in Italy. The report scrutinized accident data from 2015 to 2019, revealing that collisions with vehicles, particularly cars, constituted the predominant cause of e-scooter accidents. Interestingly, falls also emerge as a substantial risk factor, comprising 45% of all e-scooter accidents according to the same OSR report. This underscores the paramount importance of user education and awareness campaigns to foster safer e-scooter practices. These findings collectively point to the necessity for comprehensive safety measures. This includes enforcing helmet usage, promoting rider education, and ameliorating road safety to prevent accidents and usher in a safer, more sustainable era of urban mobility in Italy.

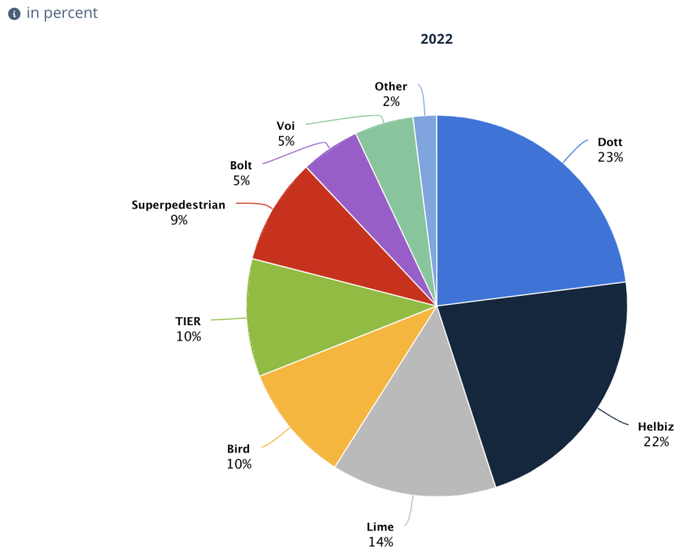
In response to safety concerns surrounding e-scooter usage in Italy, various operators have implemented innovative technological solutions. One notable development is the integration of Artificial Intelligence (AI) in e-scooter systems. AI algorithms analyze real-time data, such as traffic patterns and user behavior, to identify potential safety hazards. This allows for proactive measures, such as adjusting e-scooter speeds or sending alerts to riders in high-risk areas, contributing to a more secure riding experience.

Additionally, the Italian government has been exploring collaborations with urban planning experts and city architects to create designated e-scooter lanes and zones. These specialized areas aim to separate e-scooter traffic from pedestrians and traditional vehicles, reducing the likelihood of accidents. Integrating e-scooter infrastructure into urban planning reflects a forward-looking approach to accommodate the evolving needs of sustainable transportation.

In an effort to further improve safety awareness, some e-scooter operators have introduced virtual reality (VR) training modules. These modules simulate various riding scenarios, allowing users to experience potential challenges and hazards in a controlled environment. VR training not only enhances rider competence but also instills a heightened awareness of safety considerations, fostering a culture of responsible e-scooter use.

Moreover, the Italian government, in collaboration with e-scooter companies, is exploring the possibility of implementing a national e-scooter safety certification program. This program would require riders to undergo a brief training session, covering safety protocols and regulations, before being allowed to use e-scooters. Such certification initiatives aim to ensure that riders are well-informed about safety measures, ultimately contributing to a safer urban mobility landscape.

These recent developments highlight the dynamic nature of the e-scooter industry in Italy, with a focus on leveraging technology, infrastructure improvements, and educational initiatives to enhance safety and foster responsible e-scooter usage.



Most recent update: Mar 2023

Source: Statista Market Insights

4

The graph illustrates the main key players in the market of shared e-scooters in Italy, with Doot holding the largest share at 23%, closely followed by Helbiz at 22%.

4.The graph illustrates the main key players in the market of shared e-scooters in Italy.

01.4
conclusion

In conclusion, the evolution of the shared e-scooter industry in Italy has been a compelling journey marked by rapid growth and transformative potential. With the presence of prominent operators like Lime, Bird, Tier, Helbiz, Dott, and VOI, these electric scooters have become increasingly accessible, particularly in major cities such as Rome and Milan. Public perception reflects a complex interplay of enthusiasm for e-scooters as a sustainable alternative to traditional transportation and apprehensions regarding safety. Surveys conducted by the European Cyclists' Federation and Helbiz reveal that many Italians view e-scooters favorably in terms of urban mobility and environmental impact. However, concerns persist, with a significant portion of respondents highlighting safety risks associated with e-scooter usage. A critical aspect of this safety concern relates to helmet usage, with a stark contrast between legal mandates and actual compliance. A study by the Italian Consumer Association found alarmingly low adherence to helmet laws among e-scooter riders in Rome. This underscores the need for stringent enforcement and public awareness campaigns to promote helmet use and safer riding practices.

Moreover, accident data analyzed by the Italian Road Safety Observatory exposes the substantial risks faced by e-scooter riders, particularly in collisions with cars and through falls. These findings underscore the urgency of enhancing road safety measures, including dedicated bike lanes and speed limits, to mitigate accidents and protect vulnerable road users. As Italy continues to embrace e-scooters as a mode of urban transportation, it becomes imperative to foster a culture of responsibility, education, and safety among riders. Encouraging helmet usage, promoting adherence to traffic rules, and raising awareness of the risks associated with e-scooter usage are paramount steps in this direction. Ultimately, the shared e-scooter industry in Italy represents a dynamic and transformative force in urban mobility. By addressing safety concerns, enhancing infrastructure, and promoting responsible riding practices, Italy can harness the full potential of e-scooters as a sustainable and safe mode of transportation, contributing to a more eco-friendly and efficient urban landscape.

6

The majority of scooters are readily available for use in the historical center of Rome, with a particular concentration near iconic monuments and historical landmarks. This accessibility contributes to the convenience and ease of transportation for both locals and tourists navigating the rich tapestry of historical sites that define the heart of the city. Whether exploring the ancient wonders surrounding the Colosseum, traversing the cobblestone streets near the Pantheon, or meandering through the historic squares and fountains, the presence of scooters enhances mobility and provides a flexible means of transportation in these culturally significant areas. This not only aligns with the modern trend of micro-mobility solutions but also aligns with the practical needs of individuals seeking efficient and sustainable modes of travel amid the historical splendor of Rome's city center.

5

5.Bird shared E-Scooter - Colosseum - Rome - Italy.
6. Dott shared E-Scooter - Sant Angelo - Rome - Italy.
7. Link shared E-Scooter - Piazza Venezia - Rome - Italy.

7

02
Case studies and Methodology

In the exploration of shared e-scooters in Italy, the research conducted an in-depth benchmark analysis of eight prominent companies: Lime, Link, Tier, Helbiz, Bird, Voi, Dott, and Bolt. These selections were made based on their significant influence as key players in the Italy market, focusing on three key pillars: Sustainability, Safety, and Innovation.

Sustainability practices within each company were rigorously examined, encompassing aspects such as electric-powered vehicles, responsible manufacturing, and eco-friendly materials. The findings were meticulously documented and presented in a benchmark map and table, offering a comprehensive overview of sustainability initiatives. The safety of riders and pedestrians in the micro-mobility landscape was a critical consideration. The research conducted an extensive analysis of safety measures implemented by these companies, including user well-being, regulatory adherence, and technological innovations. Outcomes were methodically compiled and presented alongside sustainability data in the benchmark map and table. The innovative strategies of micro-mobility companies were scrutinized to understand technological advancements shaping the industry. The research provided insights into current technological features and future trajectories of micro-mobility innovation.

Complementing the benchmark analysis, the research extended to field studies in prominent tourism spots in Rome, aiming to identify practical challenges associated with shared e-scooters. On-site observations and user engagement bridged the gap between theoretical analyses and real-world challenges. A meticulously crafted questionnaire, a crucial tool in this research initiative, aimed to gather diverse insights from participants. Focusing on micro-mobilities, the questionnaire explored various dimensions, including user experiences, training needs, and a statistical examination of accidents, transcending nuanced qualitative data obtained through interviews. Building upon these insights, the research identified a user persona and meticulously analyzed the user journey before and after suggested improvements, shedding light on the evolving dynamics of user interactions with shared e-scooters. The intricacies of the micro-mobility system were explored through the construction of System Maps and Stakeholders Analysis. The before-and-after comparison elucidated how the old system and proposed improvements functioned within the larger ecosystem, providing a comprehensive understanding of operational dynamics and stakeholder influence.

The empirical exploration was preceded by a thorough preliminary research phase, including a review of existing literature, industry reports, and insights from urban planning experts. This foundational step informed initial hypotheses and conceptual frameworks, setting the stage for the comprehensive study of micro-mobility dynamics in Italy.

Shared micromobility refers to a transportation service where lightweight, compact vehicles are made available for short-distance travel, often on a temporary basis. These vehicles, such as electric scooters and bikes, can be accessed and rented by users for one-way trips through a network of available units. Users typically locate, unlock, and pay for these vehicles using a smartphone app. Shared micromobility services aim to provide convenient and sustainable transportation options, especially for the "last mile" of a journey, reducing reliance on personal cars and promoting environmentally friendly urban mobility.

8.Explanation of Shared Micromobility

What is Shared Micromobility?

Shared Micromoblity encompasses all shared-use fleets of small, fully or partially human-powered vehicles such as bikes, e-bikes, and e-scooters.

Station-based bike share
(including e-bikes)

Dockless bike share
(including e-bikes)

Scooter share

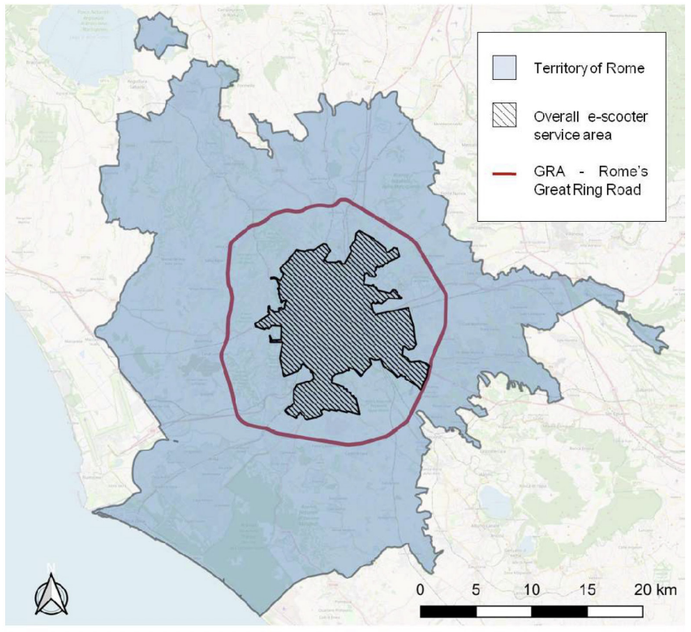
8

02.1
Benchmark

In this comprehensive exploration, we have undertaken an extensive analysis of eight major micro-mobility companies that stand as key players in both the European and US markets. Lime, Link, Tier, Helbiz, Bird, Voi, Dott, and Bolt have been chosen for their significant influence in shaping the landscape of shared scooters and bicycles across these regions. This multifaceted study goes beyond a mere examination of the companies' market presence, extending into various dimensions such as sustainability, safety measures, technological innovations, and their envisioned role in fostering an environmentally conscious future. The sustainability facet of our investigation has delved into the companies' environmental practices and commitments. This includes scrutinizing their efforts to minimize carbon footprints, employ electric-powered vehicles, implement responsible manufacturing processes, and utilize eco-friendly materials. By dissecting these sustainability initiatives, we gain a nuanced understanding of how each company contributes to the broader goal of creating eco-friendly urban transportation systems.

In addition to assessing sustainability, our study rigorously examines the safety measures implemented by these micro-mobility giants. The safety of riders and pedestrians is of paramount importance in the micro-mobility sector, and our analysis delves into the specific measures each company has taken to ensure secure and responsible operations. An essential aspect of our research involves a deep dive into the innovative technologies that characterize these micro-mobility companies. We explore not only the current state of shared scooters and bicycles but also the ongoing technological advancements that distinguish these companies in the ever-evolving micro-mobility landscape. This comprehensive examination allows us to understand the technological trajectory of the micro-mobility industry and its potential impact on urban transportation.

Furthermore, our study extends into the future vision of each company. By investigating their long-term goals and environmental aspirations, we gain insights into how these industry leaders envision their role in shaping a sustainable and eco-friendly urban future. This forward-looking perspective is pivotal for understanding the companies' commitment to continuous improvement and their contributions to broader environmental and societal objectives. The holistic approach of this study not only equips us with a nuanced understanding of the positive and negative aspects of micro-mobility but also positions us to envision potential improvements and advancements. By recognizing areas for growth and addressing challenges, we pave the way for a more robust and sustainable future for micro-mobility. This, in turn, aligns these innovative transportation solutions with broader environmental, social, and urban planning goals, establishing them as integral components of a forward-thinking and environmentally conscious urban landscape.



9.Territory of the Italian city of Rome with highlighted the area covered with service by at least one e-scooter sharing company.

9

Benchmark

Description

This benchmark is based on the main micromobility companies which their electronic vehicles are mostly used in Europe and America. This research is classified in 3 main categories which are Sustainability, Safety, Innovation. There are 6 criterias (Carbon footprint, Material recycling, Accident prevention, Hardware safety, Intelligent vehicle, Hardware technology), which defined in order to compare and analyze better each companies in area of Sustainability, Safety and Innovation.

Criteria

Carbon footprint is the total amount of greenhouse gases (including carbon dioxide and methane) that are generated by our actions.

Material recycling is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products.

Accident prevention includes all measures taken in an effort to save lives, escape from injury, lessen the degrees of injury, avoid damage to property, reduce treatment and compensation costs, and prevent the loss of productive time and morale.

Hardware safety includes designing each peace of product or designing accessories like helmet, gloves and etc.. in order to have a safer vehicle and protect drivers from accidents.

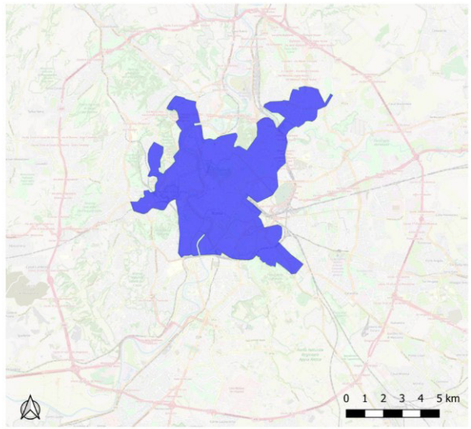
Intelligent vehicle technologies comprise electronic, electromechanical, and electromagnetic devices - usually silicon micromachined components operating in conjunction with computer-controlled devices and radio transceivers to provide precision repeatability functions.

Hardware technology includes any technology such as smart object or material design technologies that can improve and update a product.

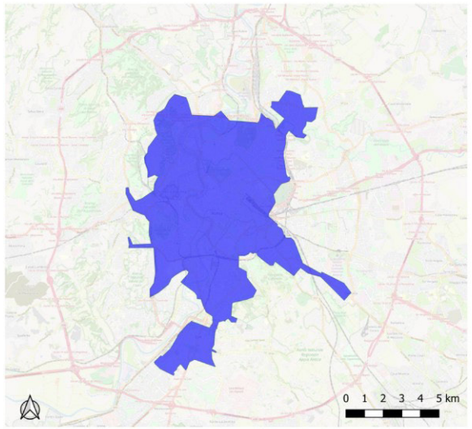
Each filled cube is equal to 20% of 100%

Yes

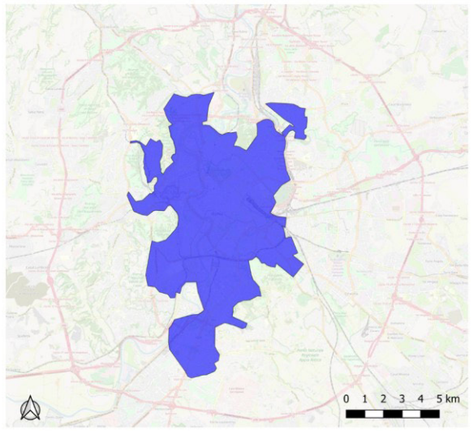
No



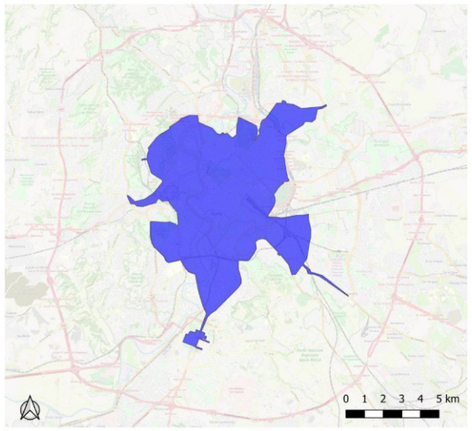
(a) BIRD's service area



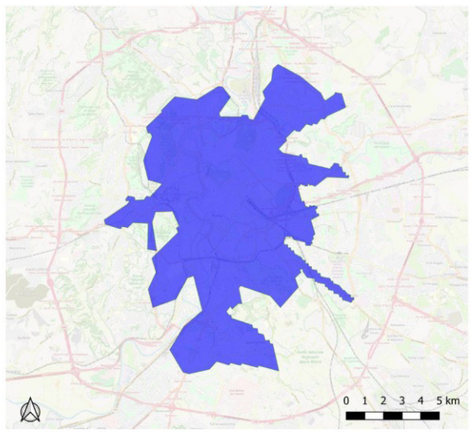
(b) DOTT's service area



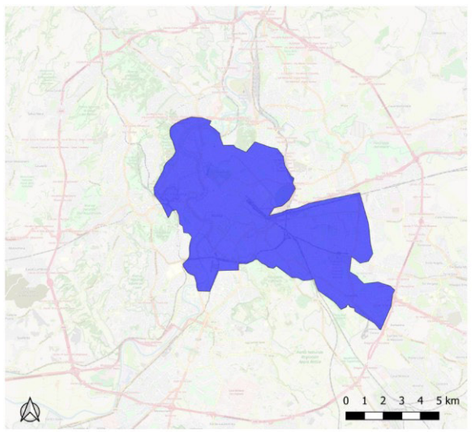
(c) HELBIZ's service area



(d) LIME's service area



(e) LINK's service area



(f) WIND's service area

10

10.Visualization of the service areas of the considered six e-scooter sharing companies

HELBIZ

E-Scooter

E-Bicycle

E-Moped

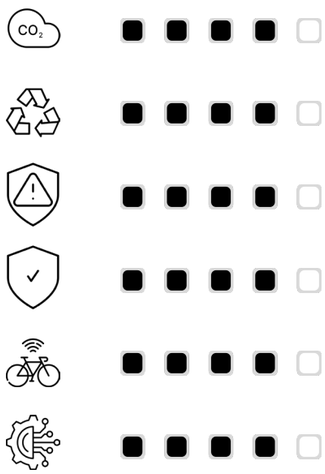
Abstract

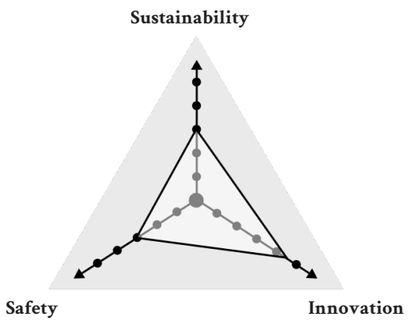
Helbiz, Inc., an intra-urban transportation company, provides micro-mobility services in Italy and the United States. It operates through Mobility, Media, and All Other segments. The company offers e-scooters, e- bikes, and e-mopeds. Helbiz, is an Italian-American intra-urban transportation company headquartered in New York City with an aim to solve the first mile/last mile transportation problem of high-traffic urban areas around the world. Helbiz was founded on 16 October 2015 by Italian serial entrepreneur, Salvatore Palella and is the first company to introduce the shared electric scooter model in Italy as early as October 2018 through legalization and regulation of the electric scooters in Italy.

Developing Features

- Artificial intelligence (Innovation)
- Rider safety (Safety)
- Smart Fleet (Innovation)
- User Privacy and Security (Safety)

Criteria





BIRD

E-Scooter ■
E-Bicycle ■
E-Moped □

Abstract

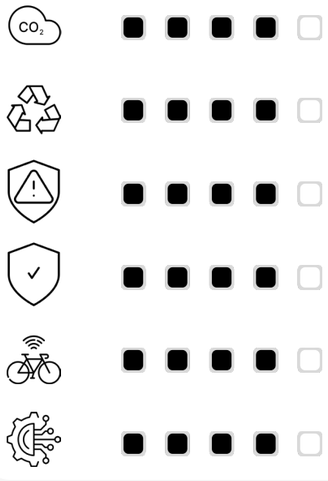
Bird Global, Inc. is a micromobility company based in Miami, Florida. Founded in September 2017, Bird has distributed electric scooters designed for short-term rental to over 400 cities. Bird was founded in September 2017 by Travis VanderZanden, formerly an executive at Lyft and at Uber. In October 2018, Bird announced its Bird Zero vehicle. The Bird Zero was designed for ride sharing with "more battery life for longer range, better lighting for increased visibility, and enhanced durability for a longer life-span.

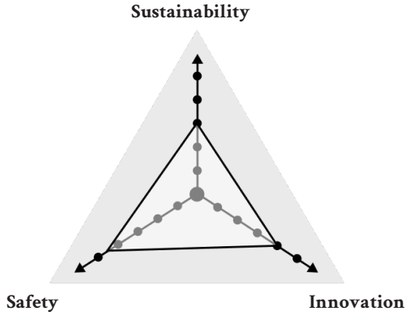
The company halted operations in six US cities (San Francisco, San Jose, Sacramento, Portland, Miami, and Coral Gables), as well as European markets, including Annecy, Antwerp, Barcelona, Berlin, Cologne, Frankfurt, Hamburg, Krakow, Lisbon, Lyon, Madrid, Marseille, Munich, Paris, Rimini, Rome, Sevilla, Stockholm, Torino, Verona, and Vienna.

Developing Features

- Shock-less scooter tires (Safety)
- Reducing environmental footprint (Sustainability)
- Carbon Neutrality (Sustainability)
- Skid detevtion (Safety)

Criteria





LIME

E-Scooter ■
E-Bicycle ■
E-Moped ■

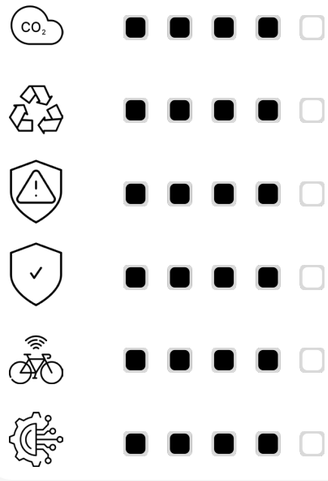
Abstract

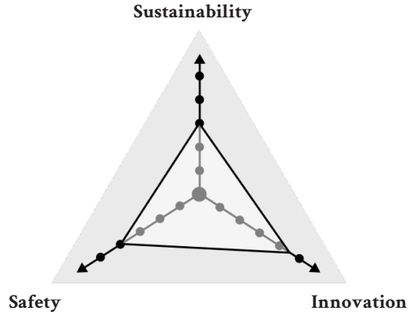
Neutron Holdings, Inc., doing business under the name Lime, formerly LimeBike, is a transportation company based in San Francisco, California. It runs electric scooters, electric bikes and electric mopeds in various cities around the world. The system offers dockless vehicles that users find and unlock via a smartphone app that knows the location of available vehicles via GPS. European Union lime production is mainly concentrated in the Mediterranean region. Spain, and Italy which represents 80% of the overall production of lime in the European Union. Lime is transitioning their operations globally to zero-emission vehicles, including electric vans and cargo bikes. They'll be fully electric across Europe in 2022 and will aggressively phase out their existing leased vehicles by 2023 across the rest of the world.

Developing Features

- Footboard's design (Safety)
- Gen4 Fleet (Innovation)
- Carbon free future (Sustainability)
- sidewalk riding detection (Innovation/Safety)
- wheel's design (Safety)
- redundant brakes (Safety)

Criteria





TIER

E-Scooter ■
E-Bicycle ■
E-Moped ■

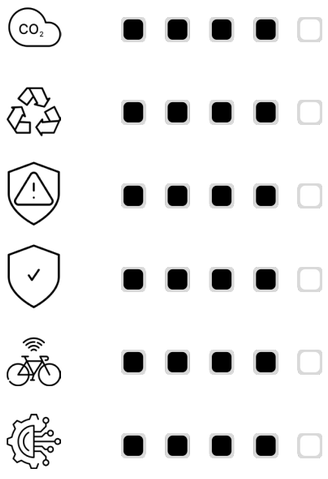
Abstract

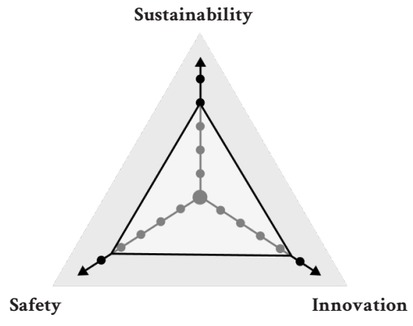
Tier Mobility is Europe's leading shared micro-mobility provider, with a mission to Change Mobility for Good. By providing people with a range of shared, light electric vehicles, from e-scooters to e-bikes, TIER helps cities reduce their dependence on cars. TIER Mobility operates in 85+ cities in 10 countries. The company is headquartered in Berlin and employs about 900 people. Founders of the company are Lawrence Leuschner, Matthias Laug. and Julian Blessin.
As part of its commitment to sustainability, the company has adopted the United Nations' Sustainable Development Goals (SDGs) as a guiding framework and has set a clear agenda for reducing and offsetting emissions. As a result of these measures, TIER Mobility has been a climate-neutral company since January 2020.

Developing Features

- Accident prevention (Safety)
- Swappable batteries (Innovation)
- Fully climate neutral (Sustainability)
- in-App safety (Safety)

Criteria





LINK

E-Scooter ■
E-Bicycle ■
E-Moped ■

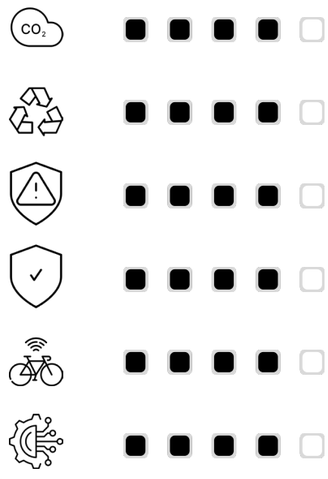
Abstract

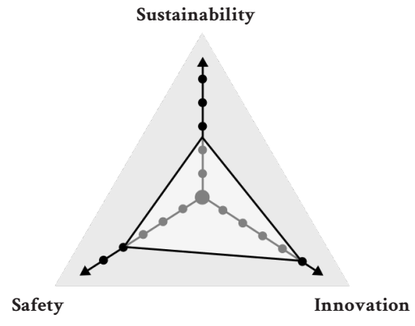
Link is a shared electric scooter designed, engineered, manufactured and operated by Superpedestrian. During prototype road-testing, it was called "the Volvo of e-scooters" for its robust build quality. The LINK scooter features an operating system that can be updated wirelessly, over-the-air. The company spend 8 years creating Vehicle Intelligence, their core technology, which makes micromobility sustainable, efficient, and safe at scale. Vehicle Intelligence enables them to invest in their workers with stable jobs, focus on community partnerships, and operate across entire cities.

Developing Features

- Wider and longer deck (Safety)
- vehicle intelligence (Innovation)
- three independent brakes (Innovation)
- High-visibility colors, lights, reflectors (Safety)
- Long-range battery (Innovation)
- Tip-over detection (Safety)

Criteria





VOI

E-Scooter ■
E-Bicycle ■
E-Moped ■

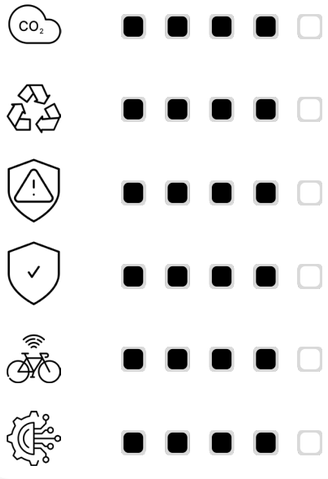
Abstract

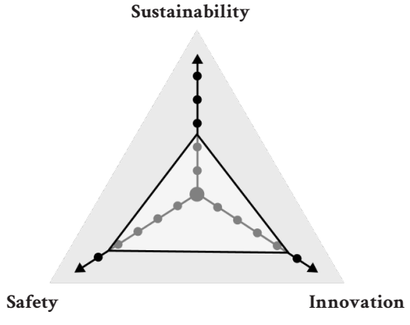
Voi is a micro-mobility startup that provides electric scooters for last-mile transportation. Douglas Stark, Filip Lindvall, and Fredrik Hjelm founded it in 2018. Its headquarters is located in Stockholm in Sweden. Fredrik Hjelm, co-founder and CEO of Voi Technology, said in a statement: “There is no doubting that micromobility is here to stay and Voi intends to be the go-to mobility platform in Europe for cities that want to give their residents and visitors an integrated, smart mode way to travel.
Their CE certificated scooters are assembled at their production warehouses in Sweden, Germany and Spain, by Voi employees they train internally. The scooters are deployed into the city streets.

Developing Features

- time-bound passes campaign (Safety)
- Carbon-neutral mobility service (Sustainability)
- Extending vehicle lifespan (Sustainability)
- Zero Emission operationes (Sustainability)
- Road safety module (Safety)
- Material recycling (Sustainability)
- Circularity (Sustainability)

Criteria





DOTT

E-Scooter ■
E-Bicycle ■
E-Moped ■

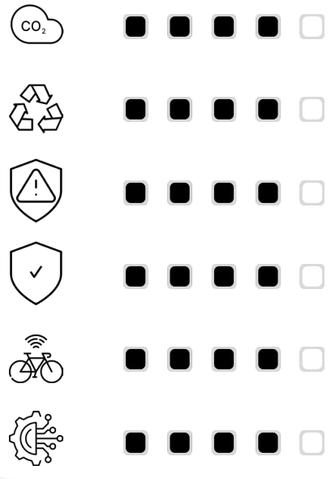
Abstract

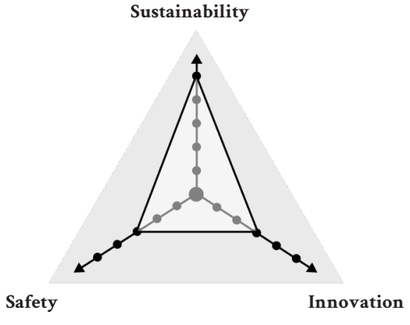
Dott is a Dutch-French micromobility company based in Amsterdam which was founded in January 2019 by Henri Moissinac and Maxim Romain. Dott operates over 30,000 shared electric scooters and electric bikes in 17 cities in Europe. The company was selected along with companies TIER and Lime to participate in a year-long trial of the use of e-scooters as a method of transportation in London. It will deploy up to 6,600 scooters there during the course of the trial, which will be available for rental use via an app.

Developing Features

- Double brake system (Safety)
- Extend vehicle lifespan (Sustainability)
- 100% electric logistics fleet (Sustainability)
- recycle 100% of used vehicle (Sustainability)

Criteria





BOLT

E-Scooter ■

E-Bicycle ■

E-Moped ■

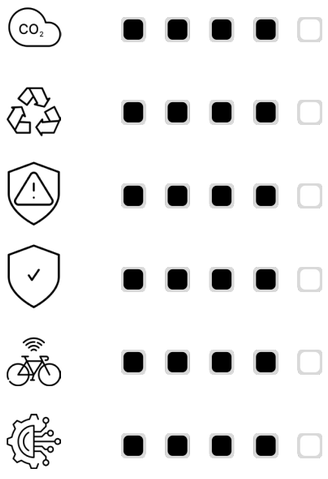
Abstract

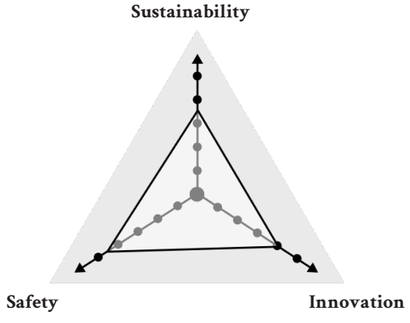
Bolt is an Estonian mobility company that offers vehicle for hire, micromobility, car-sharing, and food delivery services headquartered in Tallinn and operating in over 500 cities in more than 45 countries in Europe, Africa, Western Asia and Latin America. In March 2019, and in 2020, Bolt was ranked third in the FT 1000: Europe's Fastest Growing Companies published by the Financial Times

Developing Features

- Hardware safety (Safety)
- CO2 offsetting projects (Sustainability)
- Sustainable operations (Sustainability)
- recycling materials (Sustainability)
- Rider education (Safety)
- In-app safety (Safety)
- Accident prevention (Safety)

Criteria

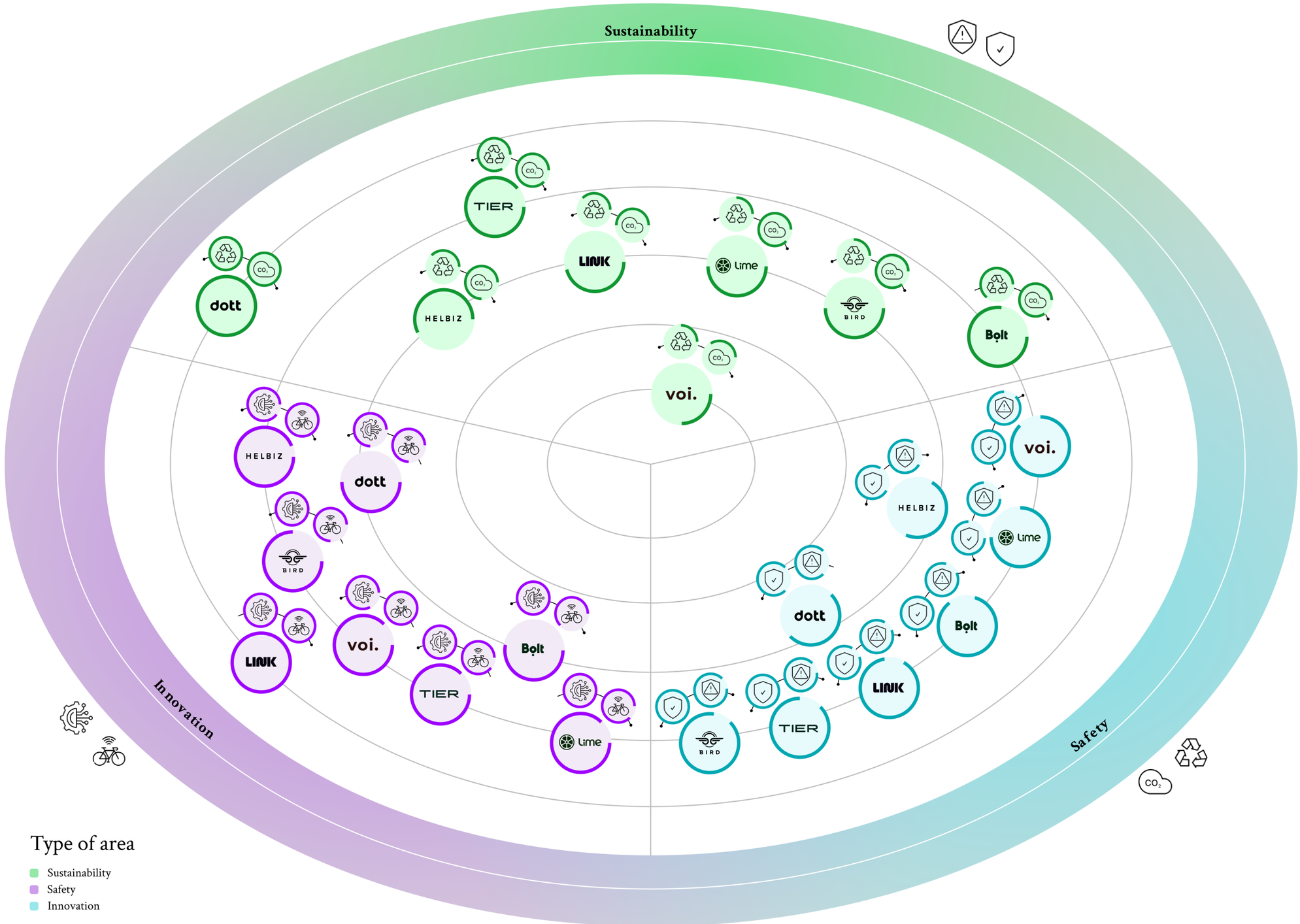




02.3
Benchmark Map 1

Criteria

- Carbon footprint
- Material recycling
- Accident prevention.
- Hardware safety
- Intelligent vehicle technologies
- Hardware technology



Map 1 in the benchmark illustrates the categorization of all case studies into three distinct categories: Sustainability, Safety, and Innovation. This categorization takes into account specific criteria for each category, such as Carbon footprint and Material recycling for Sustainability, Accident prevention and Hardware safety for Safety, and Intelligent vehicle technologies and Hardware technology for Innovation.

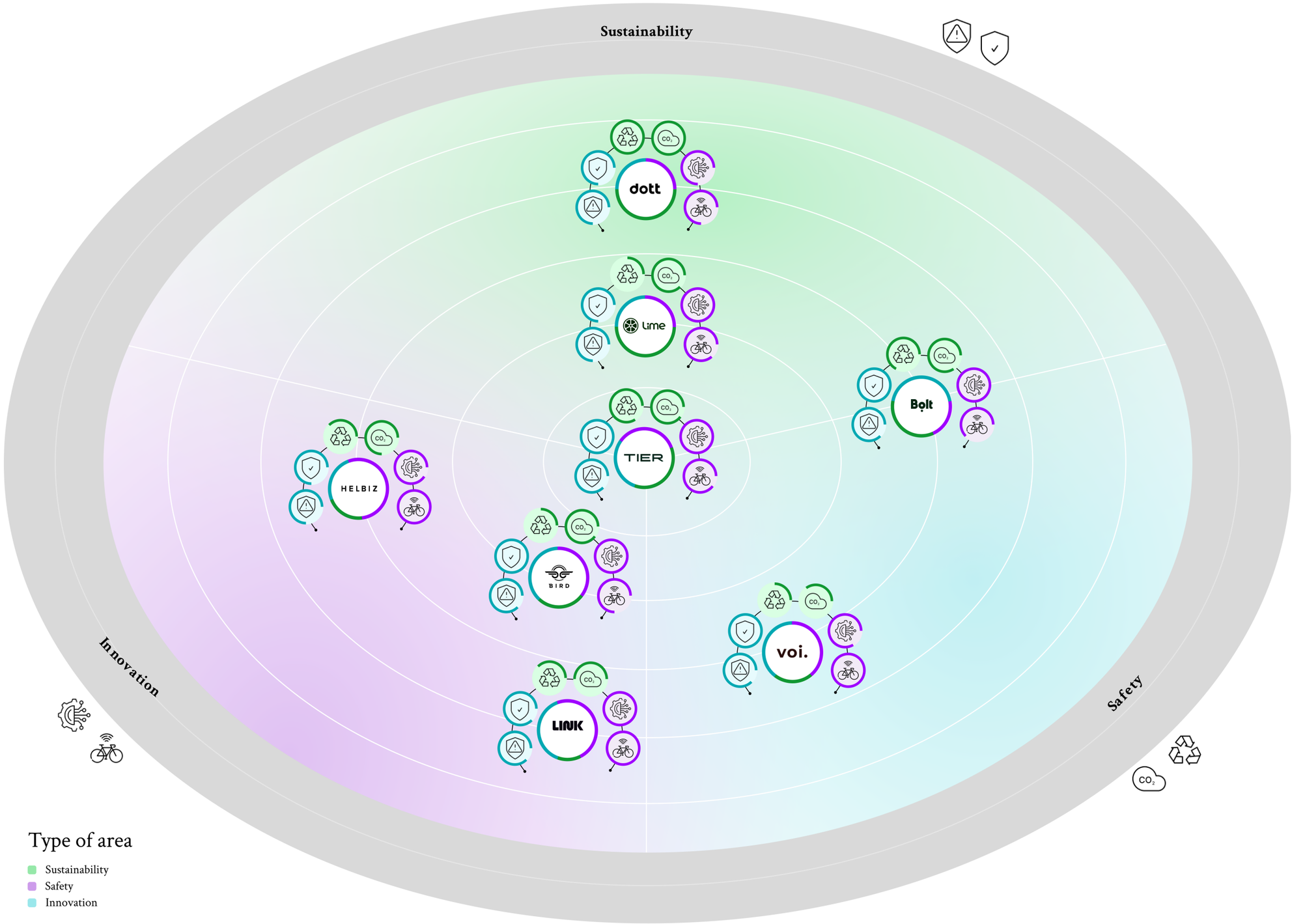
Type of area

- Sustainability
- Safety
- Innovation

02.3
Benchmark Map 2

Criteria

- Carbon footprint
- Material recycling
- Accident prevention.
- Hardware safety
- Intelligent vehicle technologies
- Hardware technology



Map 1 in the benchmark visually represents the classification of all case studies into three overarching categories: Sustainability, Safety, and Innovation.

Type of area

- Sustainability
- Safety
- Innovation

02.4
Benchmark Table

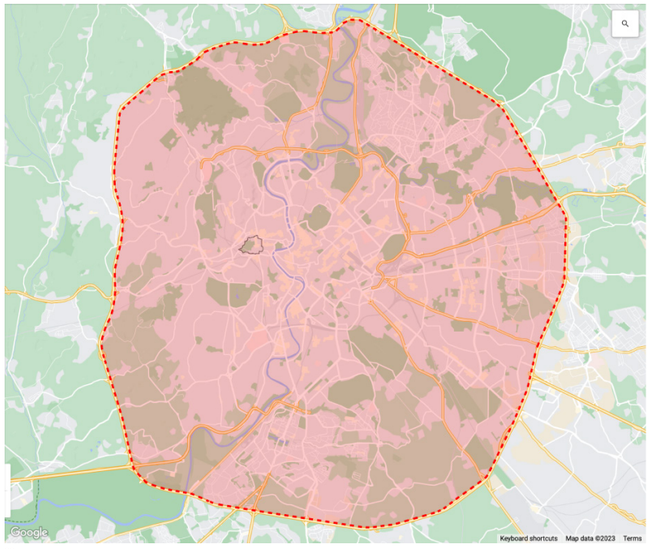
	dott	lime	Bolt	HELBIZ	TIER	BIRD	voi.	LINK
Device Model	E-Scooter ■ E-Bicycle ■ E-Moped □	E-Scooter ■ E-Bicycle ■ E-Moped □	E-Scooter ■ E-Bicycle ■ E-Moped □	E-Scooter ■ E-Bicycle ■ E-Moped ■	E-Scooter ■ E-Bicycle ■ E-Moped ■	E-Scooter ■ E-Bicycle ■ E-Moped □	E-Scooter ■ E-Bicycle ■ E-Moped □	E-Scooter ■ E-Bicycle □ E-Moped □
Carbon Footprint	High	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Material Recycling	High	Low	Medium	Low	Medium	Low	Low	Low
Accident Prevention	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Hardware Safety	Medium	Medium	High	Medium	High	High	High	High
Intelligent Vehivle	Medium	Medium	Medium	High	Medium	Medium	High	High
Hardware Technology	Medium	High	High	Medium	High	High	Medium	High
Link	https://ridedott.com	https://www.li.me	https://bolt.eu/it-it/	https://helbiz.com	https://www.tier.app	https://www.bird.co	https://www.voi.com	https://superpede-strian.com

The comprehensive benchmark table meticulously presents the evaluation of each company across six fundamental criteria, namely Sustainability, Safety, and Innovation. This systematic categorization considers specific metrics for each category, ensuring a thorough and detailed analysis. Within the Sustainability category, the evaluation encompasses critical aspects such as Carbon footprint and Material recycling, shedding light on each company's environmental commitment. In the Safety category, the assessment delves into Accident prevention and Hardware safety, providing insights into the measures implemented to ensure the well-being of users. The Innovation category scrutinizes Intelligent Vehicle Technologies and Hardware technology, offering a nuanced understanding of the companies' technological advancements. This structured and detailed evaluation framework aims to capture the diverse dimensions of each company's performance, fostering a comprehensive perspective on their contributions to the micro-mobility landscape.

03
Field Study and Observation

The research expanded its scope by venturing into field studies conducted in prominent tourism spots in Rome. This strategic extension aimed to gain firsthand insights and identify practical challenges associated with the utilization of shared e-scooters in real-world, high-traffic scenarios. By immersing itself in the dynamic environment of popular tourist destinations, the research sought to bridge the gap between theoretical analyses and the tangible challenges encountered by users and operators within the micro-mobility landscape.

Through on-site observations and direct engagement with users, the research aimed to unearth nuanced issues related to shared e-scooter usage. Factors such as user behavior, infrastructure compatibility, and the interplay between tourists and local residents in utilizing these micro-mobility solutions were carefully examined. By focusing on tourism spots, the research acknowledged the unique challenges that arise in areas with diverse user demographics and varying levels of familiarity with shared e-scooter services.This field study not only enriched the research with practical insights but also provided a contextual understanding of how shared e-scooters integrate into the daily dynamics of a tourist-heavy environment. The findings from these field studies were instrumental in informing subsequent analyses and recommendations, ensuring that the research outcomes are rooted in the real-world challenges faced by users and operators in Rome's tourism hubs.



11

The research conducted on-site field studies in prominent tourism spots in Rome, including Colosseo, Piazza Venezia, Fontana di Trevi, and the Pantheon. These observations aimed to identify practical challenges associated with shared e-scooters in high-traffic and iconic locations. The study focused on aspects such as user behavior, scooter parking, safety considerations, and the integration of micro-mobility solutions within the historical and architectural context. By examining specific sites, the research sought to capture site-specific nuances and provide valuable insights into the real-world challenges faced by users and operators in these iconic destinations.

12

11.Territory of the Italian city of Rome.
12. Tourism spot in Rome which is chosen for field study and observation.

03.1
Result of Observation

In the heart of Rome, where ancient history meets modernity, the introduction of electric scooters, or e-scooters, has woven a tapestry of convenience and complexity. While these zippy two-wheelers promise an eco-friendly and accessible mode of transport, the Eternal City finds itself grappling with an array of unforeseen challenges that extend beyond the conventional safety concerns. Safety Hazards and Creative Riding Practices: The safety hazards associated with e-scooters in Rome extend beyond accidents and injuries, revealing a tapestry of unconventional riding practices that add layers of complexity. One creative yet perilous issue is the phenomenon of two people sharing a single scooter. This not only violates the intended usage but also poses a heightened risk of imbalance and accidents, challenging the very foundation of safety regulations.

Sidewalk Chaos and Pedestrian Navigation Woes: The improper parking of e-scooters has been a widely acknowledged issue, but the chaos is further exacerbated by riders opting to navigate sidewalks. This creates a labyrinth for pedestrians, transforming once-walkable paths into obstacle courses. Moreover, the blending of e-scooter riders with foot traffic adds an additional layer of unpredictability, making sidewalks less safe and convenient for pedestrians.

Reckless Directional Riding and Traffic Misalignment: As e-scooters dart through the historic streets of Rome, a novel challenge emerges—riders navigating in the wrong direction. Riding against the flow of traffic not only violates traffic norms but also disrupts the expected flow, leading to potential collisions and a general disregard for road safety. This creative yet hazardous approach adds a layer of unpredictability to the bustling streets of the Eternal City.

Disregard for Safe Distances and Community Dynamics: A unique challenge arises from e-scooter users displaying a lack of respect for safe distances between vehicles and pedestrians. The close proximity of scooters to pedestrians raises concerns about the potential for accidents and injuries. The complex dynamics between e-scooters, pedestrians, and other vehicles further highlight the need for riders to exercise caution and consideration for the safety of all road users.

Riding in Tandem: A Tangled Web of Risks While the image of two individuals sharing a single e-scooter might seem lighthearted, it unveils a tangled web of risks. This practice not only compromises the stability of the scooter but also raises questions about the legality and safety of such unconventional riding arrangements. The potential for loss of control and accidents is heightened, underscoring the need for stringent regulations and public awareness campaigns.

Unraveling the Enforcement Dilemma: Enforcing regulations in the face of these creative challenges becomes a formidable task for authorities. Infrequent police checks and rare fines contribute to a sense of impunity among riders engaging in unconventional practices. The lack of robust enforcement mechanisms further complicates the efforts to instill a culture of responsible e-scooter use.

In conclusion, the challenges presented by e-scooters in Rome extend beyond the realm of traditional safety concerns, weaving a tapestry of unconventional and creative riding practices. As the Eternal City grapples with these multifaceted issues, there is an urgent need for innovative solutions, robust enforcement strategies, and public awareness campaigns to ensure the safe and harmonious integration of e-scooters into the intricate urban fabric of Rome.

13.Riding Scooter without helmet.
14.Riding in the opposite direction of the street.
15.16. Parking scooters on the sidewalks without regard for pedestrians and physically disabled.
17.Falling of parked scooters.
18. Two users ride on an e-scooter.
19.Failure to pay attention to traffic rules.
20.Ride on sidewalk.

13


14

15


16


17

18


19


20

04
Questionnaire

The questionnaire was administered to a sample of 84 participants, and the outcomes of the survey are presented in the following pages. The gathered responses offer valuable insights into various aspects, including user experiences, training needs, and statistical data on accidents, contributing to a comprehensive understanding of the micro-mobility landscape from the perspective of those directly involved. The subsequent pages will delve into the details and findings derived from the collected data, shedding light on user perceptions and preferences in the context of shared micromobility.

In the context of our research initiative, the use of a carefully crafted questionnaire emerged as a crucial method to complement the insights gleaned from initial interviews. This questionnaire served as a comprehensive tool, designed strategically to broaden the scope and depth of information gathered. By reaching out to a diverse and extensive participant pool, it aimed to transcend the nuanced qualitative data obtained through interviews.

The questionnaire was intricately simple with a specific focus on micro-mobilities, aiming to unravel various dimensions. Its objective was not only to understand user experiences and training needs but also to delve into the statistical landscape of accidents, providing a thorough examination of safety concerns surrounding these innovative modes of transportation. The multifunctional nature of the questionnaire became evident through its strategic design, covering a spectrum of inquiries to extract granular details. Foundational demographic information, such as age and gender, was collected to provide crucial contextualization for subsequent responses. Participants were encouraged to articulate their past experiences with electric micro-mobility transports, ranging from e-bicycles to e-scooters, creating a continuum of experiences that spanned from familiarity to those of novices in this evolving landscape.

A key facet of inquiry centered on participants' encounters with accidents related to these modes of transportation. The questionnaire aimed to unravel the narratives of incidents, shedding light on the complexities and variables contributing to safety challenges. This nuanced exploration, coupled with participants' initial experiences with e-scooters or e-bikes, forged a comprehensive narrative that extended beyond statistical abstractions to reveal the lived experiences of individuals engaging with micro-mobility. Expanding the scope further, the questionnaire incorporated inquiries related to controlling user behavior during the riding of shared e-scooters and real-time monitoring of users during the journey. Beyond the individual lens, the questionnaire extended its investigative reach into the broader socio-educational landscape. Participants were prompted to share their perceptions regarding the availability of educational resources for e-micro-mobility users. Furthermore, the questionnaire sought to distill participants' beliefs regarding the transformative potential of education in this domain, probing whether increased awareness and training could serve as catalysts for heightened safety and accident mitigation.

In essence, the questionnaire stood as a multifaceted instrument, intricately woven to capture the kaleidoscopic panorama of opinions, experiences, and aspirations within the realm of micro-mobilities. As responses flowed in, the questionnaire not only enriched the quantitative arm of the research but also provided qualitative depth, ensuring a holistic understanding of the intricate interplay between user behavior, safety perceptions, and the educational landscape in the dynamic arena of shared e-scooter mobility.

QUESTIONNAIRE

Electric micro-mobility transport

Electric micro-mobility transport means using small electric vehicles, like scooters or bikes, to get around in cities. They run on batteries and are good for short distances. It's a convenient and ecofriendly way to travel in crowded areas.

1. Age

- ( ) Under 18
- ( ) 18-24
- ( ) 25-34
- ( ) 35-44
- ( ) Above 44

2. Gender

- ( ) M
- ( ) F
- ( ) Prefer not to say

3. Have you ever used electric micro-mobility transports, such as e-bicycles or e-scooters?

- ( ) Yes
- ( ) No

PAGE 1

4. Have you ever had any accidents with these e-micro-mobilities?

- ( ) Yes, I had an accident with another vehicle
- ( ) Yes, I had an accident with a human
- ( ) Yes, I fell off while riding
- ( ) Yes, But as a pedestrian, not the scooter rider
- ( ) Yes, But as a car driver, not the scooter rider
- ( ) No, I have never had any accidents

5. How was your first experience with an e-scooter or e-bike?

(If you never ride any Electric micro-mobility, please don't answer this question)

1	2	3	4	5
( )	( )	( )	( )	( )

Very Bad — Very Good

6. Do you know how to use the e-scooter or e-bike for the first time?

- ( ) Yes, I am familiar with that and never struggle
- ( ) No, I am not familiar with that and struggled
- ( ) I need to practice a little bit at first

7. Are you aware of the potential risks associated with using e-micro mobilities on the street?

- ( ) Yes
- ( ) No

PAGE 2

8. On a scale of 1 to 5, how safe do you believe riding an e-scooter is

1	2	3	4	5
Not Safe				Safe

9. Do you know the rules regarding how to use e-scooters or e-bikes on the street?

- Yes, I know all of the regulations of using e scooters
- I am familiar with some regulations
- No, I know almost no regulations

10. Do you feel there is a lack of education regarding the use of e-micro mobilities for users?

- Yes, totally
- Yes, in some levels
- No

11. Do you think that having education regarding the use of electric micro mobilities would help improve safety and reduce accidents?

- Yes, absolutely
- Yes, it might help
- No, it won't help

PAGE 3

04.1 Summary and Finding of Questionnaire

After a thorough analysis of the questionnaire results, the compiled statistics present a nuanced picture of participants' sentiments regarding education on e-micro-mobilities. Strikingly, 42.9% of respondents strongly expressed a prevailing sense of deficiency in education concerning the usage of e-micro-mobilities. This highlights a notable gap in knowledge that warrants attention and intervention.

Moreover, a majority of participants, totaling 51.2%, articulated a varying degree of need for education on e-micro-mobilities. This collective acknowledgment underscores the significance of addressing educational gaps to enhance safety and user awareness in the dynamic landscape of micro-mobilities. Conversely, only a small percentage, a mere 6%, disagreed with the notion of needing additional education in this domain, indicating a broad consensus on the importance of educational initiatives.

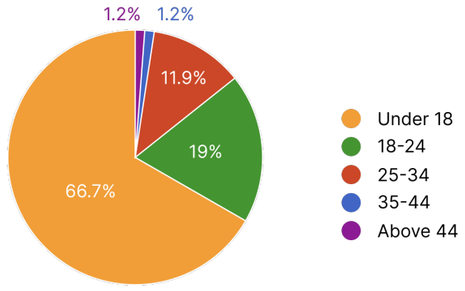
Delving into the qualitative insights garnered from interviews, participants provided compelling reasons supporting the perceived lack of education. Key issues highlighted include the absence of license plates for micro-mobilities, contributing to challenges in regulation and identification. Additionally, interviewees pointed out the absence of a special certificate required for driving micro-mobilities within city limits, underscoring a potential regulatory gap that demands attention.

The interviews also shed light on the risky behaviors exhibited by micro-mobility users, further emphasizing the need for educational interventions. Instances of such behaviors were noted, ranging from reckless riding to a lack of awareness regarding traffic rules and safety protocols. These observations align with the participants' collective call for increased education to mitigate such risks and enhance overall safety.

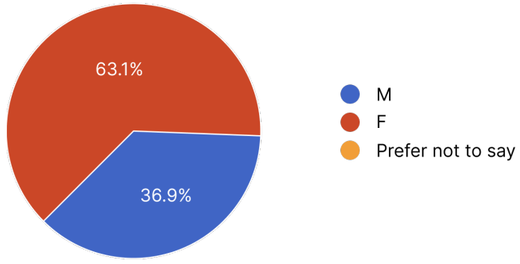
One particularly concerning observation was the high usage of micro-mobilities by teenagers in crowded and potentially dangerous environments. This demographic's involvement in micro-mobility without adequate education and awareness raises concerns about safety and the potential for accidents. Addressing these issues through targeted educational initiatives becomes imperative to create a safer environment for all users.

In light of these findings, it becomes evident that a comprehensive educational approach is crucial to bridge existing knowledge gaps, enhance user awareness, and mitigate safety concerns in the realm of e-micro-mobilities. The identified issues underscore the importance of tailored educational resources and initiatives to foster responsible usage, ultimately contributing to a safer and more informed micro-mobility ecosystem.

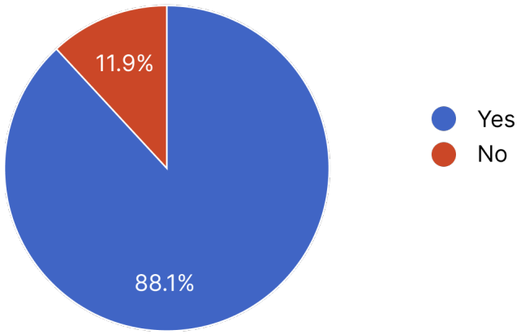
1. Age



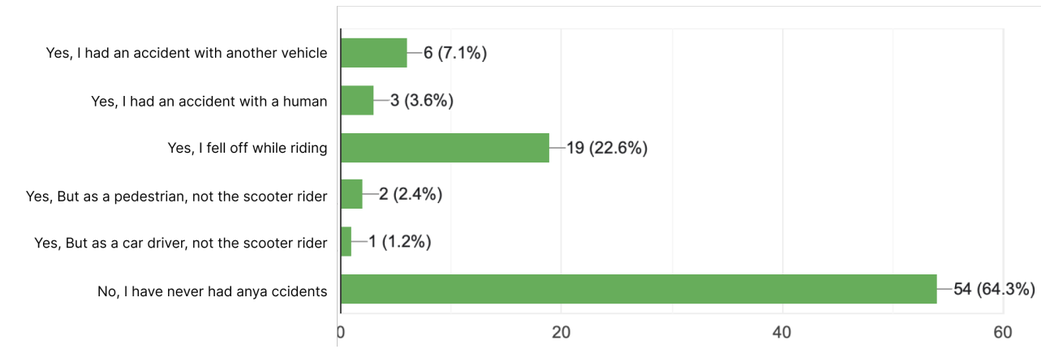
2. Gender



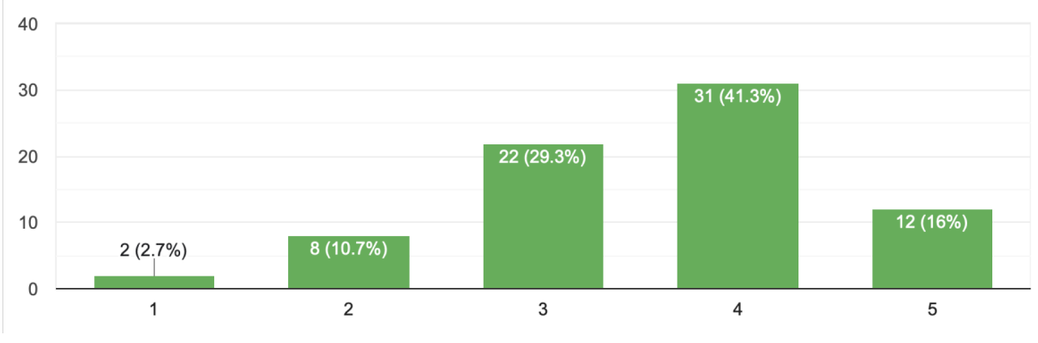
3. Have you ever used electric micro-mobility transports, such as e-bicycles or e-scooters?



4. Have you ever had any accidents with these e-micro-mobilities?

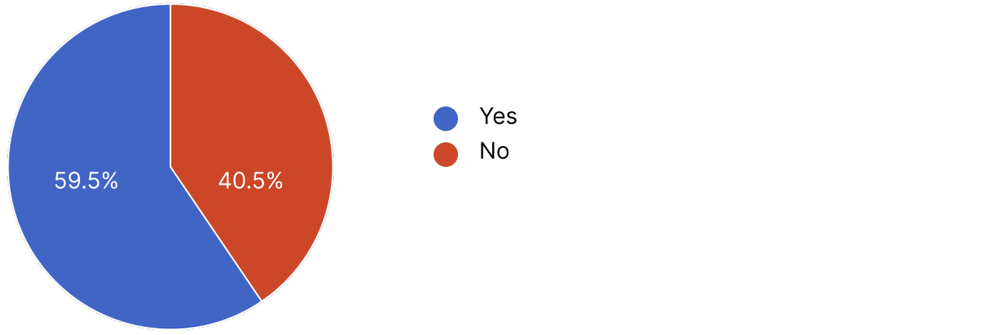


5. How was your first experience with an e-scooter or e-bike?
(If you never ride any Electric micro-mobility, please don't answer this question)



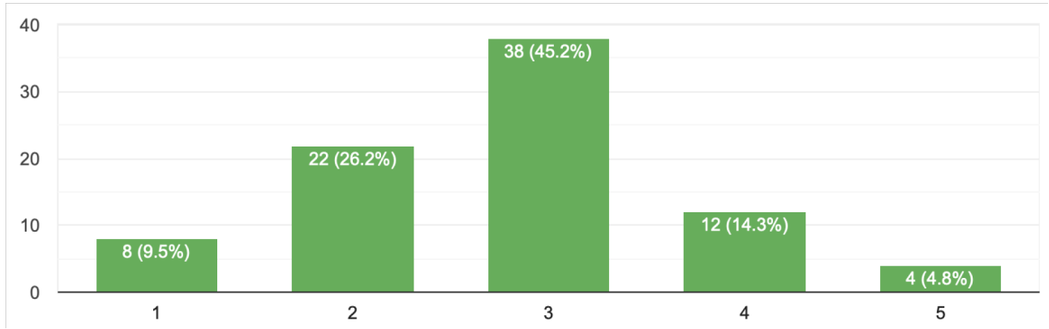
6. Do you know how to use the e-scooter or e-bike for the first time?

7. Are you aware of the potential risks associated with using e-micro mobilities on the street?

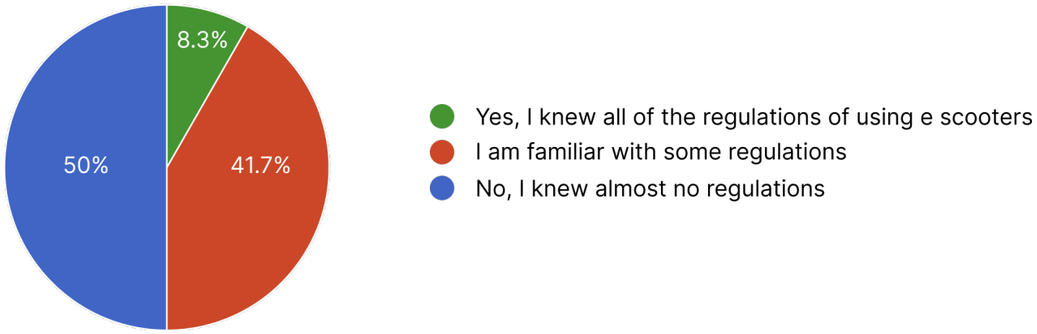


8. Do you think that having education regarding the use of electric micro mobilities would help improve safety and reduce accidents?

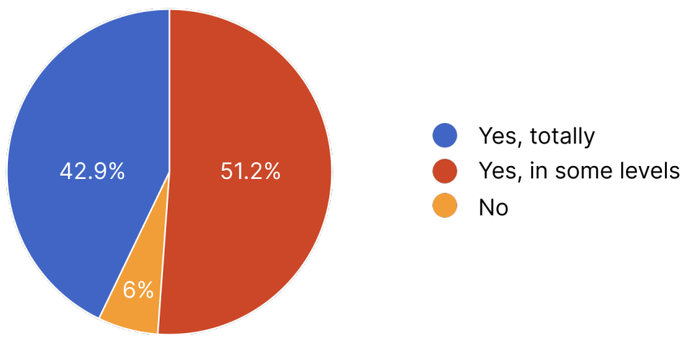
9. On a scale of 1 to 5, how safe do you believe riding an e-scooter is?



10. Do you know the rules regarding how to use e-scooters or e-bikes on the street?



11. Do you feel there is a lack of education regarding the use of e-micro mobilities for users?



04.2 Interview

Embarking on the journey of empirical exploration, the preliminary research phase served as a foundational step in orienting the study towards the intricate dynamics of micro mobility. This involved an exhaustive review of existing literature, industry reports, and insights from urban planning experts. The synthesis of this knowledge laid the groundwork for the formulation of initial hypotheses and conceptual frameworks.

Following this preparatory phase, a purposive and systematic interview strategy was meticulously devised to engage with the diverse perspectives of individuals deeply embedded in the academic milieu. The selected cohort of interviewees comprised ten students from Sapienza University, each representing distinct academic disciplines such as engineering, social sciences, and business studies. The deliberate inclusion of participants from varied fields sought to capture a holistic spectrum of insights, ensuring a comprehensive understanding of the multifaceted implications of shared e-scooter mobility.

The interviews, conducted in a face-to-face format, unfolded within the familiar confines of the university premises. This intentional choice of setting was aimed at fostering a comfortable and open dialogue, allowing for the emergence of nuanced narratives. Probing discussions were facilitated to extract not only explicit opinions but also the tacit nuances that often underlie perceptions of safety, innovation, and sustainability in the context of micro mobility. Beyond being a data-gathering exercise, the interviews evolved into a dynamic exchange, providing a qualitative depth that goes beyond numerical representation. The participants, aged between 19 and 28, were strategically chosen to represent a demographic particularly relevant to the adoption and experience of shared e-scooter systems. Through these in-depth conversations, the goal was not just to illuminate challenges but to discern patterns, identify latent needs, and propose context-specific solutions that resonate within the unique ecosystem of university life.

As the interviews progressed, the narrative shifted towards a collaborative exploration of potential solutions and best practices. This transformative dialogue not only informed the ongoing research trajectory but also positioned the study as a catalyst for informed discourse on safety enhancements within the broader landscape of shared e-scooter mobility, with a distinct focus on its intersection with the educational realm.

INTERVIEW WITH USERS OF E-SHARED SCOOTERS

Hello, {interviewees name}. I have the pleasure to spend some minutes having a conversation with you for my thesis project. So let us start with your memories.

1. When was the last time you had a scooter accident? Why that happened and what was wrong? I would like to hear the whole story. {as this is a semi-structured interview, we may ask for some details to understand more aspects of the data we hope to achieve. But for now, this question will help us know if they ever have experienced being on any side of a scooter accident, and also it gives us clear data about the whole process of how and why the accident happened which helps us create our empathy map and User Journey map.}

2. Any actions after the accident happened? How did you feel and what did you wish for? I was previously experienced an accident driving on my car and at the moment all I wished for was a completely new engine and probably hearing at least less horrible curses in front of my girlfriend. What about you? {the aim of this question is to demonstrate the post-accident behavior of the interviewees and also to reach a deeper level of the data around their needs, actions, and feelings}

3. One of the most common mistakes that people usually do a few hours after an accident is that they ask themselves too many what-if questions. The answer to a what-if question usually leads to an ideal, perfectionistic situation which only causes more regret. We must learn from our bad experiences and stop panicking. But now let us record these questions to avoid other people from asking the same ones! When did the first what-if questions come to your mind? If possible let me know exactly what were those questions about? Let's start with the biggest regret you had! {it is expected that this question will provide us with some deep data around the pain points and the needs of the case and how he or she prioritizes them in his or her opinion usually at the time or sometimes before or after the accident.}

INTERVIEW WITH USERS OF E-SHARED SCOOTERS

4. Interesting, now please tell me about the long-term effects of the event. How did the accident change your opinion, needs, and behavior? Specifically speaking: In what aspects did your experience of using scooters change before and after the accident? {the data coming from this question will drive us deep into the problems, mistakes, and major changes in the needs, opinions, and behavior of the case caused by the accident before and after the event happened.}

5. Alright, now instead of talking about the accidents, we can talk more about the victims! Riding scooters are always fun, but no one has ever said that they are the safest way to roam around. Remind yourself of your last scooter trips and tell me how come you were sure that you are having a safe ride. Have you ever bought any products or used any services in order to help yourself have a safe ride? If yes, how much have you paid for that reason? {based on the data we will receive here we will deepen our understanding of the touch-points of the case around the topic of Safety. This will lead the research into some obvious, but deep solutions. With all the pain points gathered from the previous questions; adding the touch-points from the benchmark and the interview findings, we will finally have an analyzable clear data that will lead us to reach a more valuable solution}

6. Now I think I gathered enough data for my thesis, but before I thank you for being so positive, collaborative, and cool, I want to ask my last question: Remember your first time riding a scooter? Amateurs are usually afraid or confused and even if they try to look so confident, they still know their weaknesses and bad habits that may cause accidents for them in the future. Suppose you have had an accident on your first ride. How would that have happened and what weaknesses or bad habits in you support your statement? For example, I think if I would have had an accident, it would have been because of me losing control of the scooter for riding it with one hand! Riding a scooter with one hand is all a first-timer needs to fall and it was my bad habit! {This question is tricking the interviewee to talk about their weaknesses and bad habits without being shy in...

Thank you for being so positive, collaborative, and cool. Goodbye

04.3
Summary and Finding of Interview

Following an in-depth examination of interviews focused on micro-mobilities, a prevailing concern surfaces among the majority of participants: the glaring absence of awareness and adequate training for drivers of these vehicles. This overarching issue can be attributed to two main factors, each contributing significantly to the perceived deficiency:

Primarily, the absence of license plates for micro-mobilities emerges as a pivotal challenge. Without identifiable markings, these vehicles operate without control or oversight from law enforcement or any regulatory body. This lack of external monitoring exacerbates the potential for misuse and raises concerns about accountability within the micro-mobility landscape.

Secondly, the absence of a requirement for a special certificate or formal training to operate these vehicles is a notable gap. This regulatory loophole facilitates easy access for individuals, including teenagers below the age of 18, to operate micro-mobilities without undergoing any formal training. This not only poses potential safety risks but also underscores the need for regulatory measures to ensure responsible usage. The consensus emerging from both micro-mobility users and pedestrians is a shared perception of inadequate user behavior exhibited by drivers of these shared vehicles. This behavioral concern, in itself, creates a disruptive environment that compromises order and security for both drivers and pedestrians alike. Addressing this user behavior becomes imperative to establish a safer and more harmonious coexistence within the micro-mobility ecosystem.

In response to these discerning interview findings, a comprehensive questionnaire has been meticulously prepared and designed. This instrument seeks to cast a wider net and gather more nuanced insights from a larger statistical group, enriching the research with a broader perspective. The questionnaire aims to delve deeper into the multifaceted aspects of micro-mobilities, encompassing user experiences, safety concerns, and the impact of regulatory measures or the lack thereof. The preparatory steps undertaken, from interviews to the formulation of a robust questionnaire, underscore the commitment to obtaining a comprehensive understanding of the challenges and opportunities within the micro-mobility landscape. As this research unfolds, the hope is that the amalgamation of qualitative and quantitative data will not only highlight existing issues but also pave the way for informed recommendations and interventions to foster a safer and more responsible micro-mobility environment for all stakeholders involved.

PART TWO
DESIGN

05
Persona

Francesco

- Age: 27
- Occupation: (part time)
- Education: Pursuing a Master of Physics at Sapienza University of Rome.

Bio

Francesco, a 27-year-old physics student in Rome, primarily uses public transportation. He's open to trying shared scooters when exploring the city with his girlfriend. While he hasn't used shared bicycles, he recognizes their potential. Francesco is known for his analytical nature, passionate about astrophysics and stargazing. He's tech-savvy, active in a social group, and enjoys quality time with his girlfriend. He suggests creating green zones and dedicated lanes to ease traffic issues for micro-mobility users. Overall, he's open to micro-mobility but prefers traditional public transportation for its accessibility and reliability.

Transportation Preferences

- Francesco primarily relies on the Metro and Bus for his transportation needs. He also likes to occasionally try shared scooters, thanks to the encouragement of his girlfriend, who shares his passion for stargazing and science
- Attitude Towards Shared Scooters and Bicycles: Francesco has never used shared bicycles but is open to trying shared scooters, especially when exploring the city with his girlfriend. He prefers the Metro for his daily commute due to its accessibility and availability in his area.

Opinion on Shared Vehicles in Rome:

- He believes that bicycles and scooters used in Rome are a good idea, but mentions that there might not be enough of them. He acknowledges their usefulness for those who do use them.

Driving Habits:

- Francesco is a car driver but does not drive in Rome.

Personality Traits:

- He's perceived as analytical and detail-oriented due to his background in physics.

Views on Car Drivers and Micro-Mobility:

- Francesco thinks car drivers may pose a challenge to micro-mobility in the city by causing traffic and sometimes not noticing scooters or bicycles.

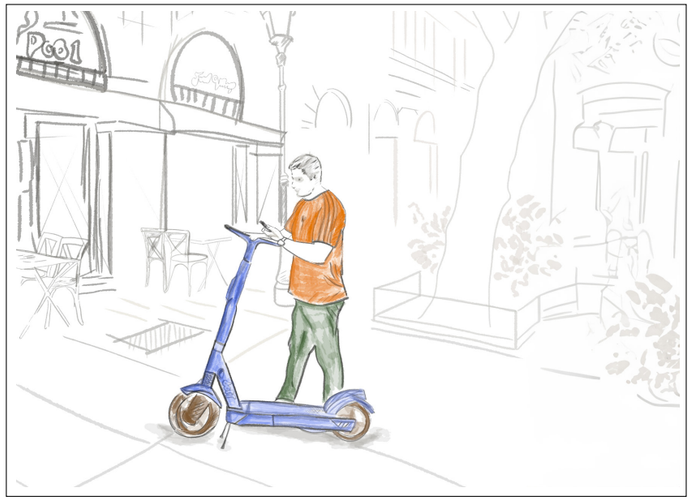
Proposed Solutions:

- He suggests creating green zones in the city and separating scooter and bicycle lanes to address the issues between car drivers and micro-mobility

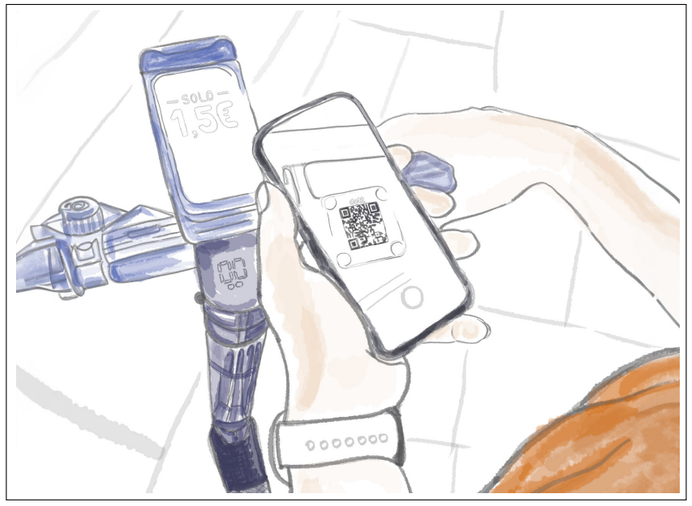
Social Life:

- Francesco enjoys spending quality time with his girlfriend, who encourages him to explore shared scooters for city adventures.

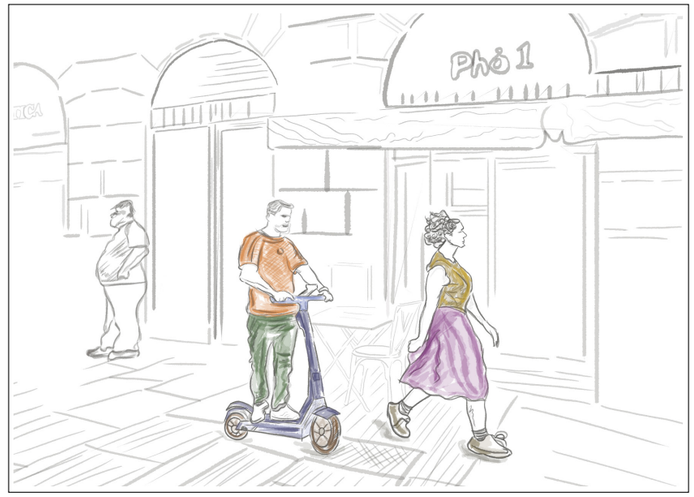
05.1
User Journey Before Improvements



1. Francesco wants to go sightseeing in the center of Rome with his girlfriend; therefore he decides to use a shared scooter. It's his first experience in his life. At first, he found a shared scooter which was parked on the sidewalk and he tried to figure out how he could start using it.



2. He saw the barcode on the scooter and scanned it to start using the scooter.



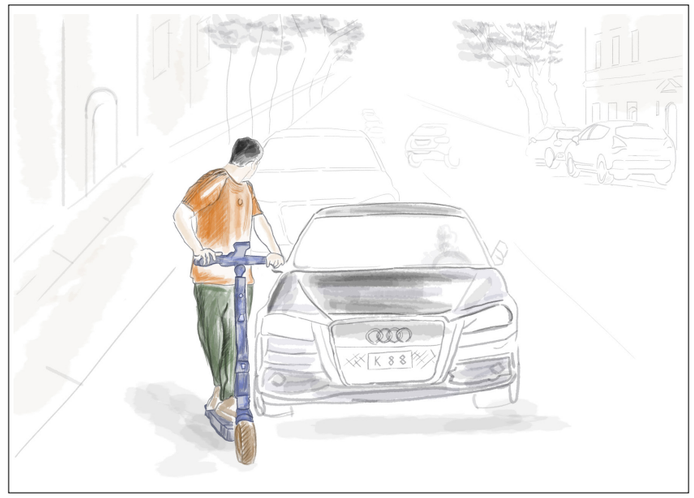
3. He started riding on the sidewalk and there were people walking there and he couldn't control his distance from the people.

4. It was difficult for him to control his speed and distance on the sidewalk so he frightened a woman that was walking in front of him. It was so close to having an accident with her.

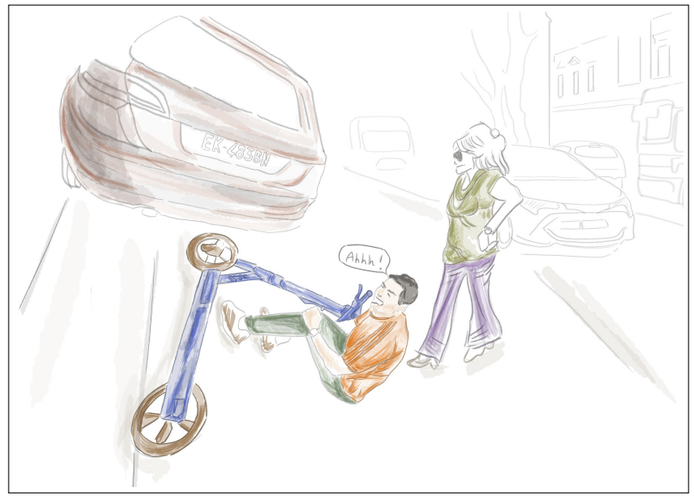
05.1
User Journey Before Improvements

5. He went near the Colosseum and picked up his girlfriend, they were 2 people riding one scooter

6. Subsequently, they rode the scooter on the sidewalk near the Colosseum monument. Despite the presence of two police officers, they were preoccupied with other matters and did not instruct them to refrain from riding the scooter on the sidewalk or address any issues related to two people sharing one scooter. As a result, they assumed that everything was in order.



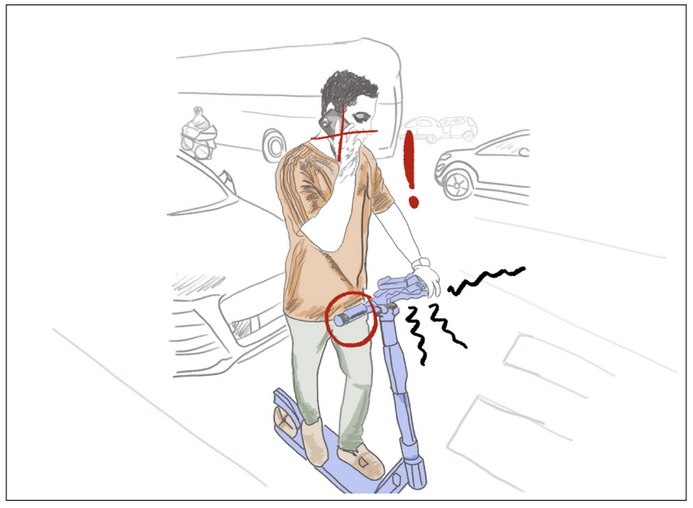
7. when Francesco wanted to come back home he had no choice but to ride on the street. there was no specific line for the scooters or bicycles so he had to ride on the street. But again He couldn't manage his distance and speed, and because he was slower than the cars he was afraid that the cars behind him have an accident with his scooter.



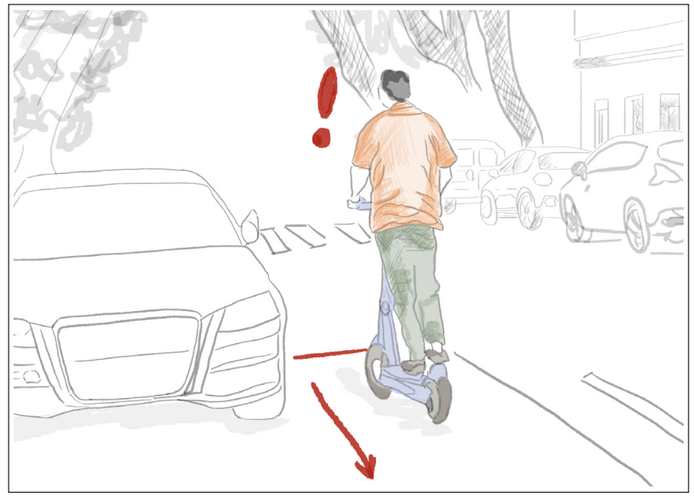
8. He was so distracted by the car behind him that he couldn't keep his distance from the car in front of him and he had an accident and fell down from the scooter.

05.2
User Journey After Improvements

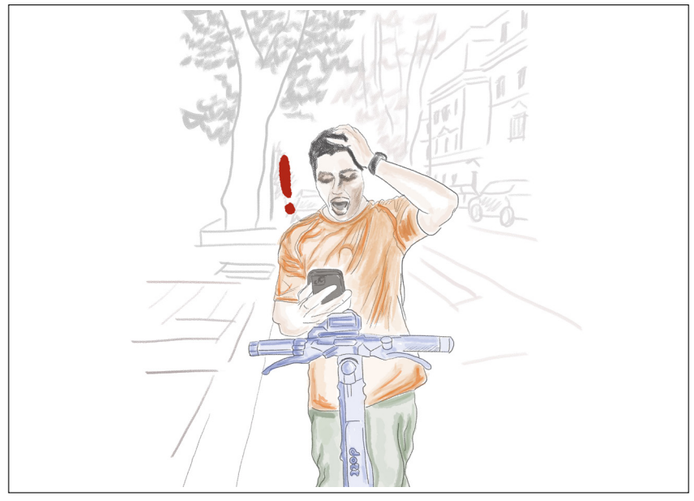
1. Francesco wants to go inside the crosswalk, but the scooter's smart system warns.



2. The smart scooter system doesn't allow the user to ride with one hand.

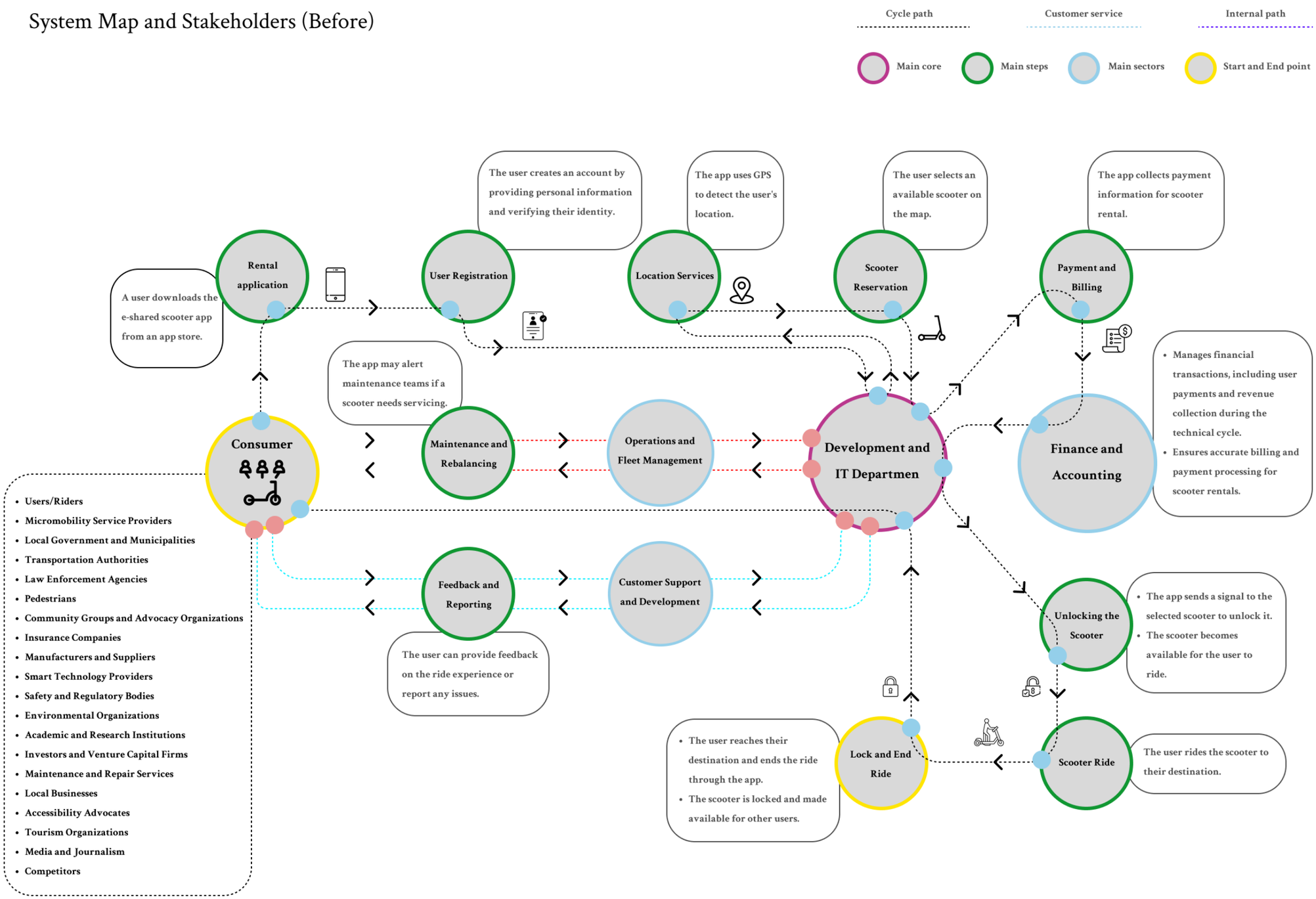


3. Riding in the opposite direction of the street is detected by a smart system. Thanks to the GPS.

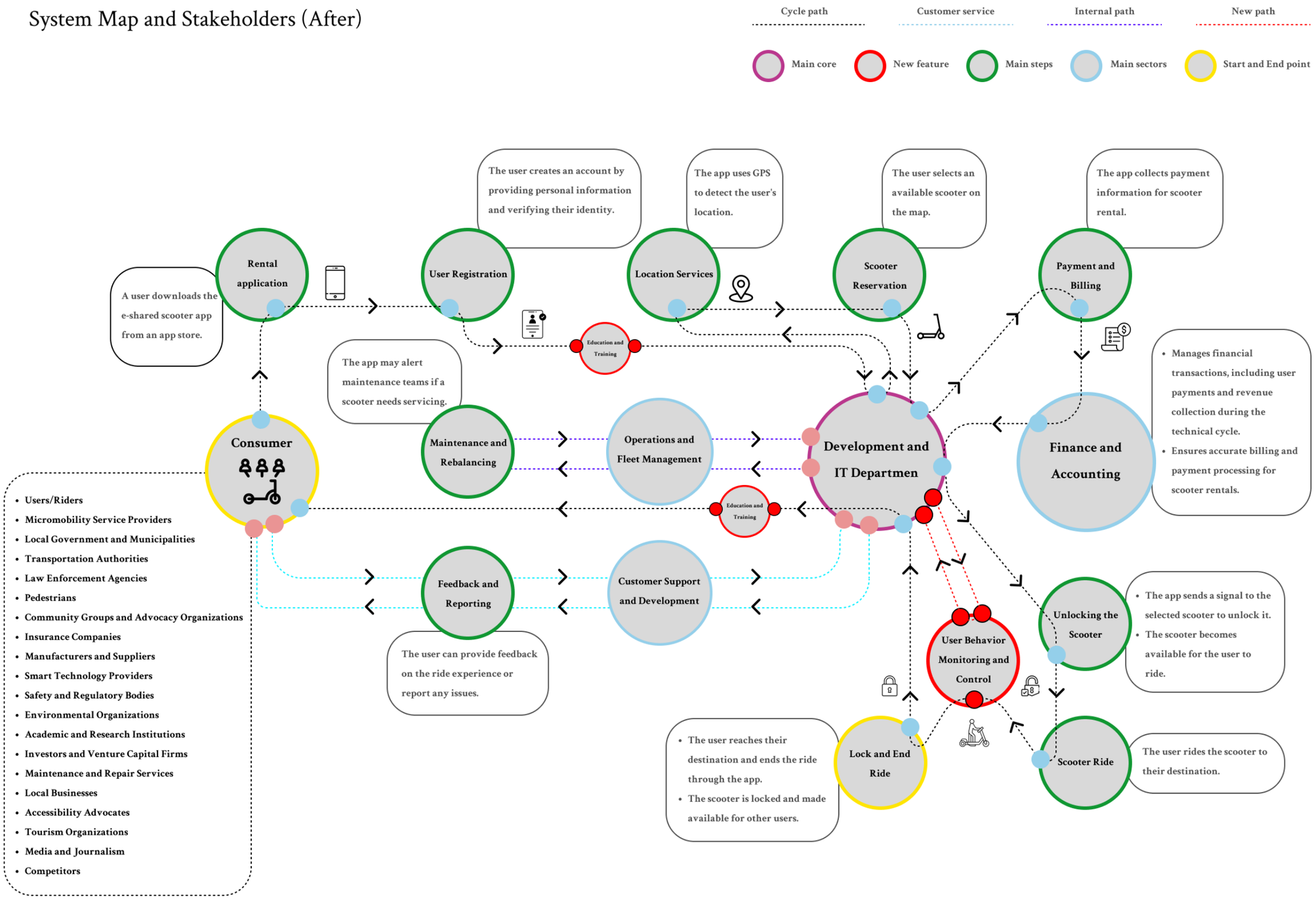


4. If the dangerous behavior continues, the user's access will be restricted by the server.

05.3
System Map and Stakeholders (Before)



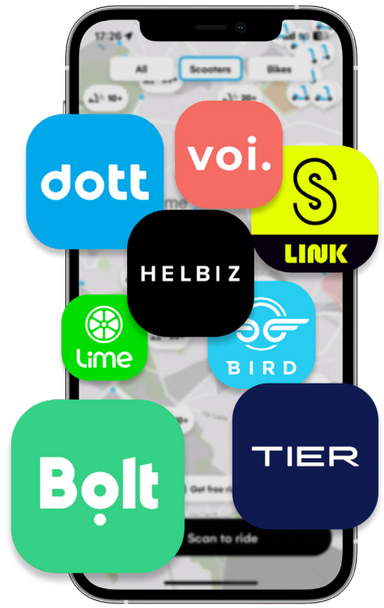
05.4
System Map and Stakeholders (After)



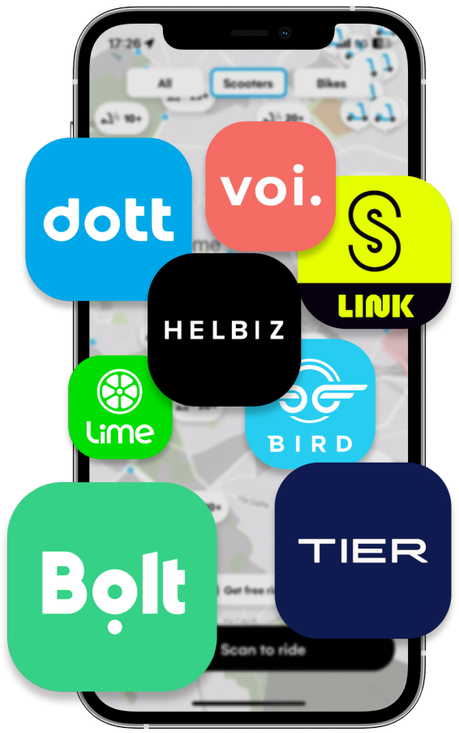
06
Adding the new features to the main existing applications of the shared E-scooters

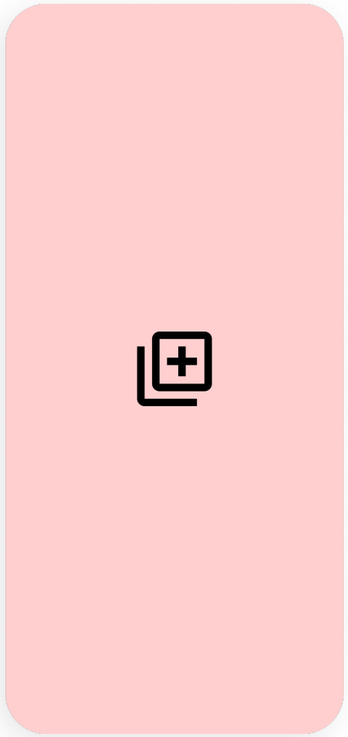
After a thorough investigation, it's clear that the proposed stand-alone application for the monitoring system might not be well-received by users or in the market. People who use electric scooters regularly are less likely to choose a service that analyzes their behavior during trips, especially when compared to companies that offer shared scooters without this feature. A more practical and widely acceptable approach is to integrate this monitoring system through legislative channels, making it a part of the applications used by all companies in the shared electric scooter sector. In this shift, the monitoring system changes from a stand-alone app to an add-on integrated into the applications of shared mobility service providers. It works in real-time and online, analyzing user behavior during scooter rides. To make sure it works well, we need to look into the details of how this integrated system operates.

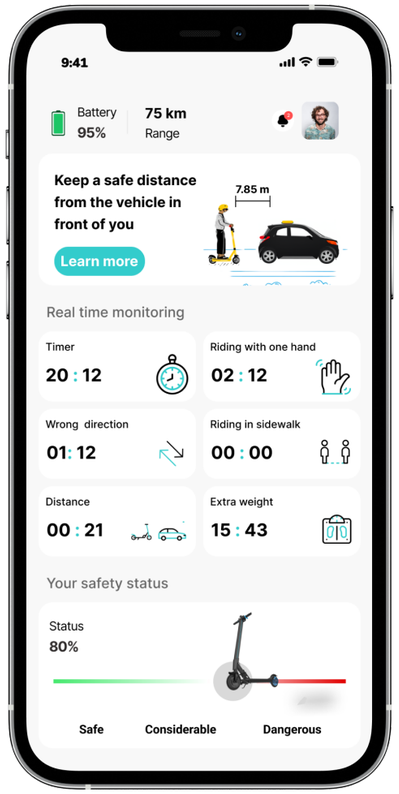
Adding this new feature, which includes both Real User Monitoring and user training, to the existing platforms in the shared electric scooter sector brings lots of opportunities and benefits. It not only makes these platforms better but also offers advantages to both the companies providing the service and the users. This combination of monitoring and training within established platforms has the potential to change the shared electric scooter experience, making it safer and more informed. Exploring the details of this integration is important to make the most of its potential and ensure it has a positive impact on the shared electric scooter landscape. As this happens, it could not only improve safety and user awareness but also redefine the user experience in the shared electric scooter world. This combination of monitoring and training within established platforms has the potential to change the shared electric scooter experience, making it safer and more informed. Exploring the details of this integration is important to make the most of its potential and ensure it has a positive impact on the shared electric scooter landscape. As this happens, it could not only improve safety and user awareness but also redefine the user experience in the shared electric scooter world. With the right implementation, this integrated system could pave the way for a new era of sustainable and secure micro-mobility solutions in urban environments. Moreover, ongoing collaboration with relevant stakeholders, including urban planners and safety advocates, will be essential to address evolving challenges and ensure the continued success of this innovative approach to shared electric scooter management.

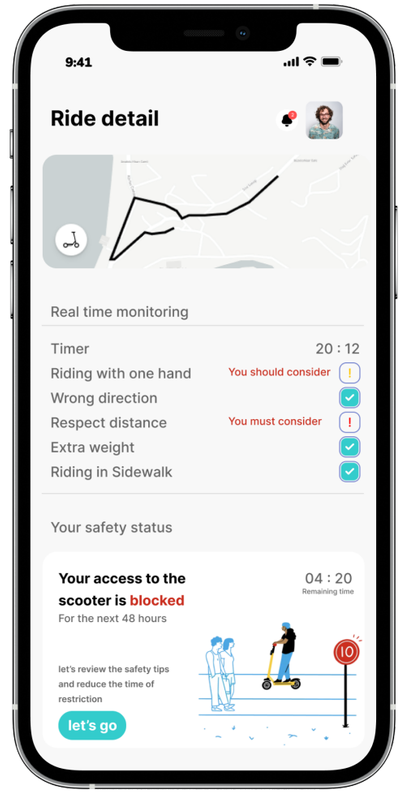


Eight existing companies for shared scooters operating in Rome. Dott, Voi, Link, Lime, Bird, Bolt, Tier.









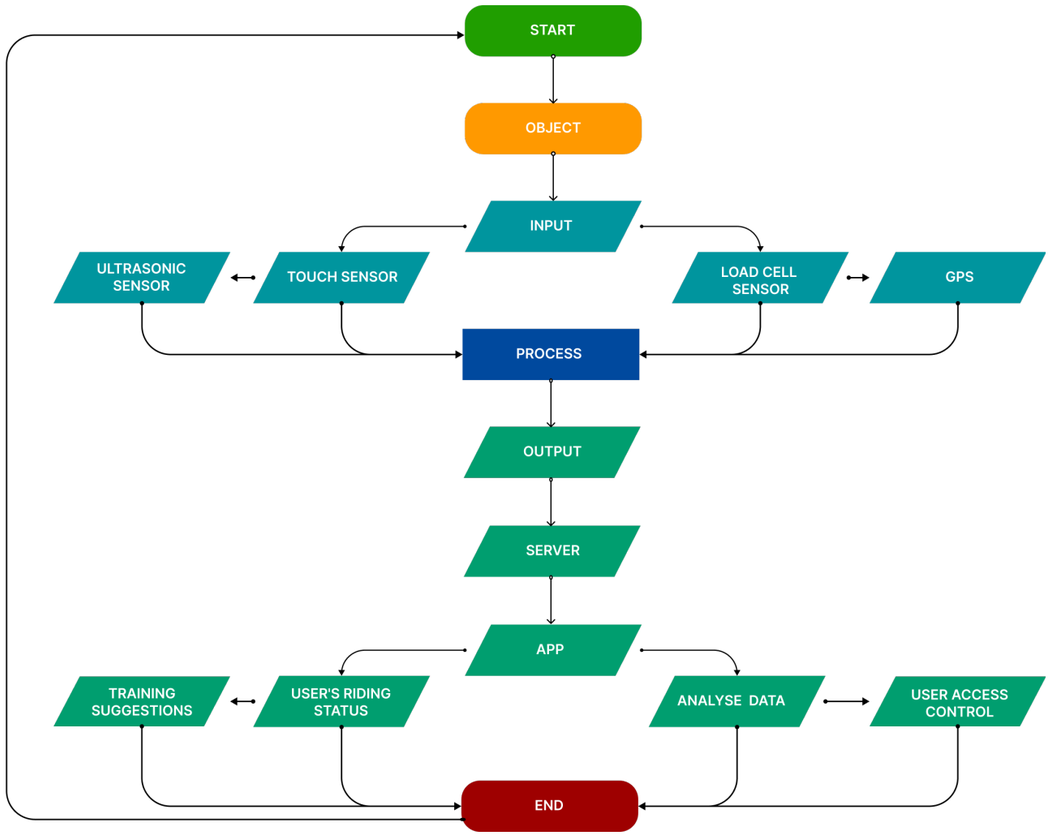
Note: The possibility of adding the new feature (Real user Monitoring as well as user training) in all existing and active platforms in this field.

06.1
Objects and Sensors

The sensors embedded in the scooter's body send their environmental data to the central core, which is the nodeMCU board. This data is then transferred to the server either wirelessly or via the Internet of Things (loT) for further processing.

- The sensors measure the following?

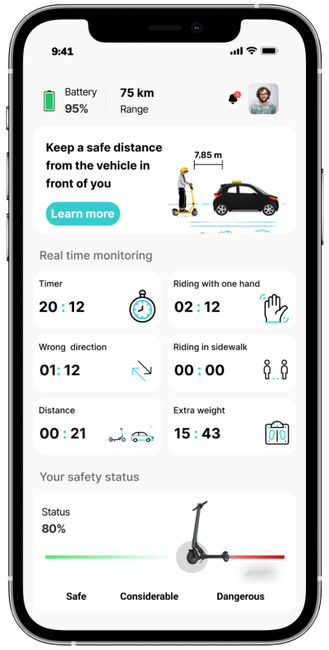
1. Distance between the scooter and other vehicles to ensure safe riding distances.
2. User's hand controls to detect if the rider is using one hand or both hands for safety
3. The input of additional weight to detect potential imbalance ensures proper scooter control.
4. GPS for scooter navigation to monitor if the rider is traveling in the opposite direction of designated paths or

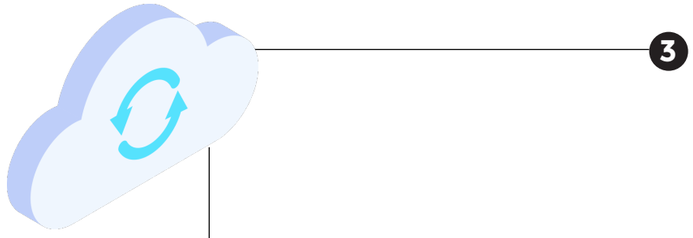


Diagram

Application

All the information collected by the sensors goes through two steps: first to the sensor and then to the server. Finally, this data is displayed visually in the application. In simpler terms, the application shows users a visual representation of all the information gathered by the sensors. The data journey involves two main parts: the sensor, which collects the information, and the server, which helps transfer this data to the application. This two-step process ensures a smooth flow of information from the sensors to the digital platform. The application, where users interact, then takes this data and shows it in a visual format. This visual representation makes it easy for users to understand the information collected by the sensors in real-time. This process follows standard practices to ensure the efficient and accurate sharing of data from sensors to users.





3

Server

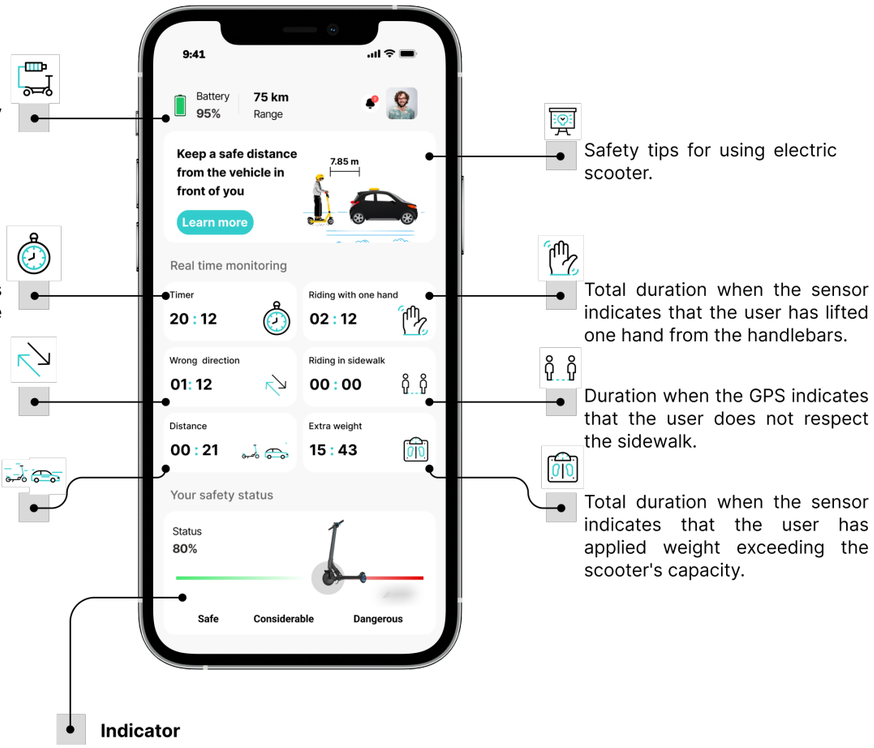
2

The sensor data collected by the smart scooter is transmitted to a central server for processing and analysis. The server plays a crucial role in receiving and interpreting the data to assess the user's behavior and safety level.

Sensors

1

6.2
Monitoring



Showing the scooter's battery level and mileage

Total duration when the user fails to maintain the desired distance from surrounding objects.

Duration when the GPS indicates that the user does not respect the sidewalk.

Duration when the user fails to maintain the desired distance from surrounding objects.

Safety tips for using electric scooter.

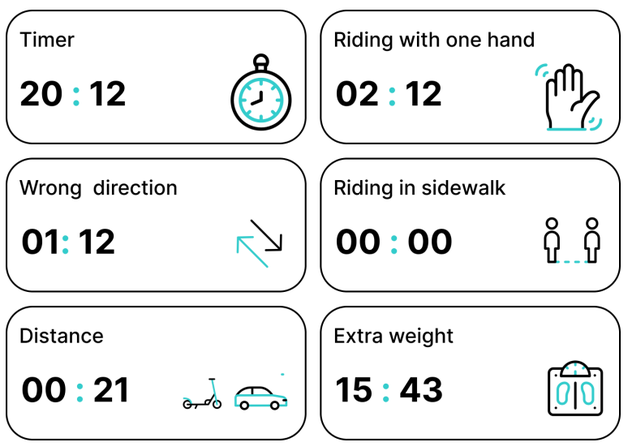
Total duration when the sensor indicates that the user has lifted one hand from the handlebars.

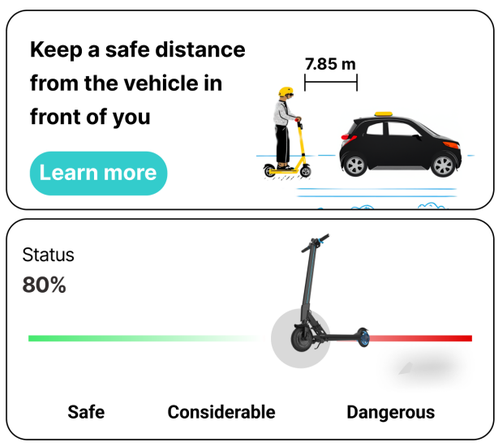
Duration when the GPS indicates that the user does not respect the sidewalk.

Total duration when the sensor indicates that the user has applied weight exceeding the scooter's capacity.

Indicator

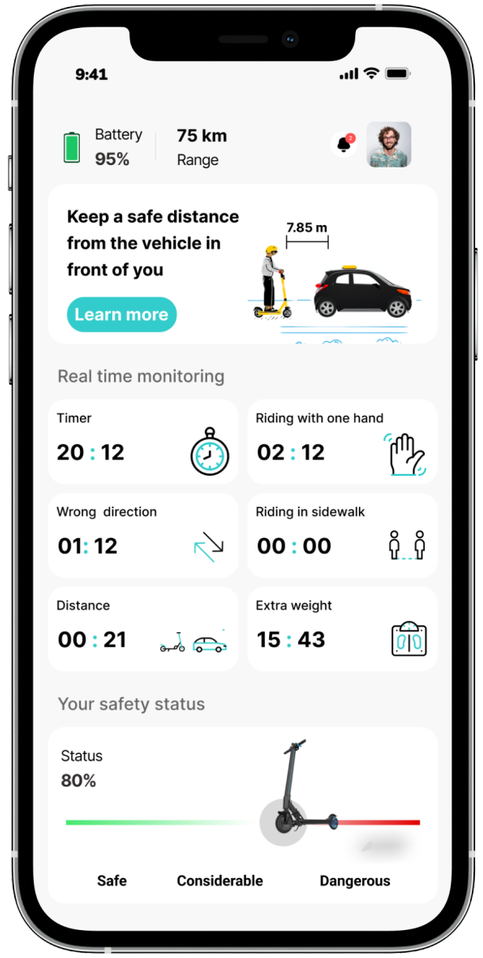
According to the data transmitted from the user's behavior during scooter riding by the sensors to the data center, the Indicator moves to the 'dangerous' and 'safe' points based on the level of risky behavior of the user.



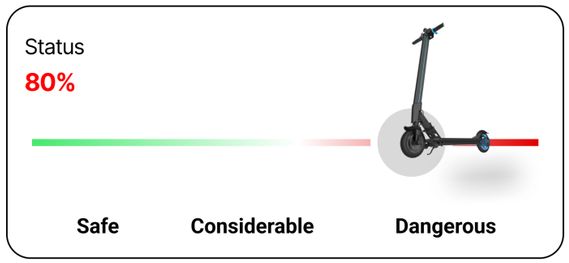


the sensor detects that the user has released one hand from the scooter's handlebar. The server identifies this as risky behavior and displays it in real-time through the scooter's interface, providing the user with an online warning about the imbalance. The indicator moves towards the right, indicating the danger zone.

Furthermore, if the user gets close to the danger zone, the server can restrict the user's access and monitor their behavior in real-time.
Additionally, based on the collected data, the server can initiate training for the user.

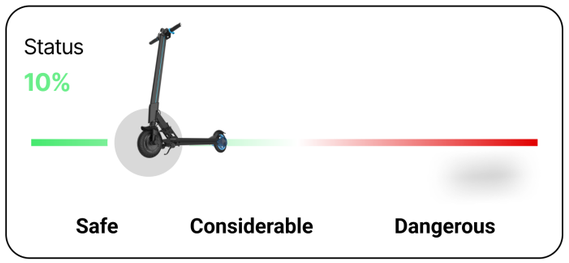


Example #1



For example, if the cumulative durations exceed 50, it goes toward "**Dangerous**"

Example #2

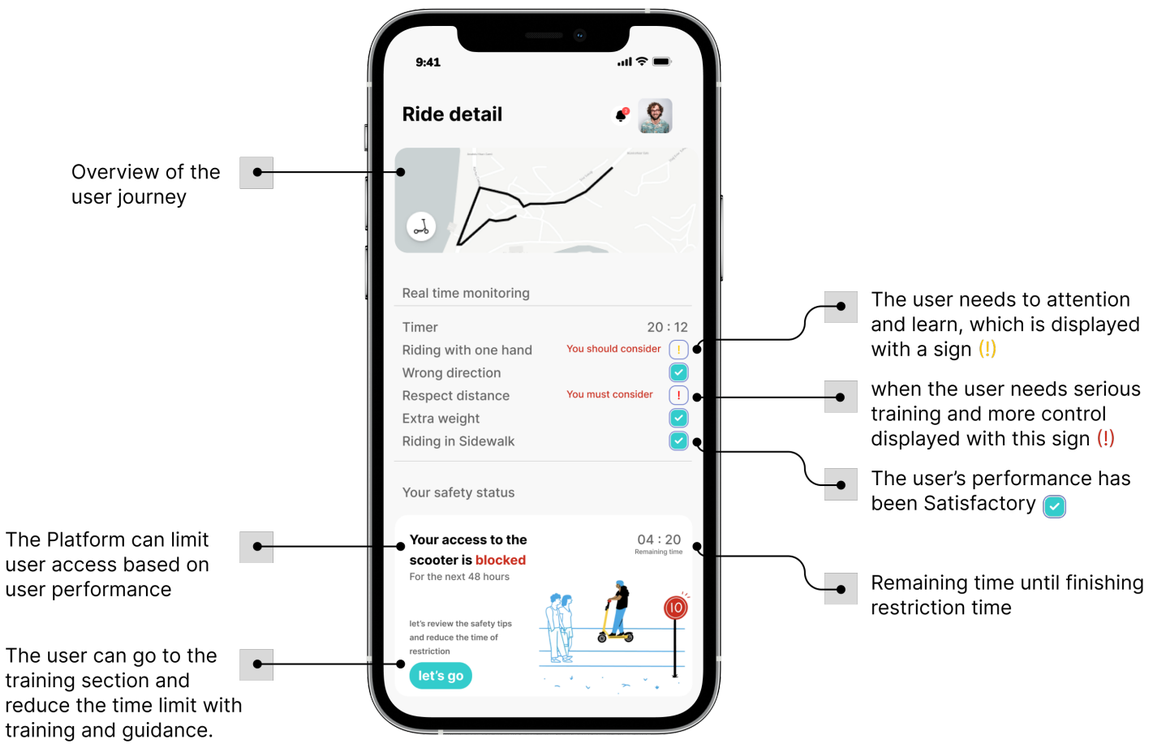


For example, if the cumulative durations under 50, it goes toward "**Safe**"

The server can provide guidance to the user through the scooter's app, offering instructions on proper scooter usage and personalized recommendations for improvement based on the gathered data.

Display user monitoring results:

- The user needs to attention and learn, which is displayed with a sign (!)
- when the user needs serious training and more control displayed with this sign (!)
- Operators offering this service have the ability to monitor users' behavior during their journeys, and access for users is subject to the company's policies, as well as the laws of the country and city where shared electric scooters are provided. Operators can also apply restrictions, such as time limits or area limitations,



Extra Weight

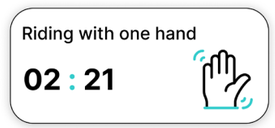
Total duration, when the sensor indicates that the user has applied weight exceeding the scooter's capacity.

Load cell

Load cell converts a force such as tension, compression, pressure, or torque into a signal

Riding with One Hand

Total duration when the sensor indicates that the user has lifted one hand from the handlebars.



Touch Sensor

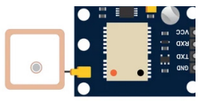
The total duration during which the touch sensor indicates that the user has lifted one hand from the handlebars.

Riding in Sidewalk

Duration when the GPS indicates that the user does not respect the sidewalk.

GPS

Using GPS, track and display the scooter's direction and location on the street.

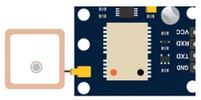


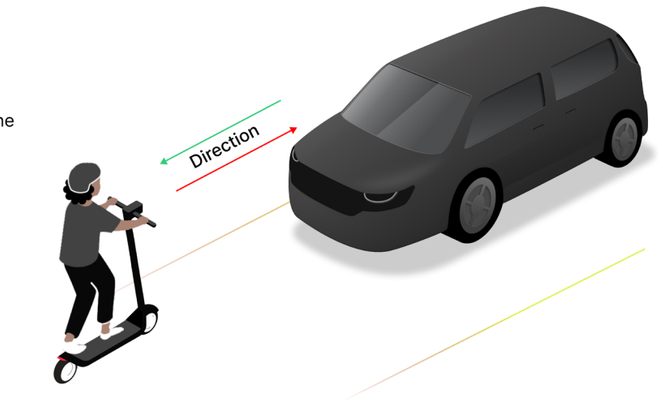
Wrong Direction

The duration when the GPS indicates that the user is riding in the wrong direction on the street.

GPS

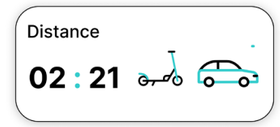
Using GPS, track and display the scooter's direction and location on the street.





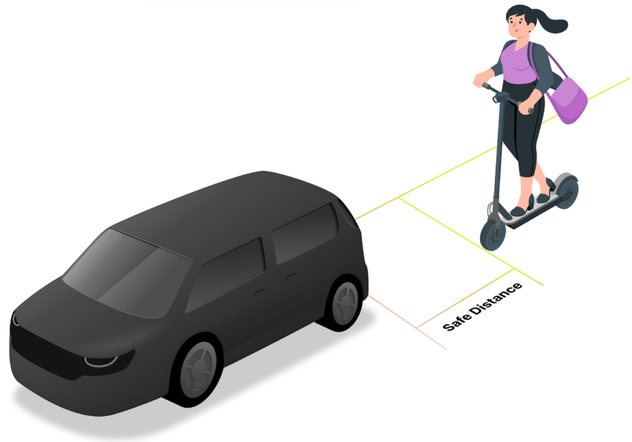
Safe Distance

Duration when the user fails to maintain the desired distance from surrounding objects.



Ultrasonic

Using an ultrasonic sensor to detect the distance from surrounding objects.

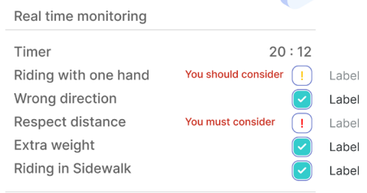


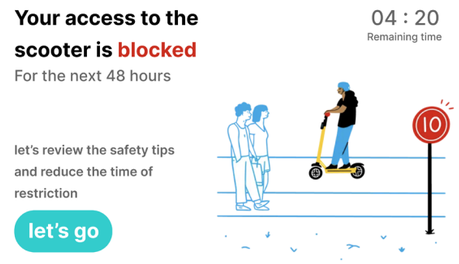
Market Average **7.85 m**

Stopping Distance from 25km/h to 0km/h
Flat ground, ASPHALT, DRY, 17 C, 3km/h side wind
±7% margin.

Indicator and Actions

Service providers can monitor user behavior throughout journeys, and access is contingent upon company policies, as well as local laws in the area where electric scooters are available. Operators may impose constraints like time limits or geographic boundaries, and they can provide users with guidance on scooter usage to modify or lift these restrictions.



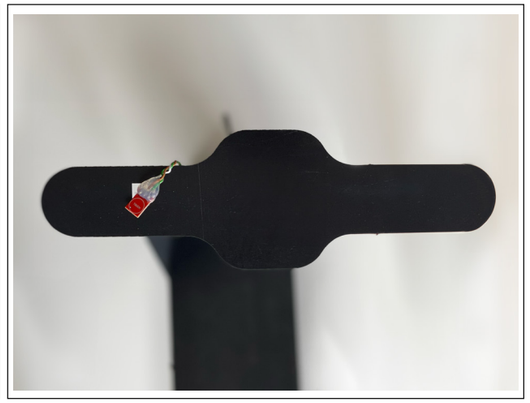


06.3
Portotype

16

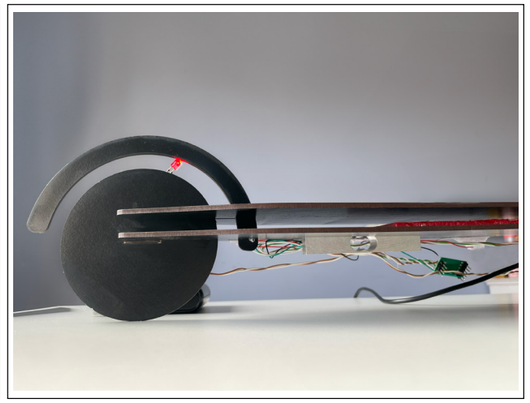
17

18

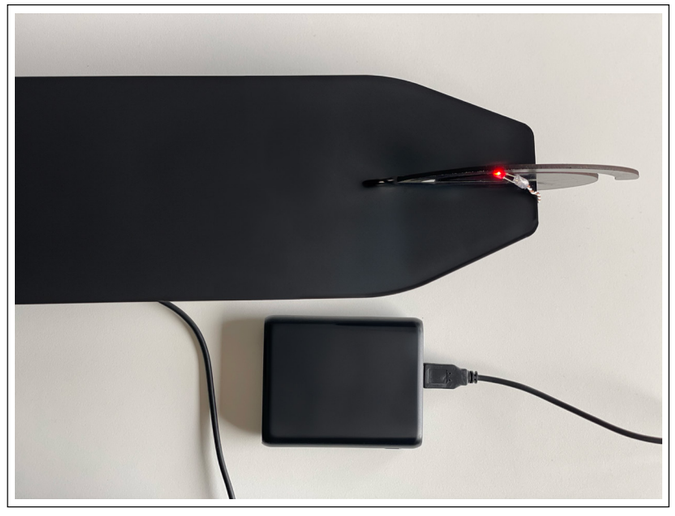


19

20



21

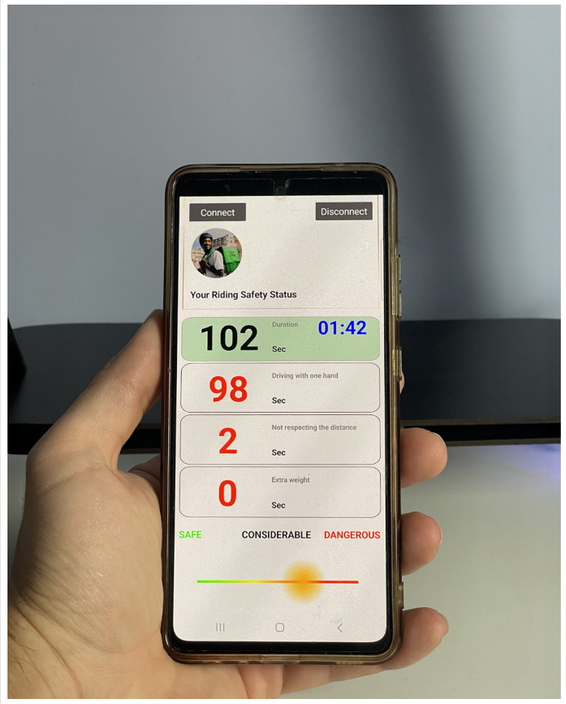


22

16.Perspective view.
17.Front view.
18. side view.
19.20.Top view.
20.21. Side view with showing more details.

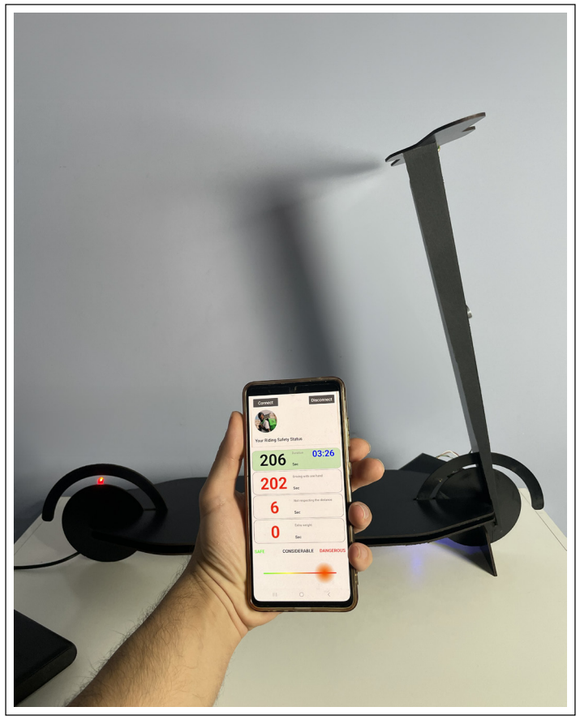
In this project, an Android application is developed that uses UDB connection, which has a very high performance and can establish live communication with sensors and does not require any IP. The board itself creates an IP and the smartphone connects to the application very easily. which must be based on Android operating system. The circuit does not need to be changed and changes are made only from within the application. We used esp 80 66 series microphones.

23.24.25.26. Photos of the application that has been developed to show the data that the server receives through sensors.

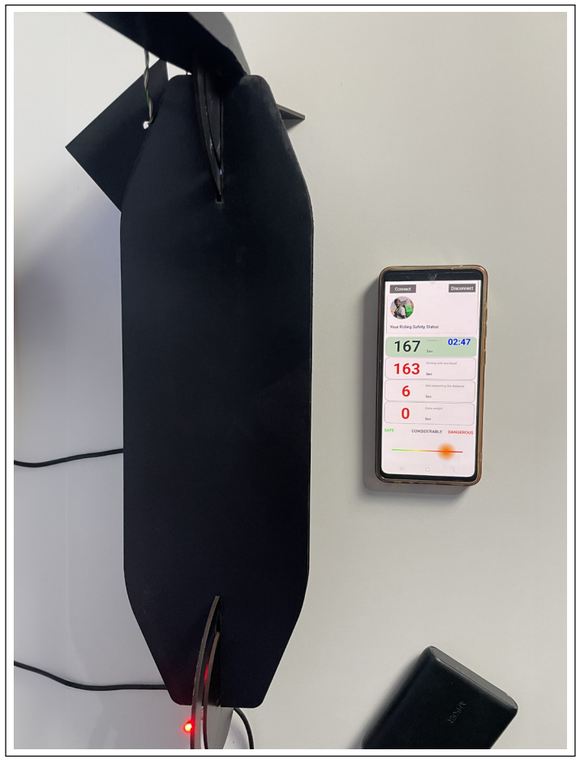


23

24

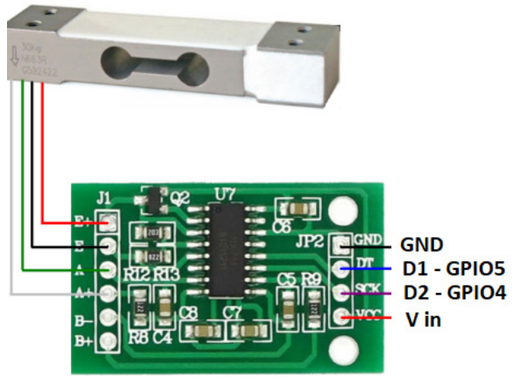


25

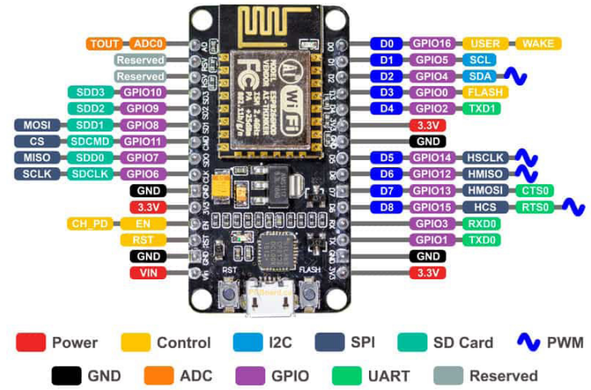


26

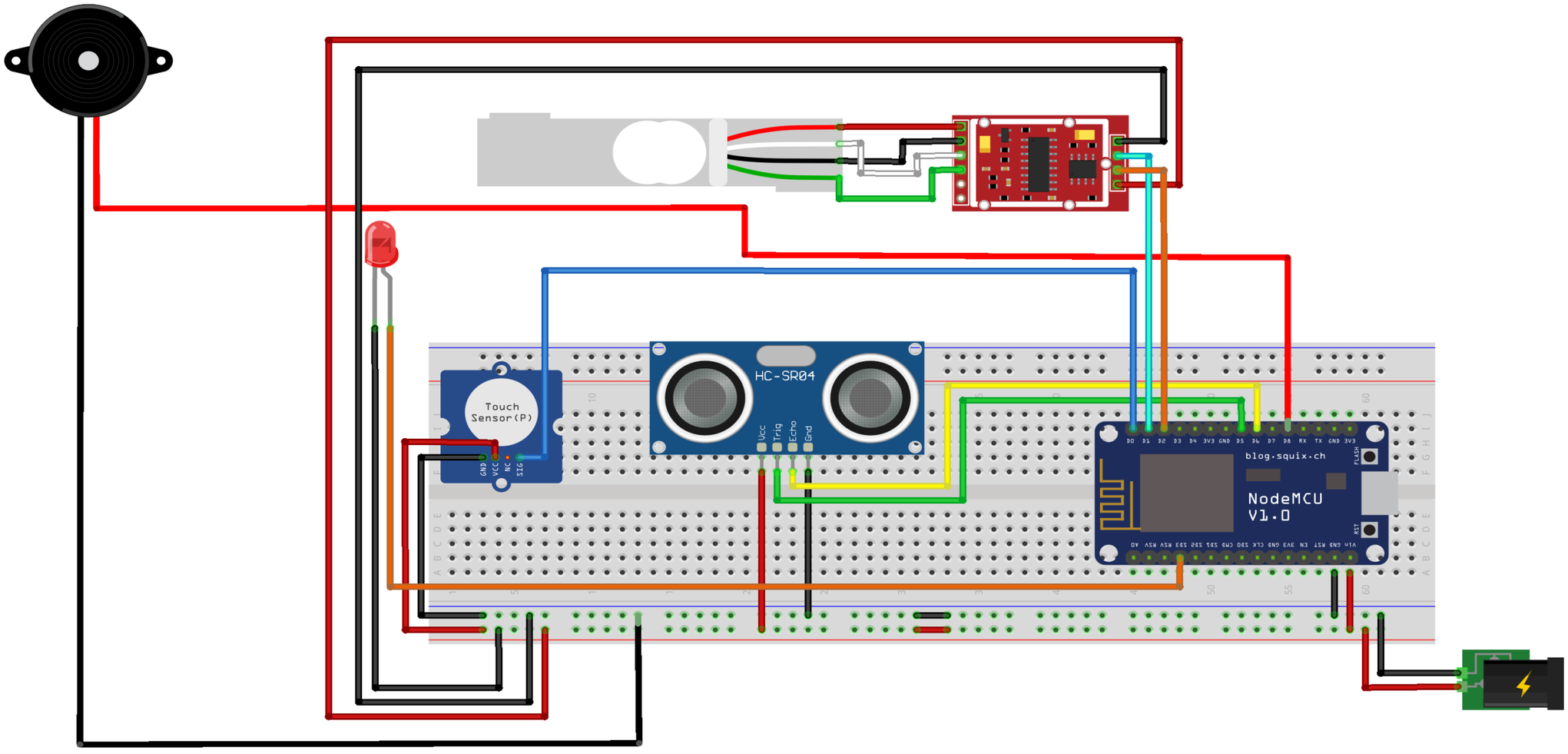
06.4
Fritzing map



23



24



25

23.Technical drawing of load cell sensor.
24. Technical drawing of nodeMCU ESP 32.
25. Technical drawing of the structure of the whole project.

06.5
Usability Testing

This testing phase is a big step, and what I've learned will help me make the system better in the future. I'm planning to keep making the system more advanced. By using better sensors and improving how data moves online, our goal is not just to meet but to go beyond what users and providers expect. This could mean more efficiency, safety, and cool innovations in how shared scooters work.

Testing the new system happened on a shared scooter, where we checked it for all the challenges we expected. The results were good, but using even better sensors could make it work even better. Still, the sensors we used did a decent job. The data went from the sensors to the app online.

During the tests, the data moved smoothly and quickly, thanks to the sensors sending it directly to the app. Even though this process worked well, thinking about using even more advanced sensors could make it work even smoother. Upgrading the sensors could make the system more accurate, responsive, and overall better. Looking at the results from this first round of testing, it's clear the system has a lot of potential. The sensors did okay, but there's room to make them work even better. Bringing in the latest sensor technology not only helps us aim for better but also shows we're keeping up with the latest tech trends for shared electric scooters. Also, the way data moved online during the tests is a good start for using it in the real world. However, we're thinking about how to make it even better. This might involve figuring out if the system can handle more users, connecting it to the cloud, and solving any problems that might come up with more data or user activity.












REFERENCES

Matt. (2021, May 18). Electric Scooter History - Complete Timeline of the Revolution. EScooterNerds. https://escooternerds.com/electric-scooter-history/

LINKING EDUCATION ON SUSTAINABLE MOBILITY WITH TRAFFIC SAFETY. (2023). In traffic safety education. European Transport Safety Council. www.trafficsafetyeducation.eu

E-Scooter-sharing - Italy | Statista Market Forecast. (n.d.). Statista. Retrieved November 16, 2023, from https://www.statista.com/outlook/mmo/shared-mobility/shared-rides/e-scooter-sharing/italy

Scquizzato, T., Gamberini, L., Stella, F., Paoli, A., Gazzato, A., Forti, A., & Semeraro, F. (2022). Analysis of road traffic accidents involving standing electric scooters reported in newspapers in Italy. Clinical and Experimental Emergency Medicine, 9(1), 36–40. https://doi.org/10.15441/ceem.21.078

Slootmans, F. (2021). European Road Safety Observatory Road Safety Thematic Report Personal Mobility Devices. European Commission. https://road-safety.transport.ec.europa.eu/system/files/2021-07/road_safety_thematic_report_personal_mobility_devices_tc_final.pdf

D'Andreagiovanni, F., Nardin, A., & Carrese, S. (2022). An Analysis of the Service Coverage and Regulation of E-Scooter Sharing in Rome (Italy). Transportation Research Procedia, 60, 440–447. https://doi.org/10.1016/j.trpro.2021.12.057

Huang, F.-H. (2021). User Behavioral Intentions toward a Scooter-Sharing Service: An Empirical Study. Sustainability, 13(23), 13153. https://doi.org/10.3390/su132313153

Bieliński, T., & Ważna, A. (2020). Electric Scooter Sharing and Bike Sharing User Behaviour and Characteristics. Sustainability, 12(22), 9640. https://doi.org/10.3390/su12229640

Carrese, S., Giacchetti, T., Nigro, M., Algeri, G., & Ceccarelli, G. (2021, July 1). Analysis and Management of E-scooter Sharing Service in Italy | IEEE Conference Publication | IEEE Xplore. Ieeexplore.

Dias, G., Arsenio, E., & Ribeiro, P. (2021). The Role of Shared E-Scooter Systems in Urban Sustainability and Resilience during the Covid-19 Mobility Restrictions. Sustainability, 13(13), 7084. https://doi.org/10.3390/su13137084

Glavić, D., Trpković, A., Milenković, M., & Jevremović, S. (2021). The E-Scooter Potential to Change Urban Mobility—Belgrade Case Study. Sustainability, 13(11), 5948. https://doi.org/10.3390/su13115948

Fistola, R., Gallo, M., & La Rocca, R. A. (2022). Micro-mobility in the "Virucity". The Effectiveness of E-scooter Sharing.. Transportation Research Procedia, 60, 464–471. https://doi.org/10.1016/j.trpro.2021.12.060

Chicco, A., & Diana, M. (2022). Understanding micro-mobility usage patterns: a preliminary comparison between dockless bike sharing and e-scooters in the city of Turin (Italy). Transportation Research Procedia, 62, 459–466. https://doi.org/10.1016/j.trpro.2022.02.057

Campisi, T., Akgün-Tanbay, N., Md Nahiduzzaman, Kh., & Dissanayake, D. (2021). Uptake of e-Scooters in Palermo, Italy: Do the Road Users Tend to Rent, Buy or Share? Computational Science and Its Applications – ICCSA 2021, 669–682. https://doi.org/10.1007/978-3-030-86976-2_46

Li, A., Zhao, P., Liu, X., Mansourian, A., Axhausen, K. W., & Qu, X. (2022). Comprehensive comparison of e-scooter sharing mobility: Evidence from 30 European cities. Transportation Research Part D: Transport and Environment, 105, 103229. https://doi.org/10.1016/j.trd.2022.103229

les diagrammes, les rèseaux, les cartes, edito da Mouton/Gauthier-Villars, Parigi, Francia - 1967

SAPIENZA
UNIVERSITÀ DI ROMA

Master of Science in
PRODUCT AND SERVICE DESIGN
a.y. 2022-2023

Final Work

Student
Behnam Dayyan
dayyan.1954580@studenti.uniroma1.it

Supervisor
Ioannis Chatzigiannakis
Co-Supervisor
Viktor Malakuczi