Chapter 25
The Living Lab for Autonomous Driving as Applied Research of MaaS Models in the Smart City: The Case Study of MASA—Modena Automotive Smart Area

Francesco Leali and Francesco Pasquale

Abstract The revolution of digital technology in the field of mobility generates a complex environment where information technology, vehicle engineering and urban planning cooperate in the design of sustainable cities.

Keywords Autonomous driving · Connected and cooperative vehicles · Computer vision · Artificial intelligence · Mobility as a service · Smart city · Public space · Landscape

25.1 Introduction

The process of urbanization molded our cities with a series of transformations, where each one stratified and left a legacy that still testifies the culture and the technologies of that time. The revolution of modernity massively changed the urban environment in terms of infrastructures by the use of concrete and steel for roads, bridges, tunnels, stations, etc., adapting to vehicle which suddenly became faster, larger, heavier and consequently more polluting (Fig. 25.1). The digital revolution of nowadays instead, even though it occurs at the scale of a microchip or in the a-dimensionality of the ether, might be still more disruptive, as it applies no more to the implementation of physical capacity, but it debuts in the unexplored realm of simulating and replacing human intelligence.

F. Leali (✉) · F. Pasquale
UNIMORE, Modena, Italy
e-mail: francesco.leali@unimore.it

F. Pasquale
e-mail: francesco.pasquale@unimore.it

E. Arbizzani et al. (eds.), *Technological Imagination in the Green and Digital Transition*,
The Urban Book Series, https://doi.org/10.1007/978-3-031-29515-7_25

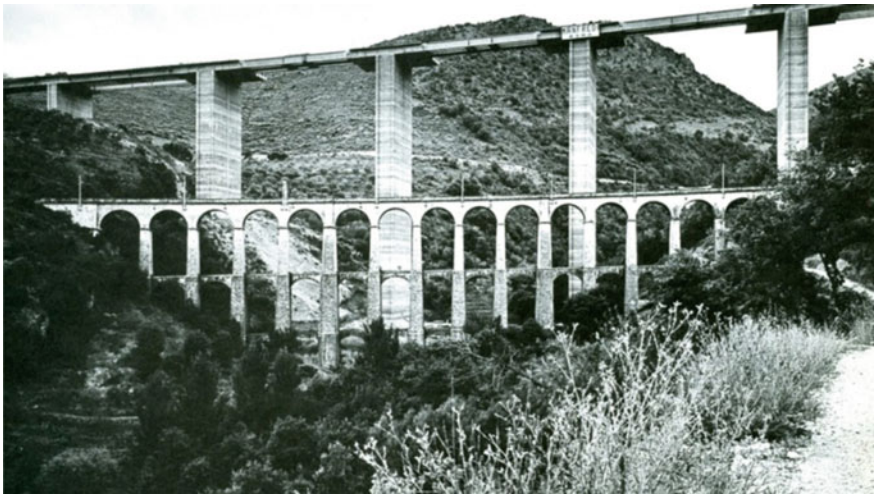

Fig. 25.1 Viaduct on A24 Highway Roma-L'Aquila, 1969. *Source* Abruzzo LIVE https://abruzzolive.it/a24-50-anni-di-autostrada-era-il-10-luglio-del-69-quando-venne-inaugurato-il-primo-tratto-della-roma-laquila/

In the global scenario, mobility as a whole is estimated to impact for about 25% of global emissions[1] and its implications on health, environment, safety and life quality are even more critical issues within the dense urban areas of the contemporary cities.

The models based on non-renewable-energy-consuming private cars are no longer sustainable as population increases, cities densify and resources become less available, so that research on sustainable and intelligent mobility has become a solid global trend, addressed in all international agendas[2] and encouraged by actions for a common jurisdictional framework[3] (Fig. 25.2).

The wider application of information technologies in the field of mobility, on both vehicles and infrastructures, is a disruptive change that is generating a deep shift in the users' habits, the automotive industry, the roads management and the way cities are shaped to embrace these transformations. The combination of computer vision, artificial intelligence and data communication technology enables vehicles to connect more and more among them and with the infrastructures of the city due to V2X[4] protocols, which is gradually leading to fully autonomous driving with ADAS[5] of level 5 (Fig. 25.3). The upcoming scenario of connected and autonomous vehicles enable a large variety of products and services based on the massive amount

[1] IPCC 2022 report. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_FinalDraft_FullReport.pdf.

[2] United Nations Agenda 2030—Sustainable Development Goals. https://sdgs.un.org/goals.

[3] EU Regulation 2019/2144 of the European Parliament and of the Council of 27 November 2019. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32019R2144.

[4] V2X—Vehicle To Everything.

[5] ADAS—Advanced Driving Assistance Systems. https://www.sae.org/blog/sae-j3016-update.

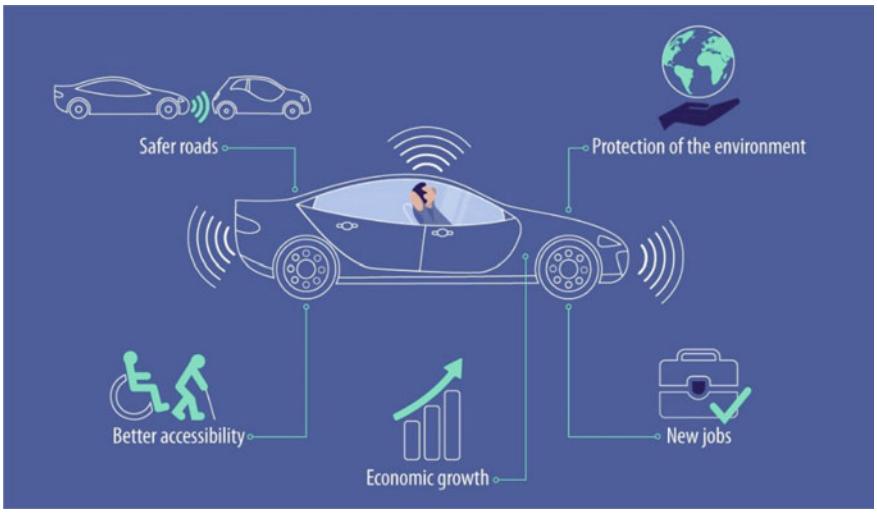

Fig. 25.2 Benefits of autonomous driving. *Source EPRS, European Commission* https://www.europarl.europa.eu/news/en/headlines/economy/20190110STO23102/self-driving-cars-in-the-eu-from-science-fiction-to-reality

of generated data, increasing diversity and complexity in the urban ecosystem of mobility.

The urban shape will not be immune from the digital revolution as a passive scenography, but instead it has to be designed according to the upcoming technologies requirements, affecting the public realm and the morphology of the connective

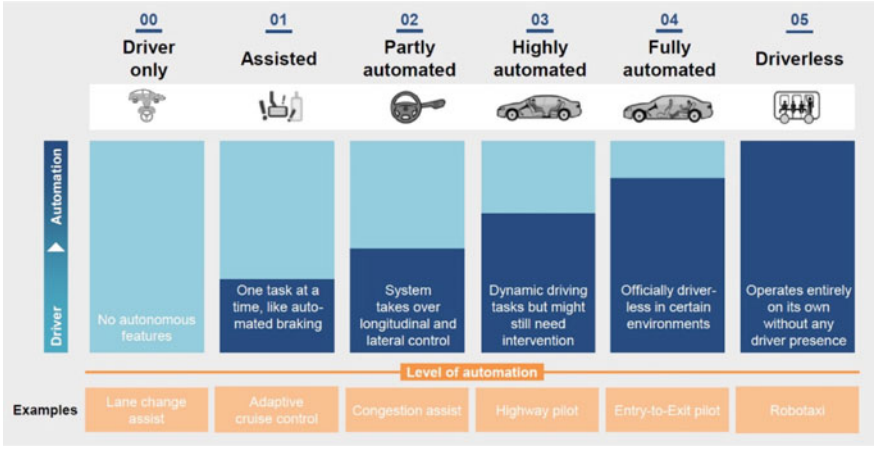

Fig. 25.3 Autonomous driving, 5 levels ADAS. *Source* SAE International, VDA; *EPRS, European Commission* https://www.europarl.europa.eu/news/en/headlines/economy/20190110STO23102/self-driving-cars-in-the-eu-from-science-fiction-to-reality

space due to different street sections, multimodal hubs, on street parking space, refueling stations, radar/LIDAR sensors, horizontal and vertical signs, wired/wireless networks, cameras, antennas, etc. Moreover, it is indeed needed a synergic integration with the other urban networks such as energy grids, green and blue infrastructures and more to approach the ecological issues on a global scale and in a multidisciplinary perspective.

In order to design, develop and evaluate innovative mobility solutions, the structure of the living lab stands out as the ideal environment where to test solutions, dealing with the full complexity of the city within a controlled ODD.[6] This model of public–private collaboration is assuming increasing importance, both at the European level, through the ENOLL[7] association, active since 2006, and in the national panorama, where the National Research Program (PNR[8]) 2015–2020 mentions living labs for the first time, defining them as a tool to support more applied and industrial research.

25.2 MASA: A Public–Private Partnership Model

The integration of knowledge and experiences in the field of vehicles engineering, information technology, urbanism, economy and law (Fig. 25.4) collect in MASA—Modena Automotive Smart Area, which is since 2017 an open and collaborative ecosystem of innovation and research for mobility, with a public–private governance, in Modena, in the heart of the motor valley. MASA operates as an open space for research and experimentation of about 3 km^2 in the context of the urban regeneration of the R-Nord district in Modena (Fig. 25.5). Here companies, research centers, public administration and end users develop new applications, technologies and services in the field of CCAM[9] and MaaS.[10] Supporting assets of the living lab are the data center, a dedicated interdepartmental laboratory of UNIMORE, a private start-up incubator, a dedicated area in the Circuit of Modena and a secured garage for recovery and maintenance of the vehicles.

MASA was officially born with a memorandum of understanding between the University of Modena and Reggio Emilia (UNIMORE), the Municipality of Modena and Maserati as an initial promoter, gathering the interests and enhancing the skills of the project participants (Fig. 25.6). UNIMORE, in its academic role, offers a fundamental contribution with research, training and teaching activities; the private partners carry the industrial research program, aimed at developing solutions for safe and efficient mobility; while the Municipality of Modena allows to implement actions on the field, improving the quality of life of citizens, investing in urban and

[6] ODD—Operative Design Domain.

[7] ENOLL—European Network of Living Labs association.

[8] PNR—National Research Program 2015–2020.

[9] CCAM—Connected and Cooperative Autonomous Mobility.

[10] MaaS—Mobility as a Service.

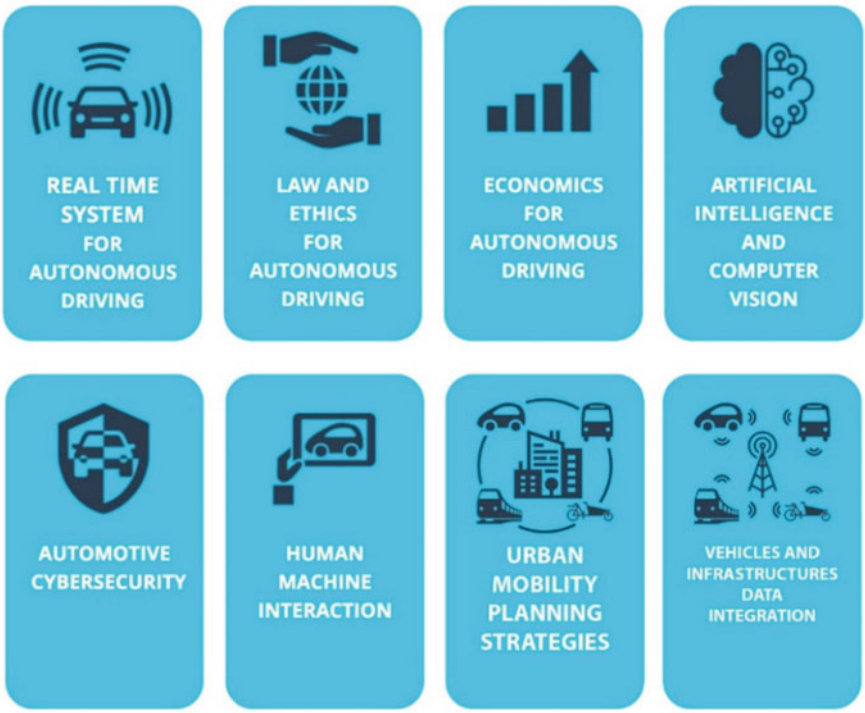

Fig. 25.4 MASA skills and competences. *Source MASA—Modena Automotive Smart Area*

Fig. 25.5 MASA in the R-Nord district. *Source MASA—Modena Automotive Smart Area*

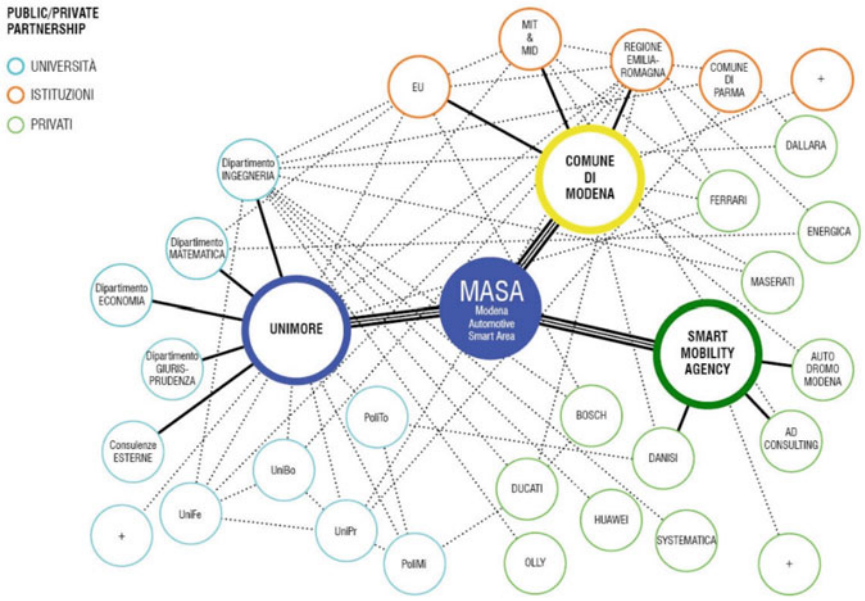

Fig. 25.6 MASA governance diagram. *Source MASA—Modena Automotive Smart Area*

technological requalification of the R-Nord district and making mobility a system with other networks and collective infrastructures.

The initiative also benefits from the endorsement of the Ministry of Transport, formalized in 2018 by signing a first three-year memorandum of understanding with UNIMORE and the Municipality of Modena to evaluate forms of collaboration and to promote the MASA experimentation area in the implementation of innovative solutions for autonomous and connected driving. The support of national institutions is renewed and expanded in 2020, when the Ministry of Infrastructure and Transport joins the Ministry of Technological Innovation and Digitization.

25.3 A Tiny Smart City: The Infrastructured Urban Area

The ODD of MASA is currently infrastructured with smart cameras, wired and wireless communication network (1 dedicated 4G antenna and one 5G antenna): sensors, servers and a data center, for the V2X operations of bidirectional communication between connected vehicles and the city (Fig. 25.7) and for the test drive of vehicles equipped with ADAS devices up to levels 3 and 4. The infrastructure installations for operation are constantly being implemented, and up to now it counts on 100 cameras, 4 fog nodes (Nvidia Titan), 10 MIND Smart Cameras, 2 mobile traffic lights and about 100 control units for weather and air quality control. The MASA

data acquisition and communication system operate with "*on the edge*" technology, i.e., through the anonymization of sensitive data by an artificial intelligence incorporated in the acquisition cameras, which generalizes its personal or sensitive data in less than 30 ms. This happens before those are sent over the network to the control unit, which will send the commands back to the vehicle to be executed (Fig. 25.8). MASA is currently the only European Living Lab where road tests are carried out with an overall latency time of less than 100 ms between acquisition and command input.

Furthermore, MASA counts on the support of operational outside the living lab ODD, such as a dedicated private area at the Modena Autodrome, active since 2017,

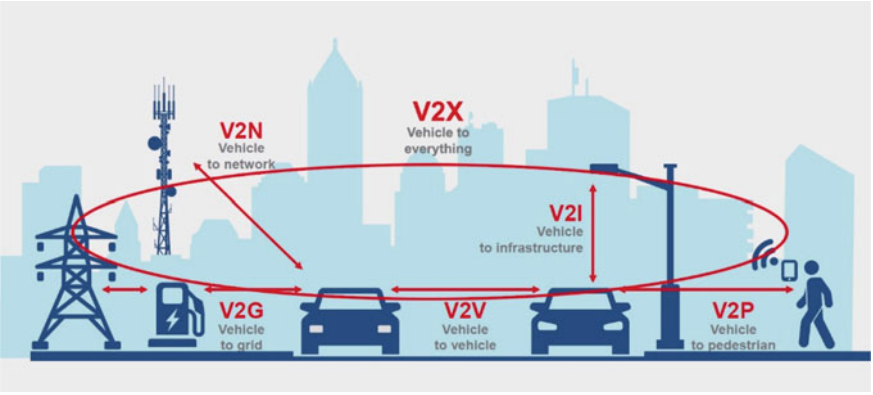

Fig. 25.7 V2X technology diagram. *Source* Porsche Consulting; *MASA—Modena Automotive Smart Area*

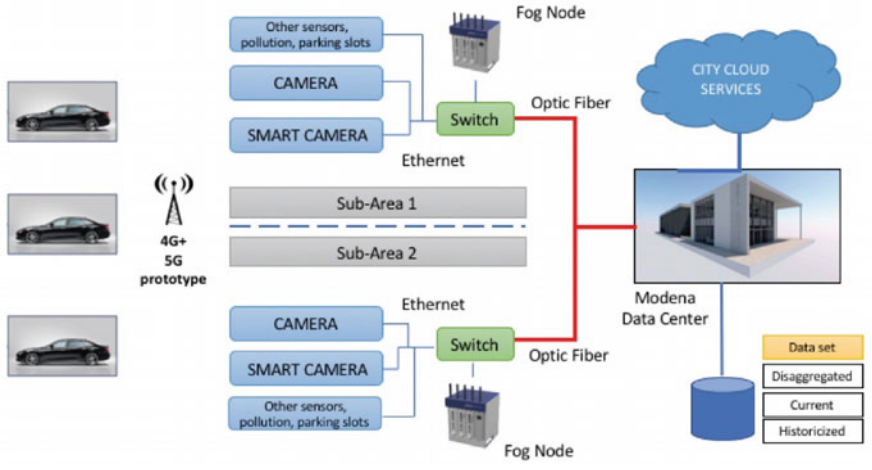

Fig. 25.8 V2X technology diagram. *Source* Porsche Consulting; *MASA—Modena Automotive Smart Area*

suitably infrastructured for the earliest test drive of self-driving vehicles and for active V2X communication, and to carry out training activities for students and users/early adopters of ADAS devices. Some technologies have already been tested in the area, such as traffic lights interconnected to the cloud system and supporting the latest industrial and automotive communication standards, digital signage, IoT cameras for obstacle recognition based on artificial intelligence, and connected with cloud servers "MASA," video analysis for the identification of parking spots to implement "*smart parking*" services, various sensors interconnected through the "*LoRa*" network. A dedicated university research laboratory has also been active since 2018, equipped with a static simulator that allows to perform "*Hardware in the loop*" for the implementation of research and development activities on autonomous driving and *Advanced Driving Assistance Systems* (ADAS), also in collaboration/supply of services with/to third-party companies, and for the realization of training activities for ADAS students and early users. Human resources from multiple disciplinary areas converge on the research laboratory, and it is the reference point for intra- and inter-university academic activities.

Also in November 2018, the E-hub private start-up incubator was inaugurated, consisting of a space of about 300 m^2 with connected and equipped workstations, meeting spaces and others for sharing resources and support services for entrepreneurship. The companies are all recently founded start-ups, sharing a strong attitude toward technological innovation in fields related to the automotive sector and its supply chain derivatives, in particular focusing on the fields of electronics, software and computer science. The incubator is positioned as an operational outpost in the pursuit of the third mission, of which MASA represents a facilitator with a key role in the network of relationships between the world of research and that of entrepreneurship.

As a facility, MASA uses a supervised garage of about 300 m^2 for the storage, custody and maintenance of some of the vehicles on which the projects are already being tested (Fig. 25.9). Currently, the fleet of vehicles on which drive testing has already started is composed of 2 Maserati Quattroporte L3 cars with LIDAR, 6 cameras, GPS, IMU and radar and HW NVIDIA PEGASUS; 1 Maserati Levante L2 car with stereo camera, HW NVIDIA TX2; 1 Motorbike Energica EVA with cameras, GPS, IMU, gyroscope and NVIDIA TX2 // XILINX ULTRASCALE; 1 LIFETOUCH Delivery Bot with LIDAR and gps; 15 SETA bus with passenger detection system; 4 Hexacopter and quadricopter drones with cameras, GPS, IMU, gyroscope and HW NVIDIA TX2 (Fig. 25.10).

25.4 MASA 2.0: An Evolving Model

The main development of the living lab is based on the creation and promotion of a regional ecosystem of connected and autonomous mobility, which favors new paradigms of more sustainable, safe and inclusive urban environment, through the conception, development and experimentation of services from part of the companies

Fig. 25.9 MASA infrastructure asset: 1. Data Center; 2. Via Rita Levi Montalcini; 3. Millemilia Garage; 4. Autodromo di Modena. *Source MASA—Modena Automotive Smart Area*

and research centers of our territory and beyond, establishing a system with other tangible and intangible, urban and extra-urban infrastructural networks.

In its evolution, MASA intends to be a model for the experimentation of research, development, design and validation services of devices and technological solutions for the management of data between vehicles and cities, making available both its physical and virtual infrastructure. The three-year protocol signed with the Ministry of Infrastructure and Transport has been renewed in June 2021, implementing the areas of shared actions on the broader frame of technological innovation for sustainability and urban regeneration. In particular, MASA has acquired skills and resources to expand services in the scientific, technical/technological, economic, legal and urban planning fields. The extent of the impact of its activities will be further implemented, starting from the local area to match the goals of the national and European agendas.

The services concern contracts between a multiplicity of actors: private and private, private and university/research institution, university and private, university and university/research institution. The leap in scale is understood as the systematization of the experiences gained so far, maximizing the operational synergies of the operators and confirming itself as increasingly authoritative interlocutors toward local, national and European institutions.

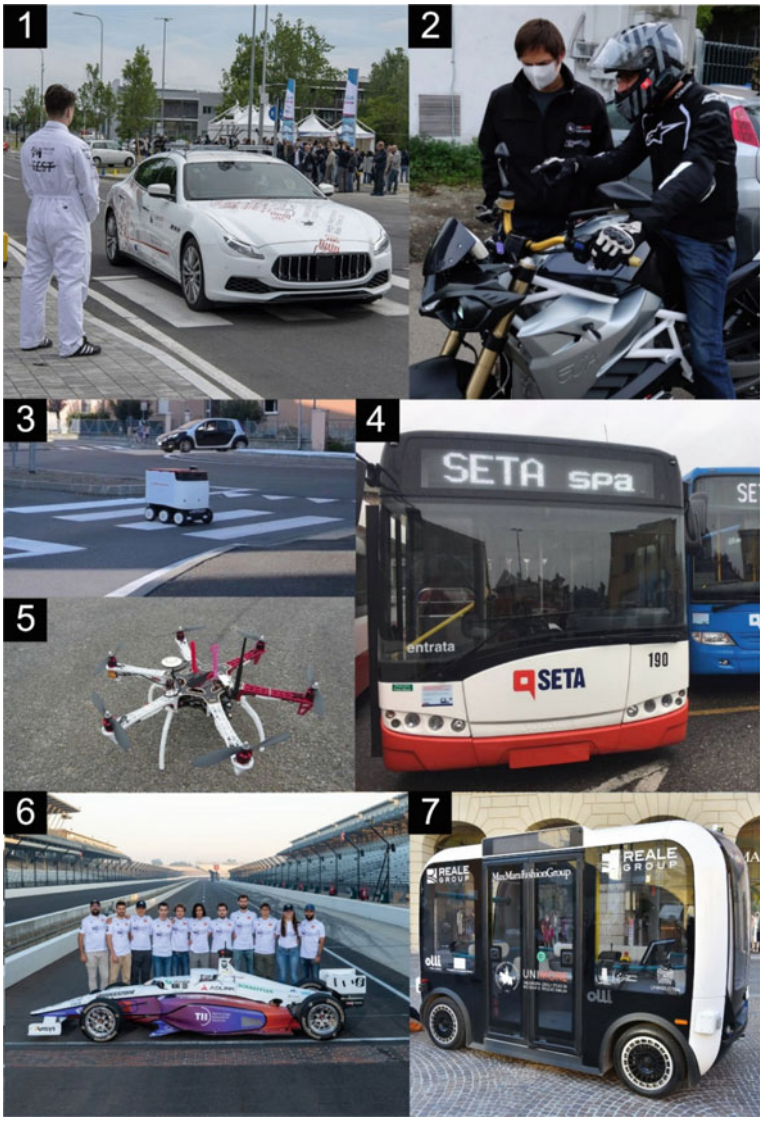

Fig. 25.10 MASA vehicle asset: 1. Maserati Quattroporte; 2. Energica Eva; 3. Delivery Bot; 4. SETA Bus; 5. Drone Hexacopter; 6. Formula Indy; 7. Shuttle Olli by Local Motors

In terms of relations with companies, UNIMORE has signed a protocol with the Smart Mobility Agency, which has been born from the collaboration of AD Consulting, Aerautodromo di Modena and Danisi Engineering. SMA participates in the technical-scientific committee that selects applicable within the projects and defines the international collaborations according to the objectives of MASA.

UNIMORE has fielded 13 departments for this collaboration protocol, confirming the multidisciplinary expansion on the issues of mobility, the city and ultimately the connected society.

MASA intends to attract resources by pursuing funding lines for research and innovation through both Italian and European applications and by seeking further private partnerships in order to broad the horizon of collaborations to non-traditional and innovative operators in the field of connected and sustainable mobility.

25.5 Developing Plans for 2021–2024

At the state-of-the-art MASA has concluded a three-year cycle of fundamental experiences for the validation of the research request and the verification of the existence of a market interested in welcoming it. Its surprising attractive value now allows to start a more ambitious three-year planning period, which will see on the one hand the implementation of consolidated core business activities and on the other structured to expand the range of services offered.

In this perspective, the governance model in the public–private partnership is evolving, with the expansion of both the public and private realm, a strategy that is believed to be the trajectory to follow as well in the upcoming future. As a result of the evolution of the model, a coherent organizational structure will be adopted, which tends to be more defined and with dedicated resources to be able to perform its functions.

Equally in progress is the legislation ruling on the use of public roads and the methods of collecting and managing sensitive data by public and private individuals. With respect to this sensitive topic, everything related to the requirements of the DGPR is being studied in depth with the Law Department.

Regarding the definition and the development of new services, the process will follow a line of inclusiveness toward new actors, able to bring skills and contributions on a broader horizon of objectives and disciplinary areas.

MASA is currently investigating potential strategies and solutions for the connective space of the district due to the use of MaaS models, again confronting with the actual conditions of an ongoing process of regeneration, with a large variety of situations of the context to be taken in account and immediate feedback on the field. The upgrade of MASA will take these data as inputs to generate a complex model as output. As mentioned before the multimodality of transport, regarding both people and goods, implicates the integration of several infrastructures, where information technologies are not merely on more layers to the system, but the enabling trigger to enlace them all.

According to the lesson learned from ancients Romans, where in the Latin language the word “city” had a semantic distinction between “urbs” and “civitas,” i.e., the city of the stones and the city of the people, society is considered as well as a crucial infrastructure that demands engagement at all levels, from the governance

body to the stakeholder until the final users, for whom right of mobility policy and inclusive services are designed.

MASA as a living lab aims to investigate on how cities will adapt to the new paradigms of mobility, where a virtual revolution is taking place faster than urban transformation processes. Learning from the lesson of the mobility revolution of the twentieth century, where an under-reactive urbanism allowed private cars to take it all, the urban design and planning should be able to fit the emerging mobility models in the complexity of the smart city as an ecosystem.