SMART SHARED MOBILITIES

RAILWAY STATION DESIGN

2024/2025 Complex Project
Qianchen YAN 6029957
A010 Research Plan
Milan Central

complex projects

2024

COMPLEX PROJECTS
Bodies and Building Milan
AR3CP100

students
Qianchen Yan

chair
Kees Kaan

CP coordinator
Manuela Triggianese

lab coordinator
Hrvoje Smidihen

group tutors
Olindo Caso
Maruli Heijman

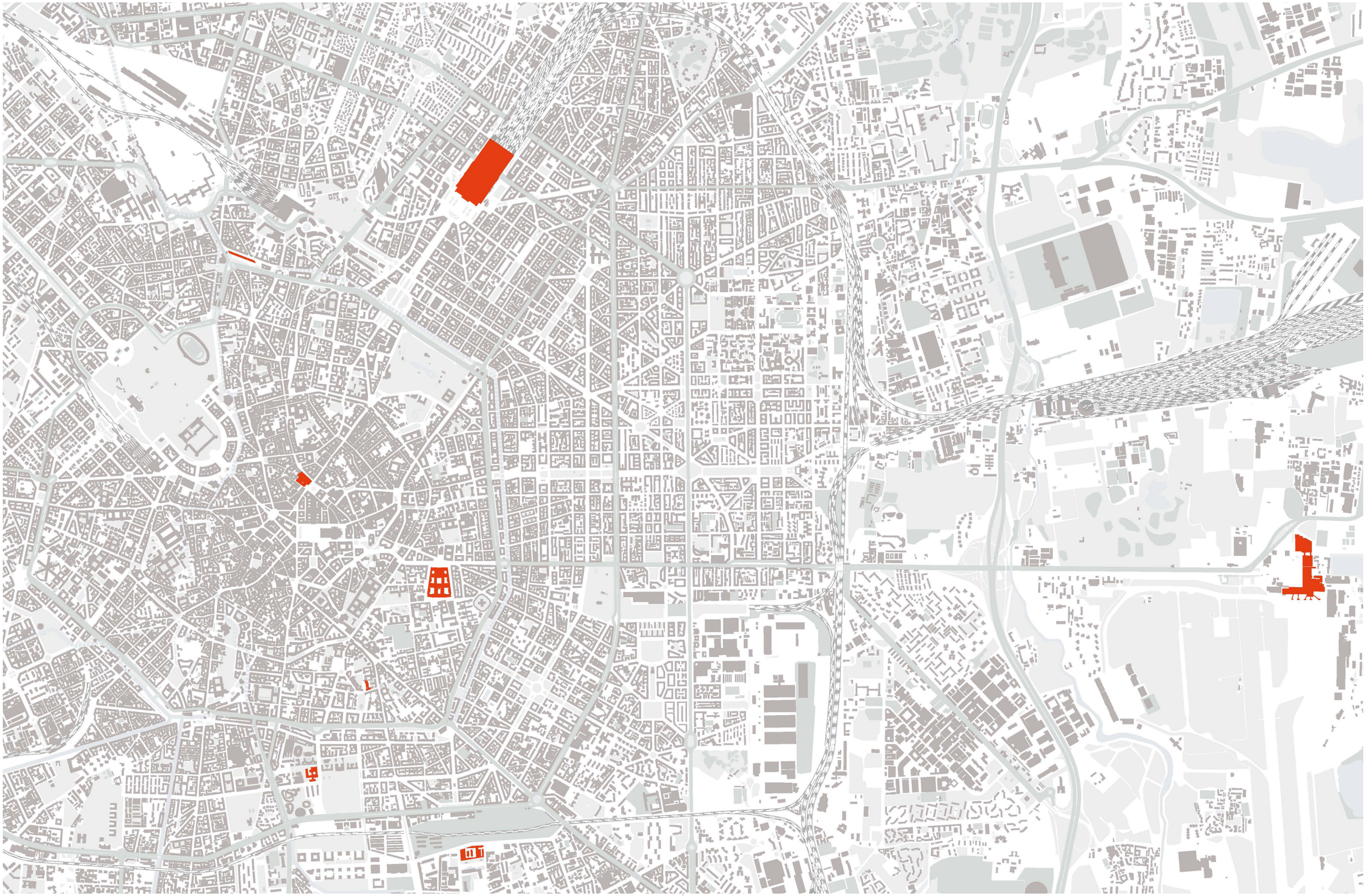
email
infocpstudios@gmail.com

Instagram
https://www.instagram.com/
cp.complexprojects/

website
https://www.tudelft.nl/bk/over-faculteit/
afdelingen/architecture/organisatie/disciplines/
complex-projects/

facebook
https://www.facebook.com/CP_Complex-
Projects-422914291241447

Bodies and Building Milan
Material



4

5

INDEX

INTRODUCTION

01

1.1 Thesis Topic

Train stations have long served as gateways to cities, often shaping the first impression visitors have of a place. Over nearly two centuries of development, advancements in technology and the diversification of travel modes have transformed train stations from simple, single-function facilities into sophisticated, multimodal hubs. Today, they are no longer just points of entry and departure for trains but integrated complexes that seamlessly connect various modes of transportation, including metros, buses, and taxis. Moreover, modern train stations have expanded their role by incorporating extensive commercial and public spaces. These areas offer visitors places for shopping, leisure, and social interaction, establishing train stations as vital and multifunctional public spaces at the heart of urban life.

This research plan centers on the theme of smart shared mobility, with the objective of exploring innovative strategies to reimagine future train stations as central multimodal hubs in urban transportation networks. With the rapid growth of smart technologies and the widespread adoption of shared mobility models, traditional train stations are no longer fully capable of meeting the demands of modern transportation systems. By re-evaluating the role and functions of train stations, the aim of this research plan is to identify effective strategies for integrating diverse transport modes, optimizing spatial layouts, and adapting to the evolving needs of urban mobility. Ultimately, it envisions train stations as dynamic, multifunctional urban hubs fully aligned with the era of smart shared mobility.

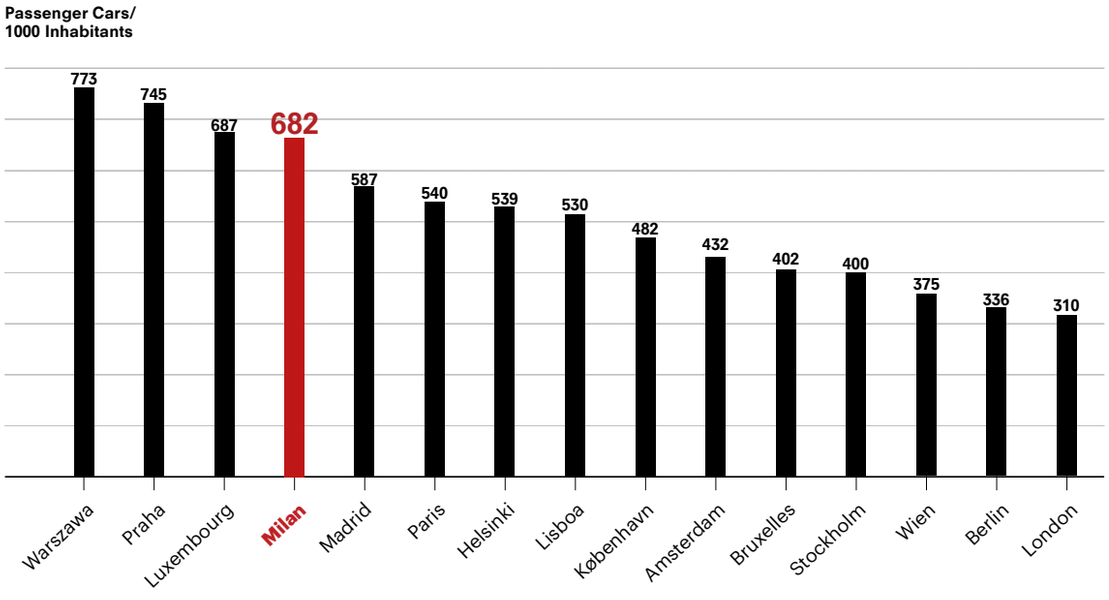


Figure 1: High Rate of Car Ownership in Milan

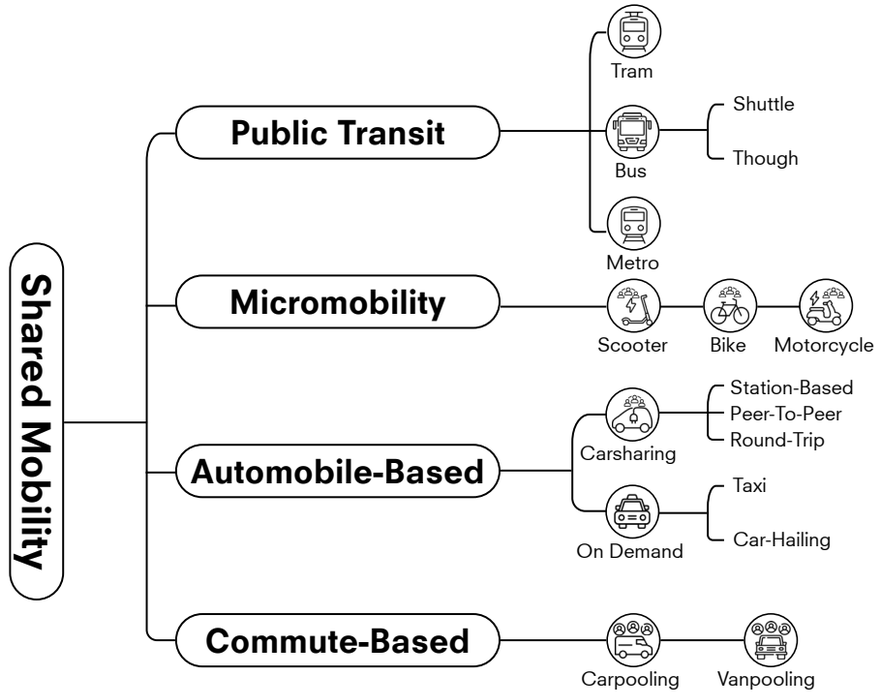


Figure 2: Classification of Shared Mobility

1.2 Problem Statement

Milan is a city characterized by high mobility, with approximately 5.3 million trips taking place daily between the city and its surrounding areas. Of these, around 850,000 people enter Milan, while 270,000 leave (EU Urban Mobility Observatory 2018). In terms of transportation modes, 57% of travelers utilize public transit, including trains and airplanes, while 40% opt for private transportation, comprising private cars (30%), motorcycles (7%), and bicycles (3%).

Milan residents show a stronger preference for private transportation compared to those in other major cities (Figure1). This inclination is largely driven by ongoing issues within the public transit system, including staff strikes, train delays, and cancellations. Moreover, overcrowding at train stations during peak hours, alongside outdated infrastructure and deteriorating facilities, often creates an atmosphere of neglect. This environment attracts homeless individuals and contributes to frequent thefts. As a result, Milan's private car ownership rate remains notably high, exceeding that of other European metropolises such as Paris, Berlin, and London, and even doubling London's rate (Eurostat 2023).

The heavy reliance on private transportation in Milan has resulted in significant energy and environmental challenges. The widespread use of private cars exacerbates traffic congestion, leading to increased time and energy waste. Noise pollution from car horns negatively impacts residents' mental health, while the extensive use of surface parking occupies valuable urban space. Additionally, high levels of vehicle emissions, coupled with poor air circulation, have made Milan one of the European cities with the highest concentrations of particulate matter (European Environment Agency 2024), creating serious air quality issues.

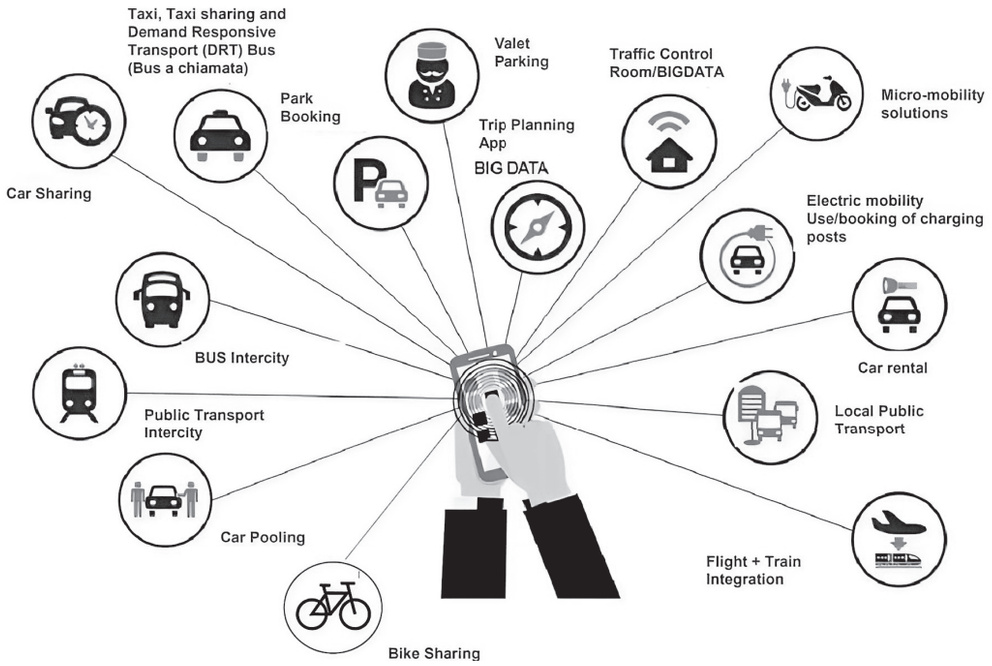


Figure 3: Mobility as a Service (MaaS)

1.3 Problem Solution

In response to Milan's pressing traffic challenges, the municipal government is actively promoting shared mobility and smart travel solutions (EU Urban Mobility Observatory 2024). Shared mobilities, as defined by Shared-Use Mobility Center, is classified into four primary categories: public transit (including trams, buses, and metros), micromobility (including scooters, bicycles, and motorcycles), automobile-based services (including car-sharing services and on-demand options like taxis and car-hailing), and commute-based services like carpooling and vanpooling (Julia Parzen 2015). These initiatives aim to reduce dependence on private cars and ease urban traffic congestion (Figure 2).

The first aspect of smart mobility is transforming transportation into a service via an intelligent platform that streamlines trip planning and ticket management (Sofia 2022). Integrating various transport modes, the platform allows users to search, book, and pay for services through a single app, enhancing convenience and connectivity (Figure 3). This innovation also helps reduce carbon emissions and traffic congestion, paving the way for Milan's future transportation development.

Another key aspect of smart mobility is the shift toward electrification and automation(Martinez and Viegas 2017), revolutionizing train station design and systems. Autonomous vehicles for "last-mile" travel reduce parking needs and improve traffic efficiency (Yap 2016), while electric vehicles and smart charging infrastructure enhance sustainability and convenience. Combining these technologies can optimize train station space, advancing their transformation into smart, low-carbon, and user-focused mobility hubs.

1.4 Research Question

Since the 1880s, train stations have shaped urban landscapes. Over nearly two centuries, Milan's transportation network and urban planning have evolved with advancements in mobility. Milan introduced its first tram line in 1893, followed by buses in 1905, and gradually transitioned from steam trains to electric trains. By 1966, Milan had inaugurated its first metro line. More recently, starting in 2015, shared mobility options like bike-sharing and car-sharing were introduced, supported by the installation of parking stations throughout the city (Chitti 2020).

Nowadays, Milan's transportation network has developed into a diverse system integrating trains, subways, trams, buses, roadways, and micromobility options (Figure 4). Milan Central Station serves as a vital hub for the city's dynamic population, functioning as both a key transit node and a convergence point for various modes of transportation. Looking to the future, Milan Central Station is set to evolve into a major multimodal transport hub, serving as an intelligent control center for shared mobility and optimizing the city's transportation systems.

So my research question is:
How can Milan train station support the development of smart shared mobilities in the future? (Figure 5)

1. What is the smart shared mobility?

2. How can the optimization of railway station spatial layout and functional design better support the smart shared mobility in the future?

3. How should passenger flow in railway stations be designed to adapt to the rapid changes and diverse demands of future smart shared mobility?

4. How to enable railway stations to reserve flexible space and structure for future long-term development and emergencies through scalable design?

5. How can sustainability and environmental principles be integrated into railway station design to support the promotion of future smart shared mobility in the future?

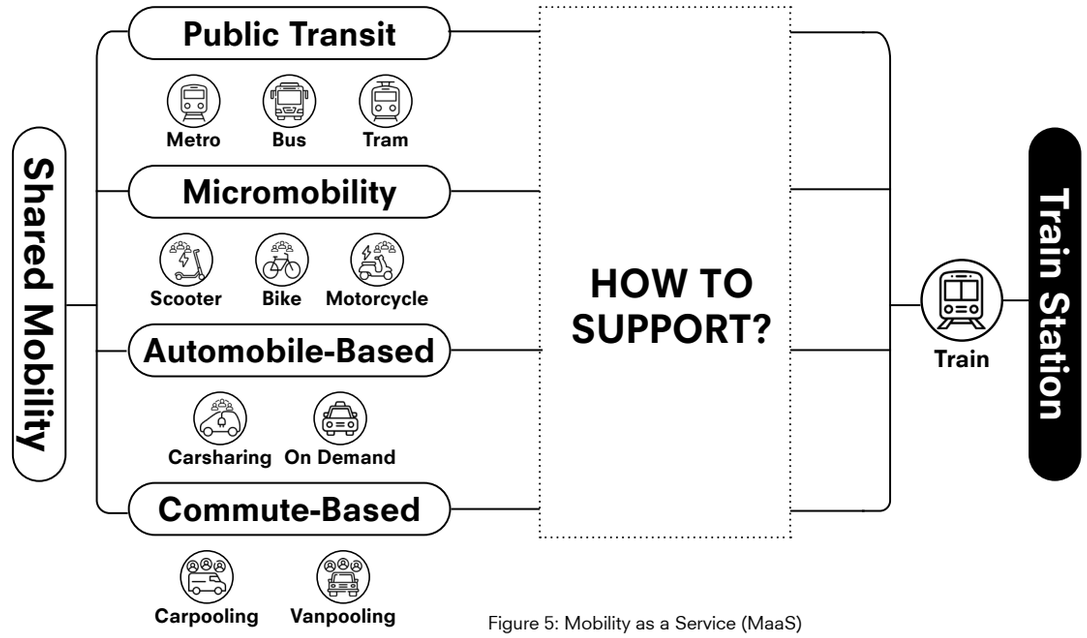
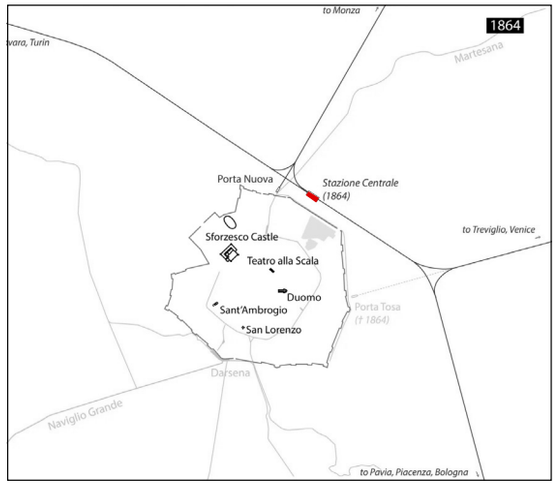
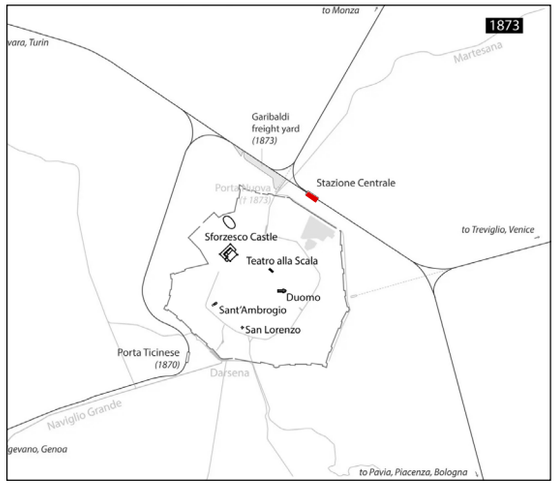


Figure 5: Mobility as a Service (MaaS)

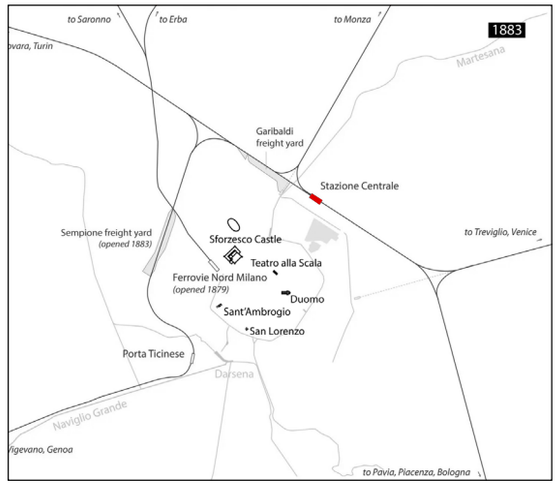
INTRODUCTION



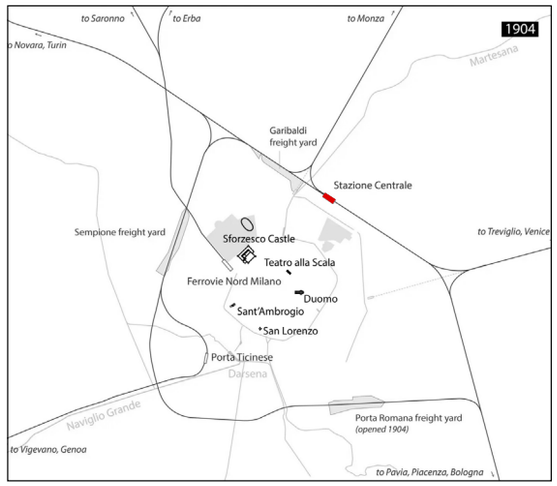
1881



1893

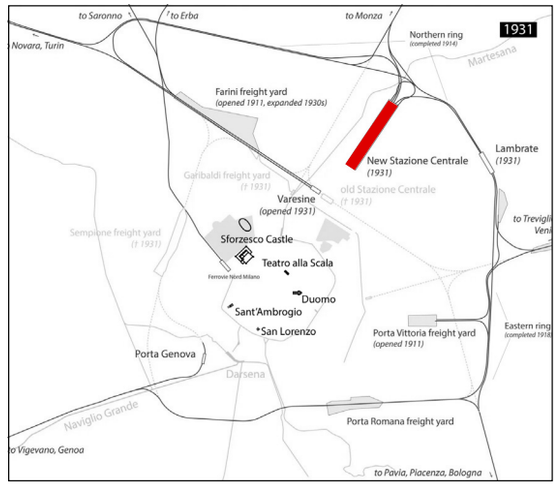


1905

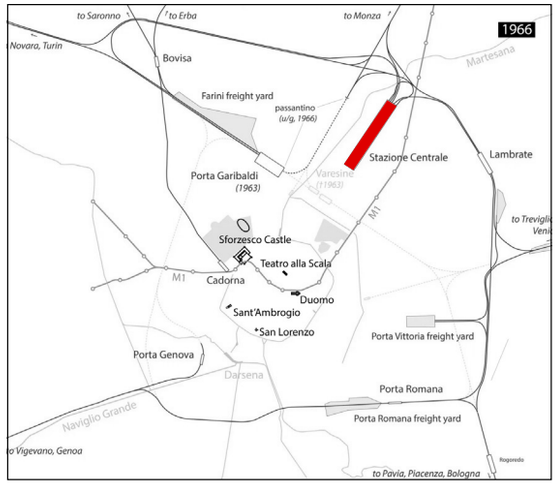


1910

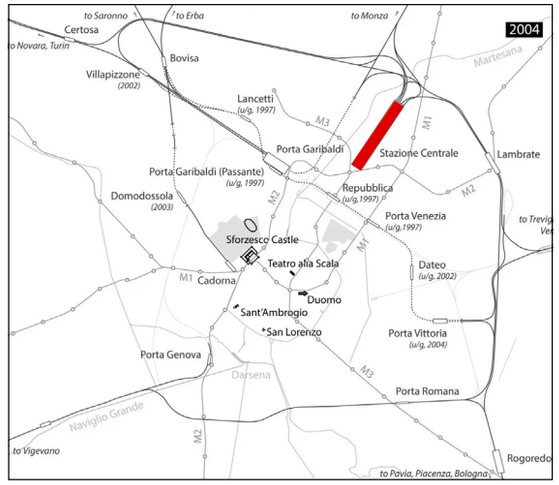
1966



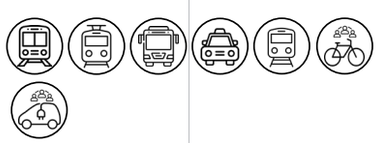
1966

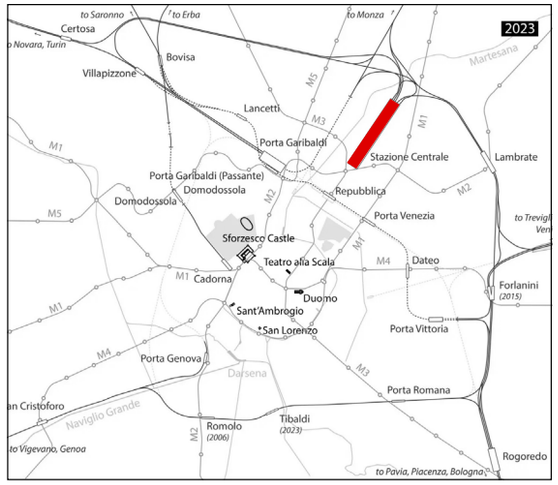


2008

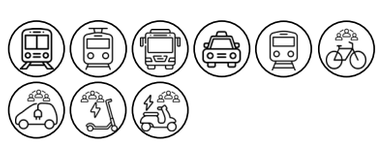


2015





2018



2024

Figure 4: Mobility as a Service (MaaS)

RESEARCH FRAMEWORK

02

2.1 Theoretical Framework:

To support the future growth of shared mobility, train stations are evolving into multimodal hubs that seamlessly integrate diverse transportation modes for efficient and sustainable travel. According to CoMoUK, shared mobility hubs are categorized into six types based on their urban context and key mobility components (Roukouni et al. 2023). Among these, the major one in the city usually is the largest interchange hub, like train stations, because they serve as seamless connectors for both regional and national transit. Within cities, shared mobility hubs can form a hierarchical network in the future, radiating from the major one to smaller ones (Jean et al. 2020). These hubs, varying in scale, work together to create a cohesive ecosystem of multimodal urban transportation (Figure 6).

The design of multimodal hubs relies on the effective planning of access points and connecting spaces for various modes of shared mobility (Figure 7). Connecting spaces are broadly categorized as movement-based or place-based (TfL Urban Design Team et al. 2015). Movement-based spaces prioritize efficiency and time savings, while place-based spaces focus on providing a high-quality waiting and service experience, fostering comfort and a sense of place. Optimizing these connecting spaces to seamlessly integrate access points for different modes of mobility will be a key focus of future research. Moreover, the operational patterns of each mode of mobility and Milan's unique urban context should be taken into consideration.

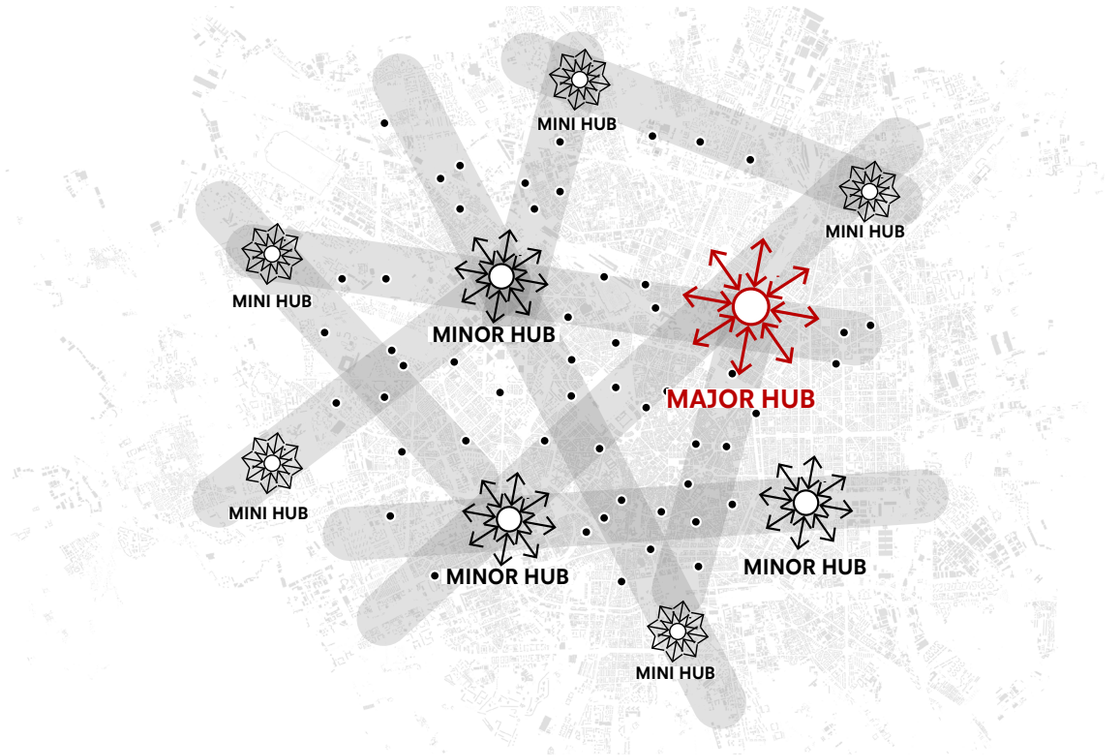
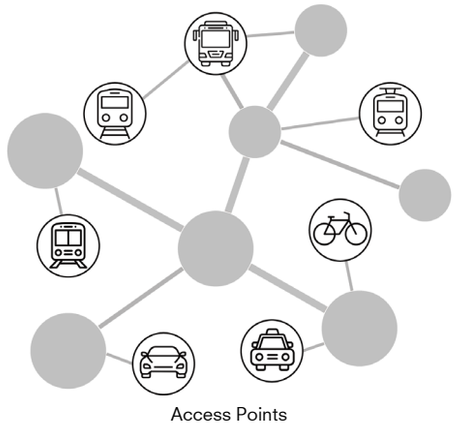
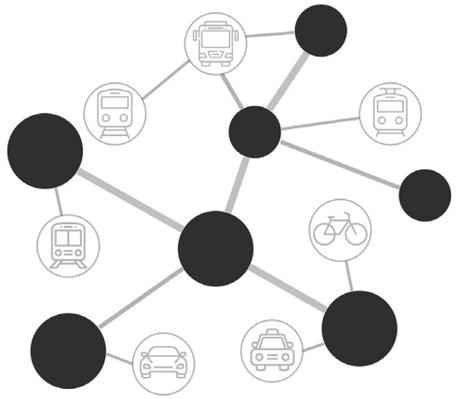


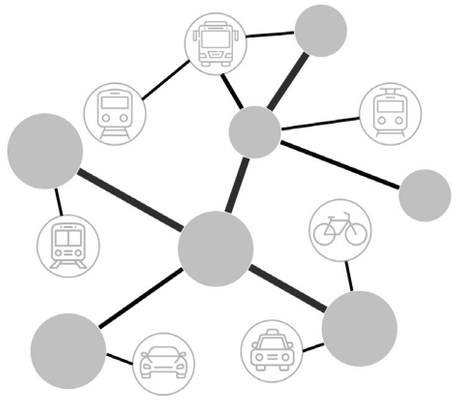
Figure 6: Ecosystem of Smart Shared Mobility Hub in Future Milan



Access Points



Connecting Space: Movement-based



Connecting Space: Place-based

Figure 7: Access Points and Connecting Space

2.2 Relevance

Transforming train station design into integrated multimodal shared mobility hubs can significantly enhance community livability. This is achieved by incorporating factors such as land use, demographics, socio-economic conditions, environmental concerns, health, safety, and public policy into a cohesive transportation strategy (Scott et al. 2013). Well-designed multimodal hubs not only stimulate development in the surrounding areas and attract substantial users, but also catalyze growth in both metropolitan and smaller urban areas (Triggianese et al. 2018).

Urban Transportation: Enhance transfer efficiency, shorten travel times, reduce dependence on private vehicles, deliver a more convenient travel experience, and ease urban traffic congestion.

Community Environment: Promoting shared mobility not only reduces traffic congestion, carbon emissions, and noise pollution while improving air quality, but also liberates substantial land previously occupied by parking facilities. These reclaimed spaces can be transformed into pedestrian-friendly areas around train stations, high-quality public spaces fostering social interaction, and commercial or service facilities. This approach enhances passengers' travel experiences and creates new revenue opportunities for the station.

Identity of Milan: As smart shared mobility continues to advance, Milan Central Station is poised to become a smart shared multimodal hub, serving as a concrete embodiment of Milan's smart city vision. This transformation not only solidifies its role as a major mobility hub but also underscores Milan's leadership in technology, sustainability, and shared economy.

RESEARCH METHODS

03

3.1 Case Study (Program)

Given Milan Central Station's unique status as a terminal station, I have selected five other terminal stations with distinct spatial characteristics as case studies: Antwerpen-Centraal Station, Atocha Station, Zürich Hauptbahnhof, London Paddington, and Paris-Gare de Lyon. The research focuses on a detailed comparative analysis of these stations' spatial layouts, pedestrian flow designs in sectional views, functional space distribution, and connections to other modes of mobility (Figure 9). The goal is to identify the unique features and strengths of each station in spatial organization and multimodal integration.

This research will also analyze case studies of various shared mobility modes, including metros, trams, buses, micromobility options, shared cars, taxis,car-hailing and carpooling services(Figure 8). Spatial diagrams are developed to visualize the layout, usage patterns, and interconnections of these modes within the urban transportation system. They can also provide valuable insights into the spatial characteristics and operational patterns of various shared mobility modes in real-world contexts.

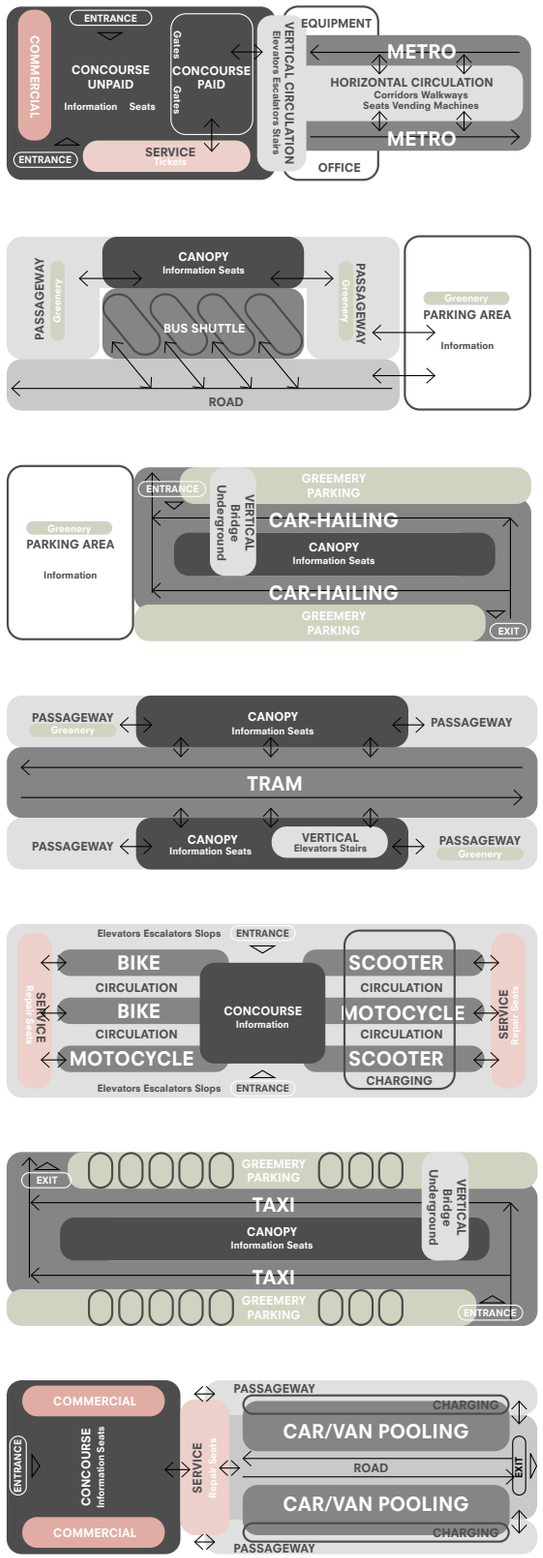


Figure 8: Case Studies of Shared Mobility

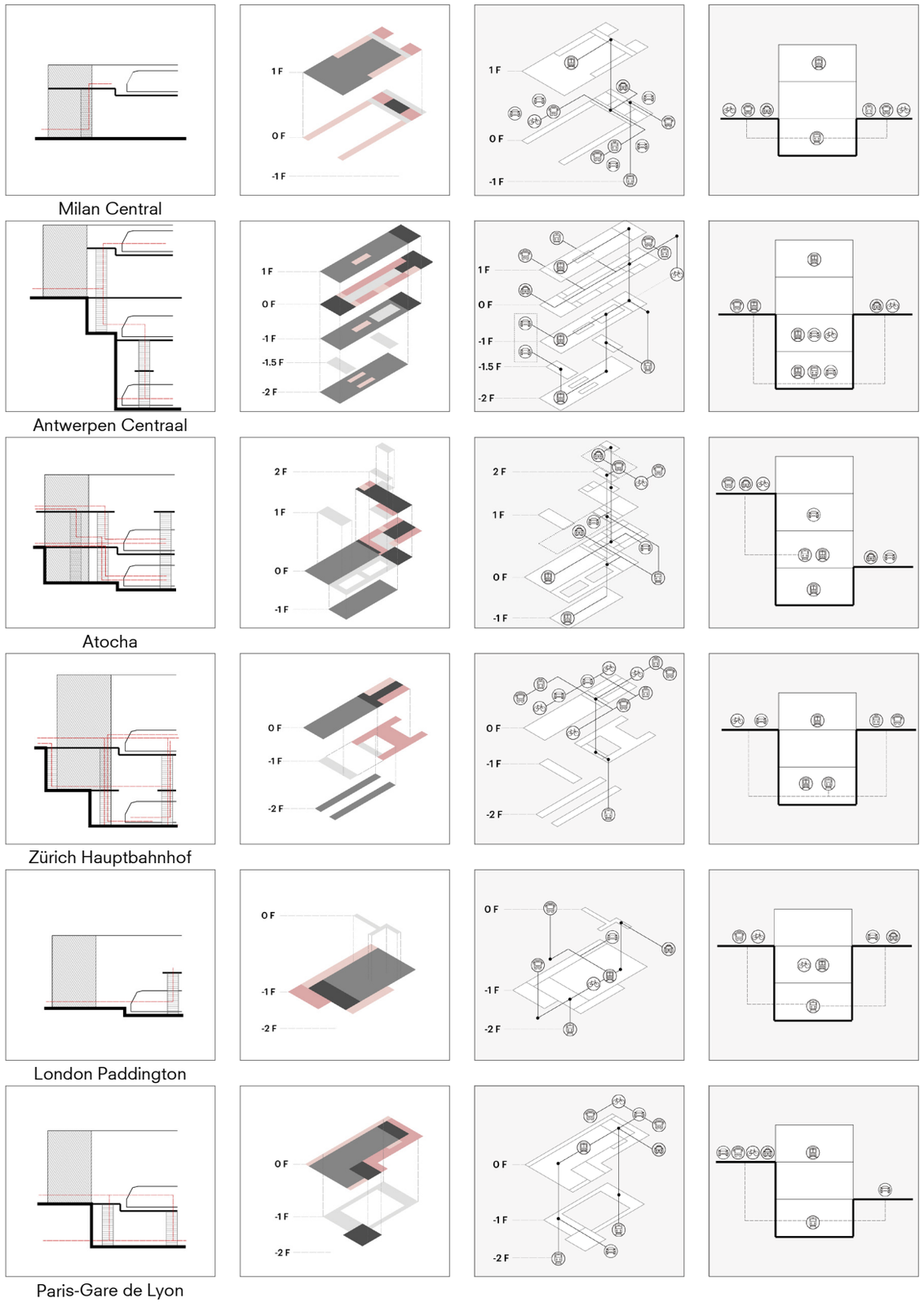


Figure 9: Case Studies of Train Station

3.2 Online Research (Client)

The official website of Italian Railways (Fsitaliane, 2024) provides access to detailed monthly passenger traffic data for Milan Central Station. visitors at the station can be broadly divided into three groups: commuters, travelers, and recreational users (TfL Urban Design Team et al. 2015) (Figure 10). Furthermore, online resources offer information on operators of various mobilities. This comprehensive data serves as a valuable resource for analyzing passenger flow characteristics and travel patterns at the station.

Commuters

Travelers

Recreational Users

Figure 10: Clients

3.3 Mapping (Site)

Mapping the existing routes and flow patterns of various mobility modes around Milan Central Station provides a comprehensive overview of current transportation conditions, establishing a solid foundation and essential framework for future redesign efforts (Figure 11).

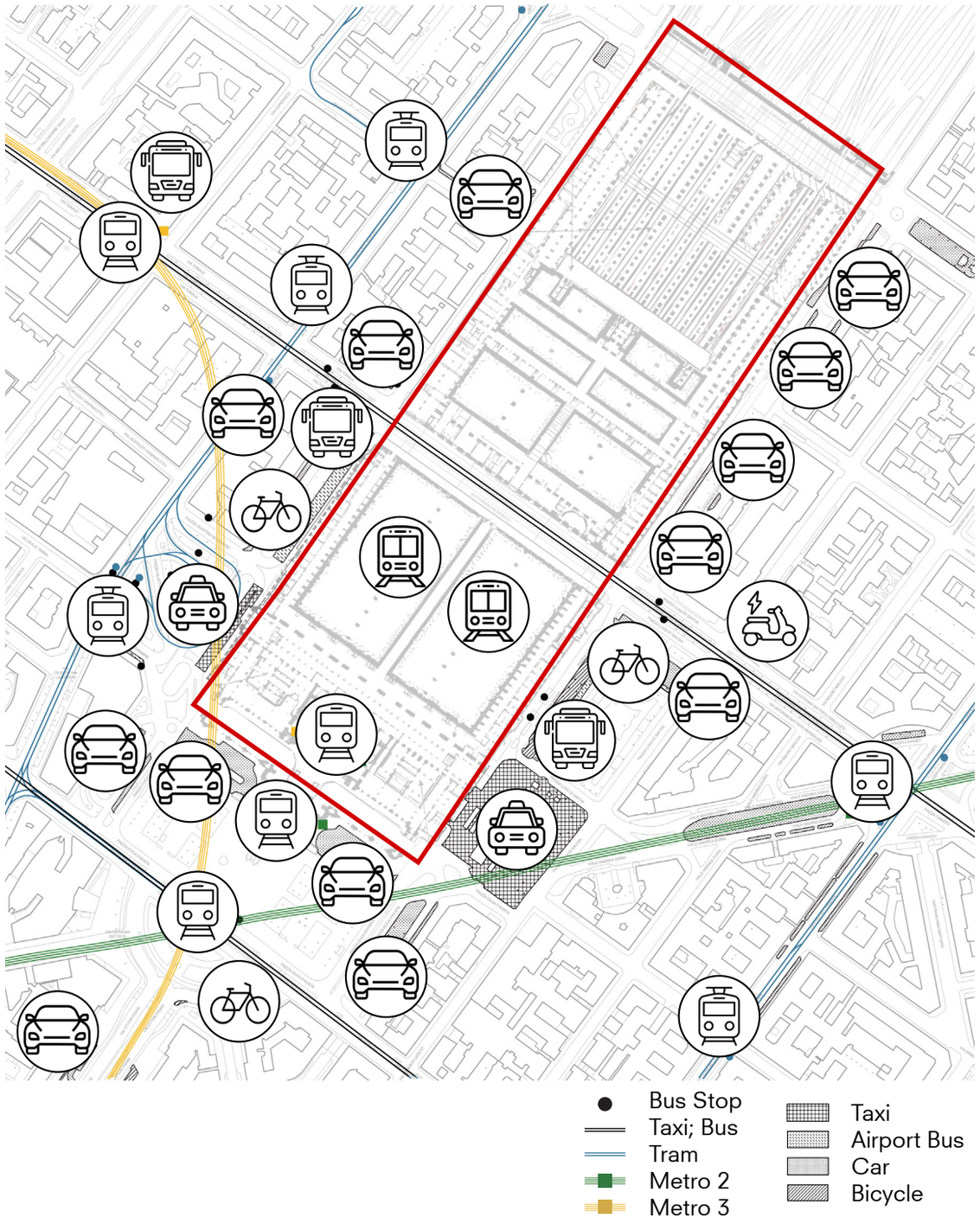


Figure 11: Site Mapping

CONCLUSION

04

4.1 Program

Milan Central Station is envisioned as a highly efficient, integrated, and smart multimodal shared mobility hub (Figure 12). Utilizing intelligent information systems, the station will seamlessly connect various shared mobility options, optimizing transfer efficiency and minimizing walking distances. This design aims to provide commuters, travelers, and recreational users with a convenient and user-friendly travel experience, addressing the growing demand for shared and diversified mobility solutions.

The station will feature two distinct spaces: movement-based and place-based. Movement-based spaces will prioritize efficiency, streamlining transfers between transportation modes, while place-based spaces will emphasize comfort, offering high-quality seating, commercial facilities, and artistic installations to enhance the passenger experience. The plaza will be transformed into a pedestrian-friendly zone, reducing parking areas, adding green spaces, and introducing walkways to improve the surrounding environment. This comprehensive redesign will not only enhance the station's functionality but also position Milan as a leading example of smart shared city.

4.2 Client

The primary users of Milan Central Station and the operators of various mobility modes are depicted (Figure 13). In the future, the station will further optimize its multimodal shared mobility connections to enhance transfer efficiency, meeting the diverse needs of commuters, travelers, and recreational users. At the same time, it will ensure seamless integration across all transportation modes, establishing itself as an efficient smart shared mobility hub.

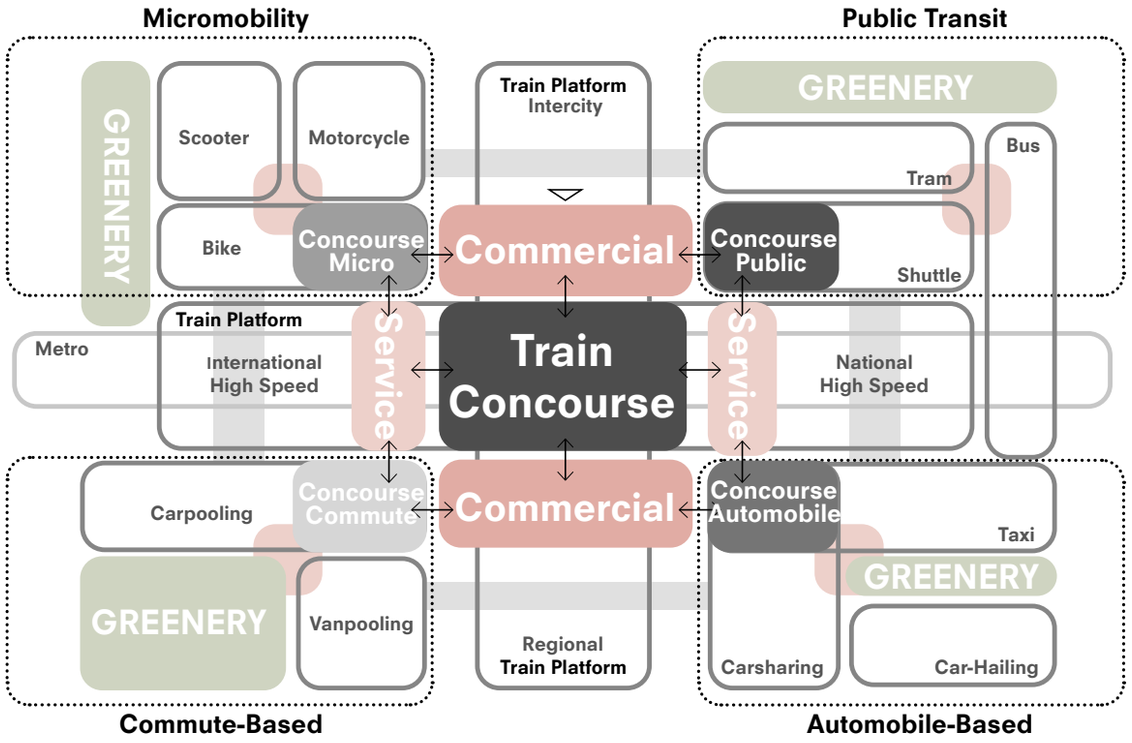


Figure 12: Program

4.3 Site

Historically, the plaza in front of train stations primarily served as a space for transportation transfers. Most Italian train stations, including Milan Central Station, were built between the late 19th and early 20th centuries, based on the transportation needs of that time. Over time, new mobility options were introduced around the station by the government, but their fragmented and uncoordinated placement led to disorganized and congested surroundings, poor environmental quality, and an outdated station image that lacked user-friendliness.
To address these challenges, Milan Central Station will undergo an integrated redesign to transform it into an efficient, environmentally friendly, and well-coordinated multimodal hub that seamlessly merges all modes of shared mobility, presenting a modern and sustainable image (Figure 14).

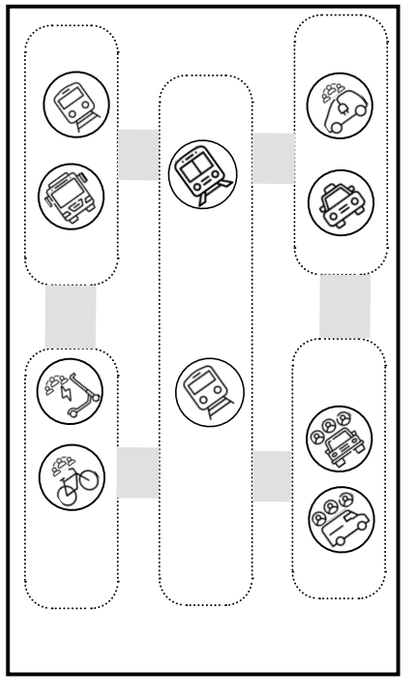


Figure 14: Site

Figure 13: Clients

CONCLUSION

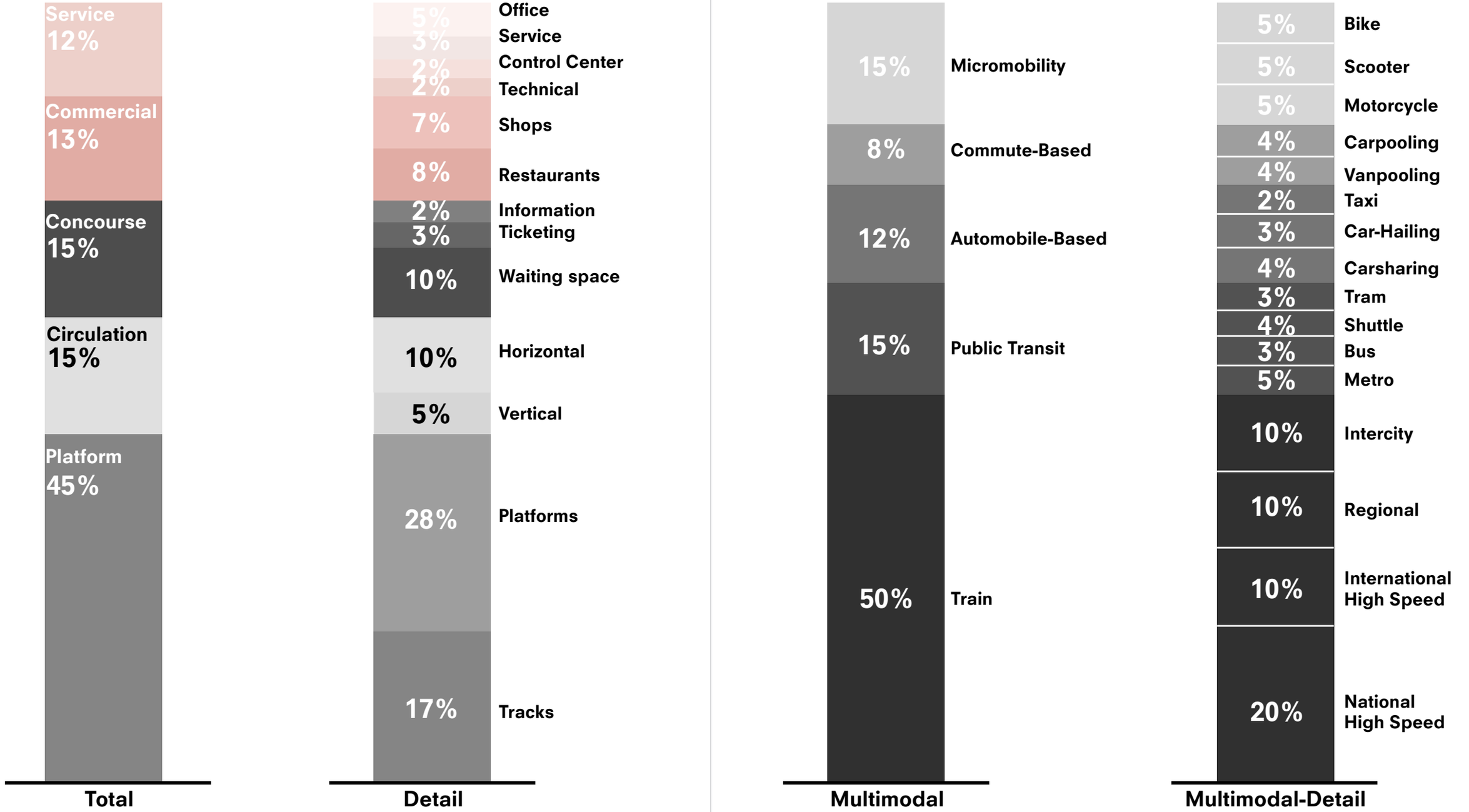


Figure 12: Program

BIBLIOGRAPHY

05

5.1 References

EU Urban Mobility Observatory. 2018. “Shared Mobility Enabling MaaS in Milan’s SUMP.” Publicated April 12, 2018. https://urban-mobility-observatory.transport.ec.europa.eu/resources/case-studies/shared-mobility-enabling-maas-milans-sump_en.

Eurostat. 2023. “Number Of Cars Per Inhabitant Increased in 2021.” Publicated May 30, 2023. https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230530-1.

European Environment Agency’s Home Page. 2024. “European City Air Quality Viewer.” Publicated August 21, 2024. https://www.eea.europa.eu/en/topics/in-depth/air-pollution/european-city-air-quality-viewer.

EU Urban Mobility Observatory. 2024. “Milan Embraces Smart Mobility And Implements An Innovative Platform To Manage Shared Mobility.” Publicated March 26, 2024. https://urban-mobility-observatory.transport.ec.europa.eu/news-events/news/milan-embraces-smart-mobility-and-implements-innovative-platform-manage-shared-mobility-2024-03-26_en.

Julia Parzen. 2015. Shared-Use Mobility Reference Guide. Shared-Use Mobility Center. https://sharedusemobilitycenter.org/wp-content/uploads/2019/08/Reference-Guide-Editsweb-version-10.24.2016_1.pdf.

Sofia, Fraschini. 2022. “The Italian Way to Mobility as a Service - InfraJournal.” InfraJournal, June, 2022. https://www.infrajournal.com/en/w/the-italian-way-to-mobility-as-a-service-2.

Martinez, Luis M., and José Manuel Viegas. 2017. “Assessing the impacts of deploying a shared self-driving urban mobility system: An agent-based model applied to the city of Lisbon, Portugal.” International Journal of Transportation Science and Technology 6, no. 1: 13-27.

Yap, Menno D., Gonçalo Correia, and Bart Van Arem. 2016. “Preferences of travellers for using automated vehicles as last mile public transport of multimodal train trips.” Transportation research part a: policy and practice 94: 1-16.

Araghi, Yashar, Niels van Oort, and Serge Hoogendoorn. 2022. “Passengers preferences for using emerging modes as first/last mile transport to and from a multimodal hub case study Delft Campus railway station.” Case Studies on Transport Policy 10, no. 1: 300-314.

Chitti, Marco. 2020. “Milan: Medieval City to Metropolitana City.” London Reconnections, December 21, 2020. https://www.londonreconnections.com/2020/milan-medieval-city-to-metropolitana-city/.

Roukouni, Anastasia, Inés Aquilué Junyent, Miquel Martí Casanovas, and Gonçalo Homem de Almeida Correia. 2023. “An analysis of the emerging “shared mobility hub” concept in European cities: definition and a proposed Typology.” Sustainability 15, no. 6: 5222.

Jean Crowther, Katie Mangle, Derek Abe, and Kat Maines. 2020. “Mobility Hub Typology Study.” City of Portland Bureau of Transportation. https://altago.com/wp-content/uploads/PBOT-Mobility-Hub-Typology_June2020.pdf.Alta

TfL Urban Design Team, Grimshaw Architects, BDP, and Gareth Powell. 2015 “Station Public Realm Design Guidance.” August 2015. https://content.tfl.gov.uk/station-public-realm-design-guidance-15.pdf.

Scott M, Kelly C, Collins E, et al. 2017. “Research of viable attributes and potential to integrate curbside intercity buses.” Transportation Research Board.

Triggianese M, Cavallo R, Baron N, et al. 2018. Stations as Nodes: exploring the role of stations in future metropolitan areas from a French and Dutch perspective. TU Delft Open.

Fsitaliane. 2024. “Station Attendance Data.” August 8. https://www.fsitaliane.it/content/fsitaliane/en/fs-research-centre/station-usage-data.html.

5.2 Figures

Figure 1: Created by author based on Eurostat, 2023. available at https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20230530-1.

Figure 2: Created by author based on Julia Parzen, 2015. available at https://urban-mobility-observatory.transport.ec.europa.eu/news-events/news/milan-embraces-smart-mobility-and-implements-innovative-platform-manage-shared-mobility-2024-03-26_en.

Figure 3: EU Urban Mobility Observatory, 2018. available athttps://urban-mobility-observatory.transport.ec.europa.eu/news-events/news/milan-embraces-smart-mobility-and-implements-innovative-platform-manage-shared-mobility-2024-03-26_en.

Figure 4: Created by author based on Chitti, 2020. available at https://www.londonreconnections.com/2020/milan-medieval-city-to-metropolitana-city/.

Figure 5: Created by author, 2024.
Figure 6: Created by author, 2024.
Figure 7: Created by author, 2024.
Figure 8: Created by author, 2024.
Figure 9: Created by author, 2024.

Figure 10: Julia Parzen, 2015. available at https://sharedusemobilitycenter.org/wp-content/uploads/2019/08/Reference-Guide-Editsweb-version-10.24.2016_1.pdf.

Figure 11: Created by author, 2024.
Figure 12: Created by author, 2024.
Figure 13: Created by author, 2024.