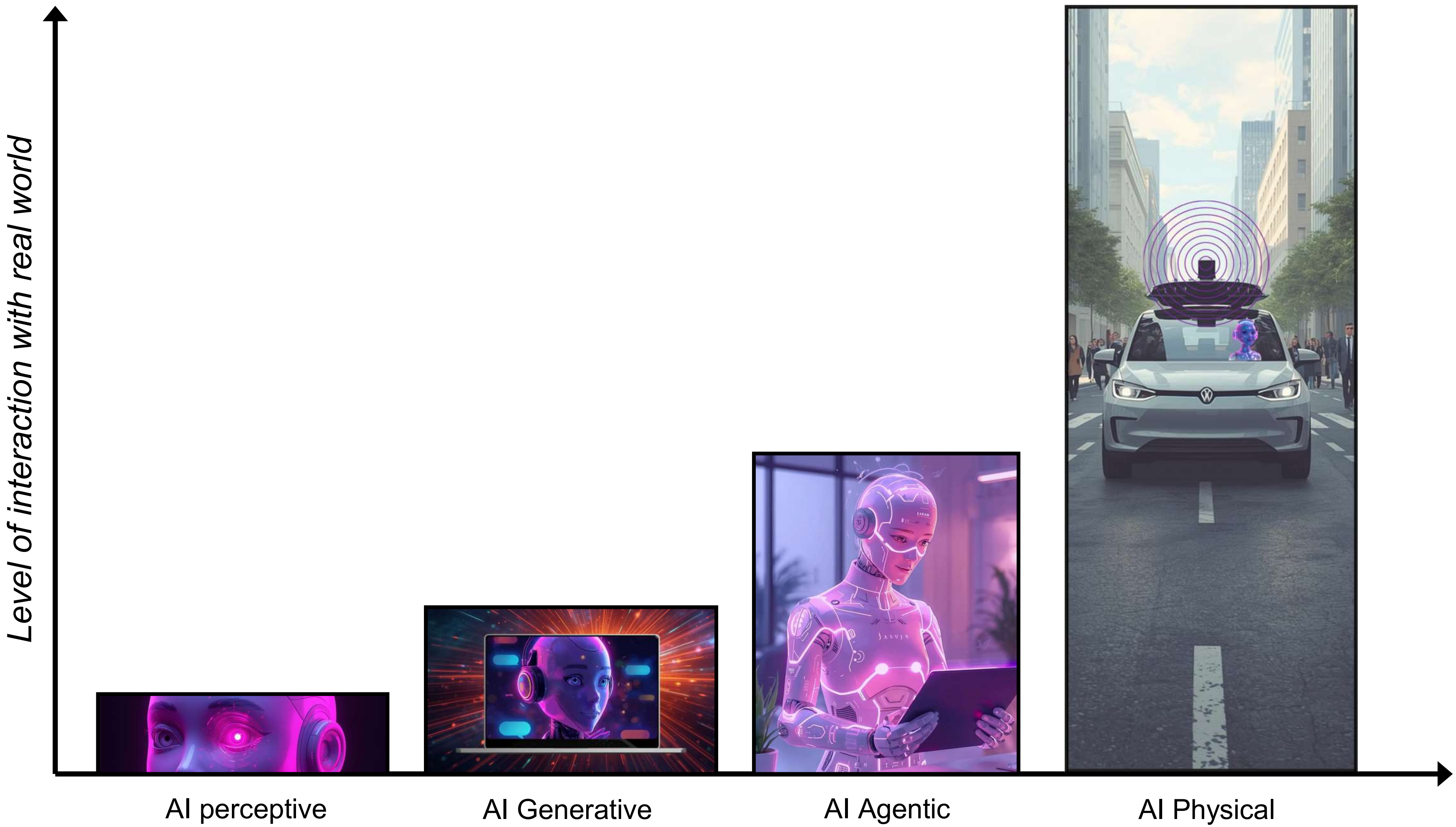
A.I. Fisica
per la MOBILITÀ

La guida autonoma e la rivoluzione della mobilità

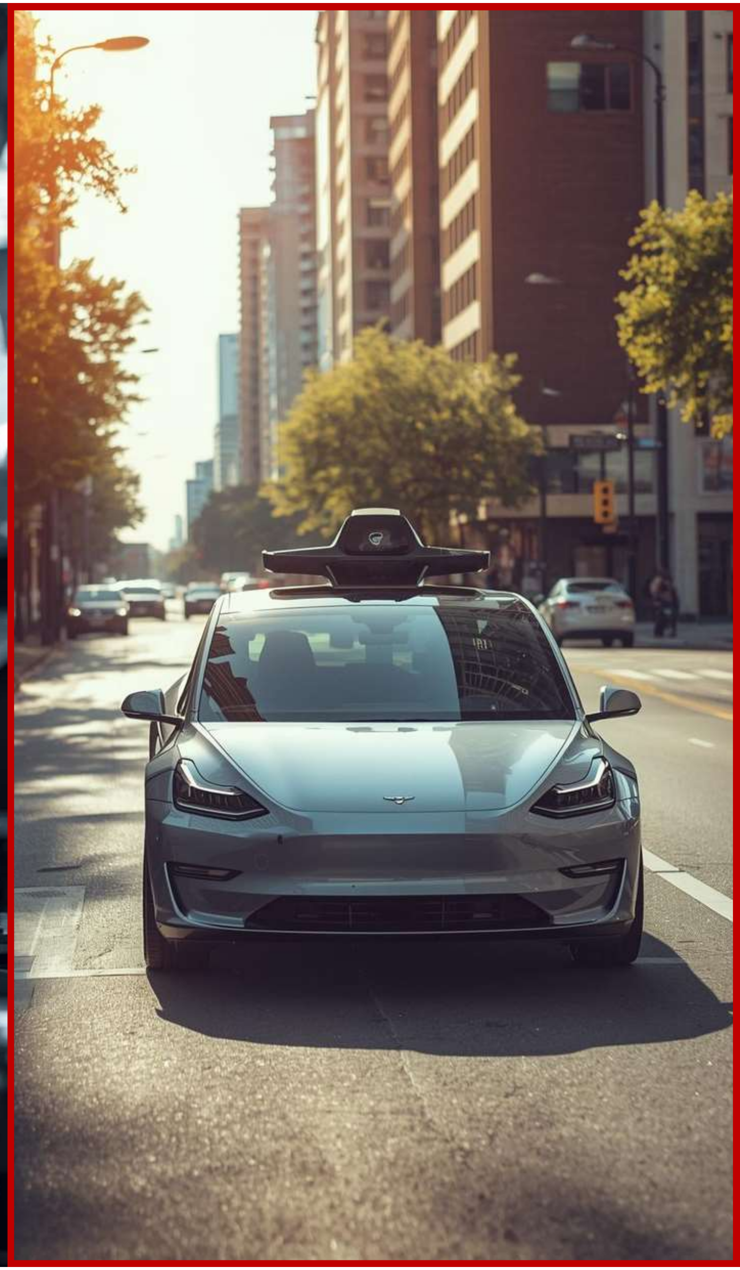
POLITECNICO
MILANO 1863

Prof. Sergio Savaresi

Milano, 18/3/2026


Level of interaction with real world
AI perceptive
AI Generative
AI Agentic
AI Physical





A clear trend of bifurcation in the mobility market

Today private car is used for both
function & emotion

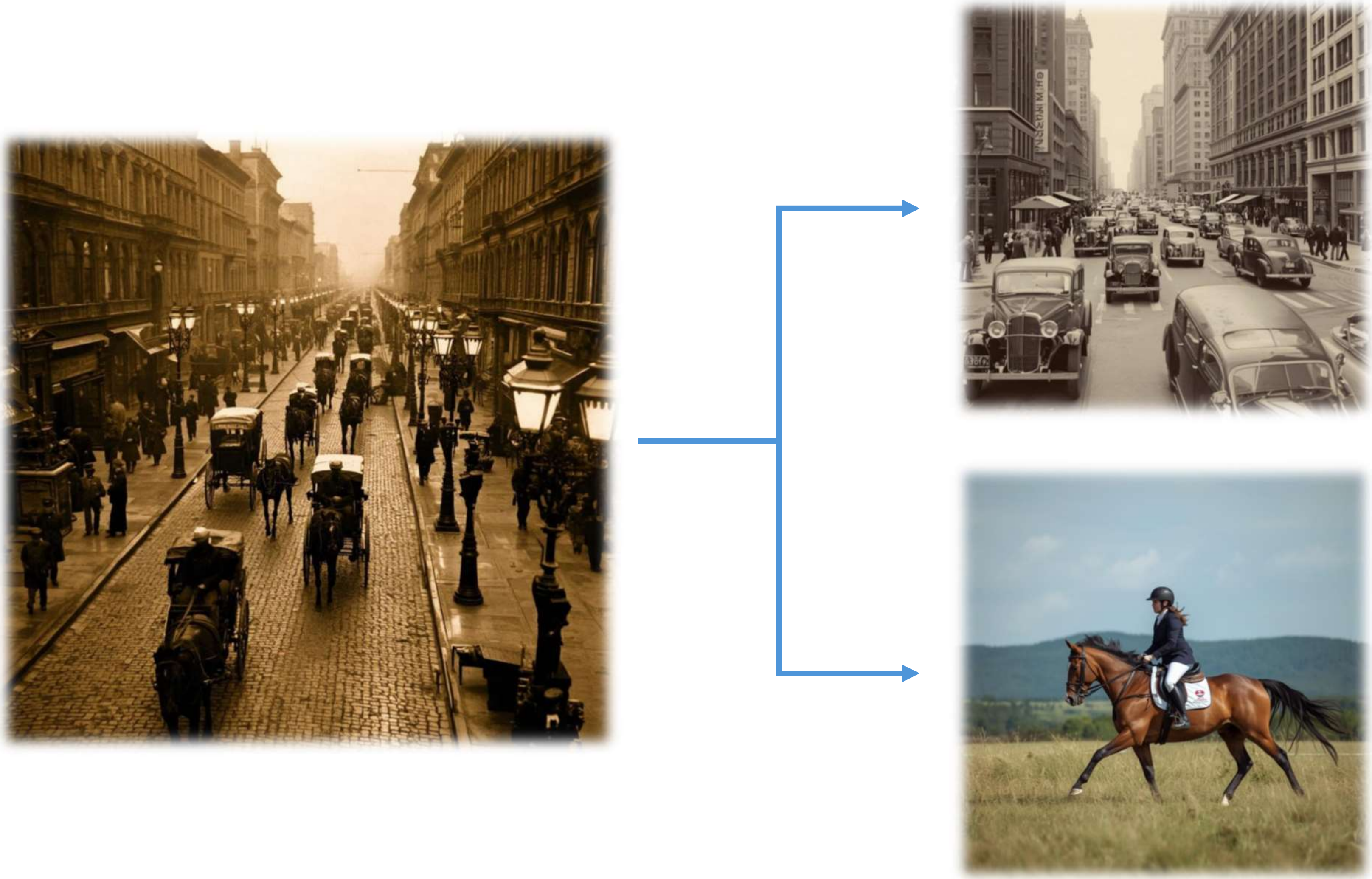
FUNCTION:
Autonomous car for MaaS = public transport

EMOTION

→ private owner or single experience

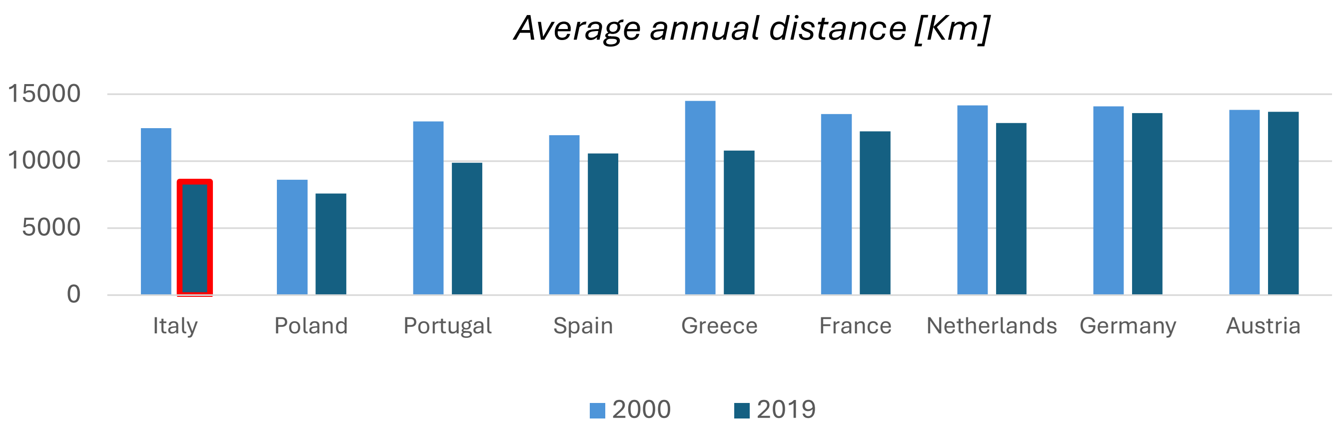
→ (banned from public roads?)

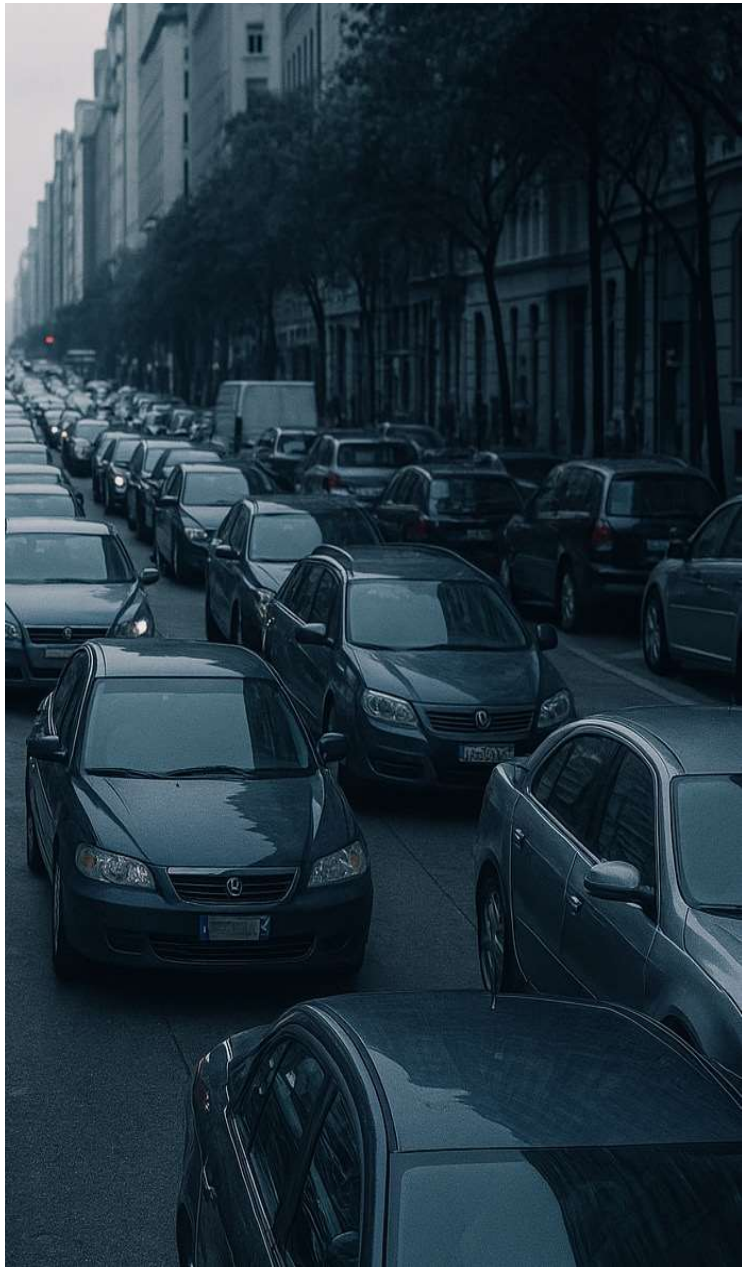
Horses to motor-vehicles...a similar revolution (100 years ago)



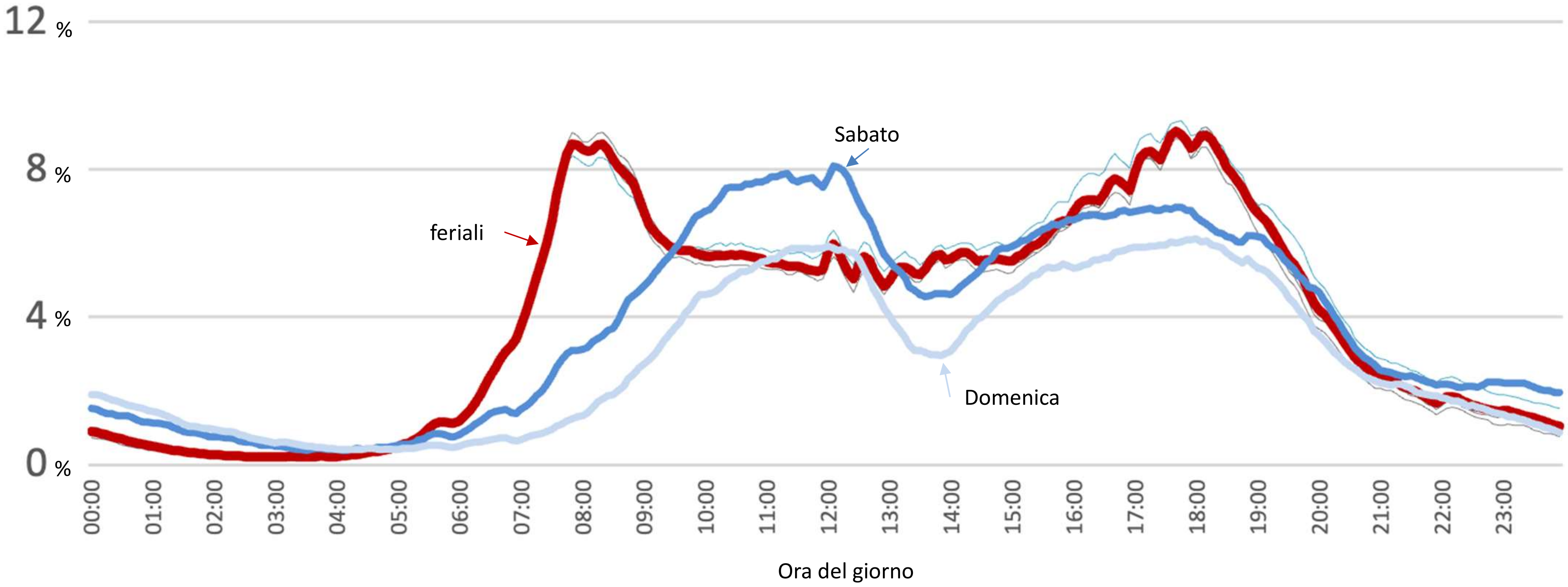
Private vehicle model: breaking point

- **High Vehicle Density: In Italy 45M cars for 60M people**
- **Low Average Mileage:** In Italy the average annual mileage per private car is only **8,000 km**
- **Space occupation: 50% of cars in Milan parked on streets**, 5M m^2 of public space occupation





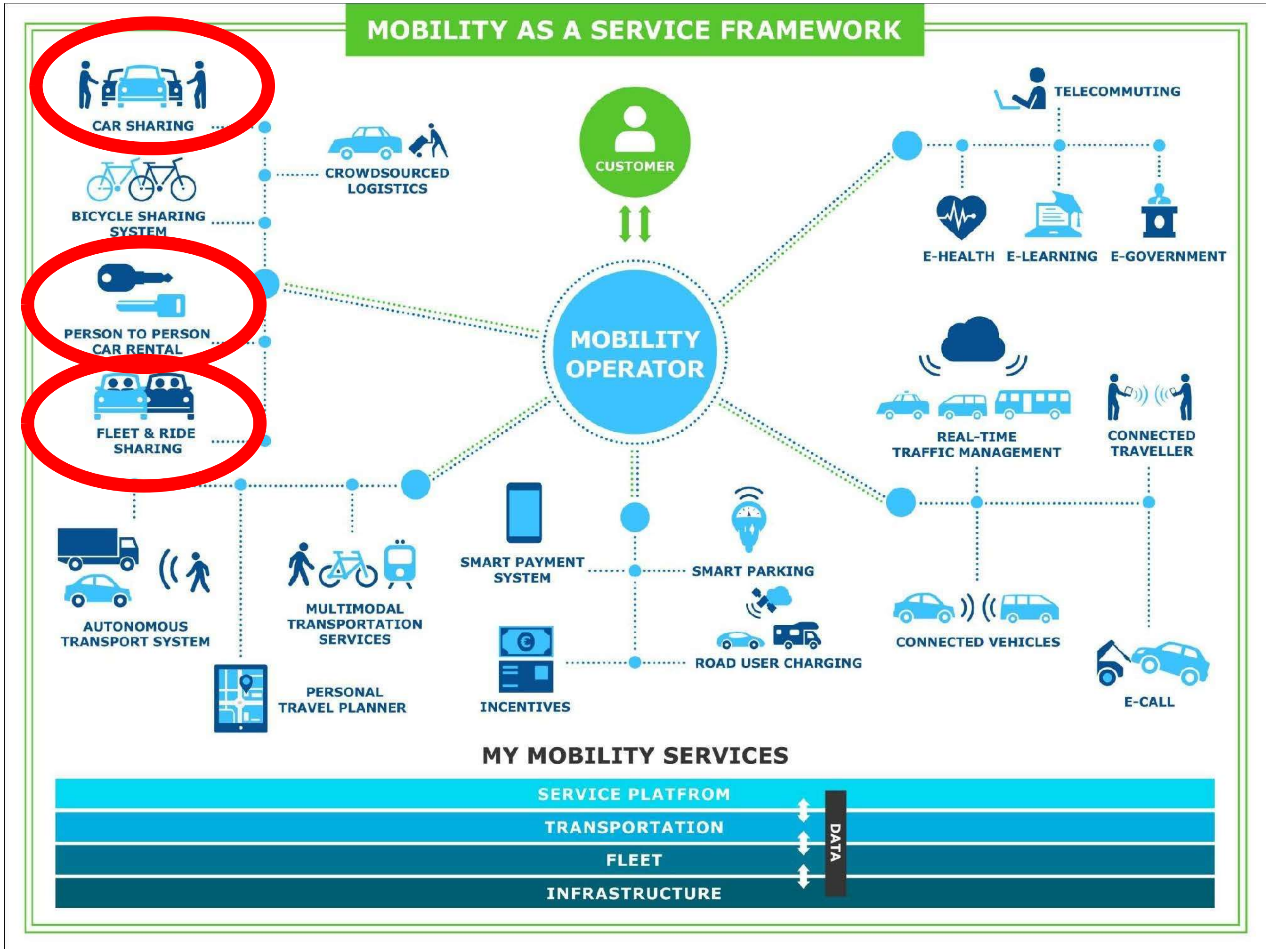
% di auto contemporaneamente attive a MILANO – settimana dal 14/3 al 20/3 2022



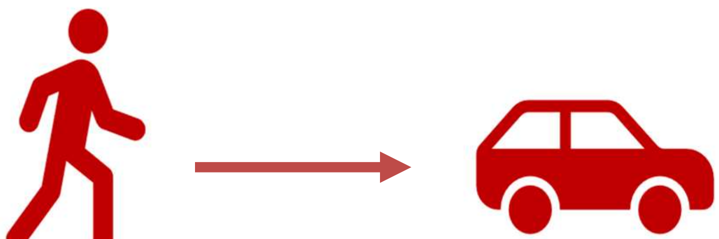
Rif.: Unipoltech e Politecnico di Milano


Exclusive personal ownership
Mobility as a Service

Mobility as a Service (MaaS): a' "user-centric" mobility framework



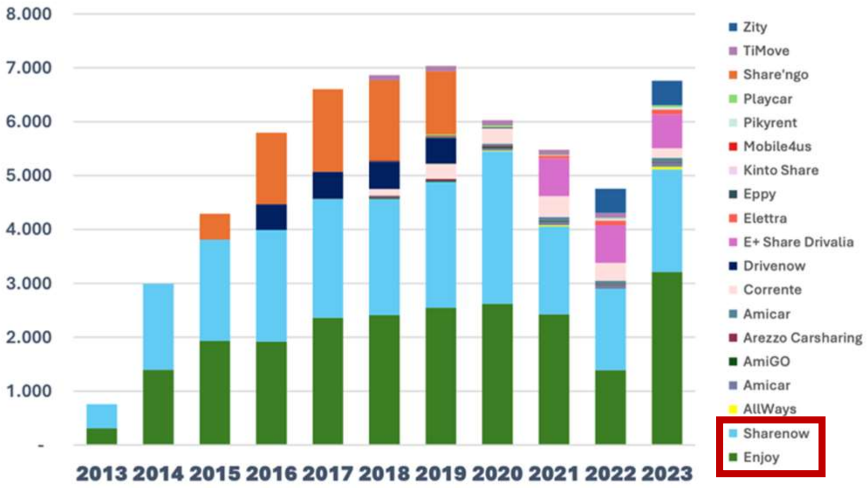
Mobility as a Service (MaaS)



Traditional car-sharing

Car-Sharing: A Market Concentrated in Few Hands

Car Sharing Free-Floating:
Operators and Fleet Distribution



Car-Sharing in Italy: only big cities

Location	# Services	# Vehicles
Arezzo	1	11
Bari	1	39
Bologna	2	342
Cagliari	1	40
Ferrara	1	23
Firenze	1	142
Genova	1	87
Imola	1	7
Milano	**4**	**3.365**
Napoli	1	65
Palermo	1	14
Parma	1	47
Roma	3	1.933
Torino	2	567
Venezia	1	5

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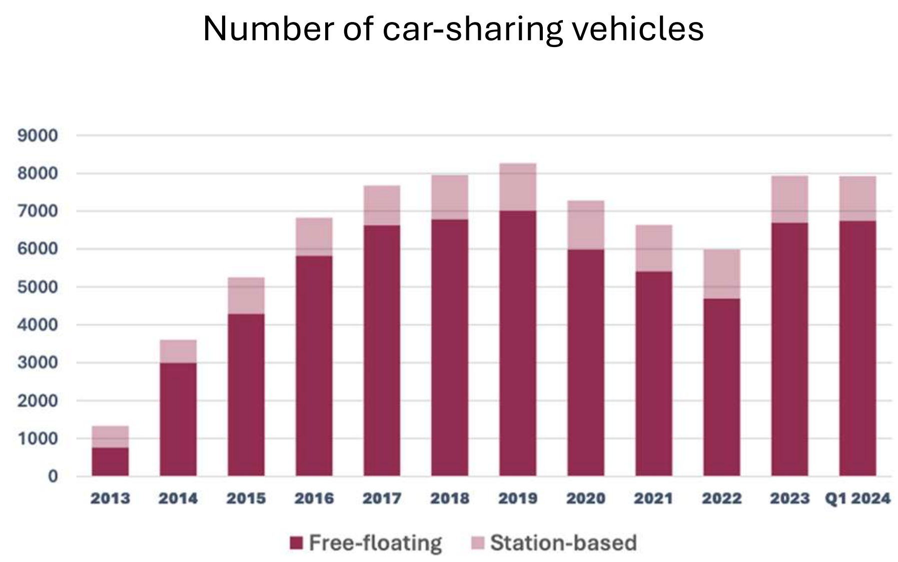
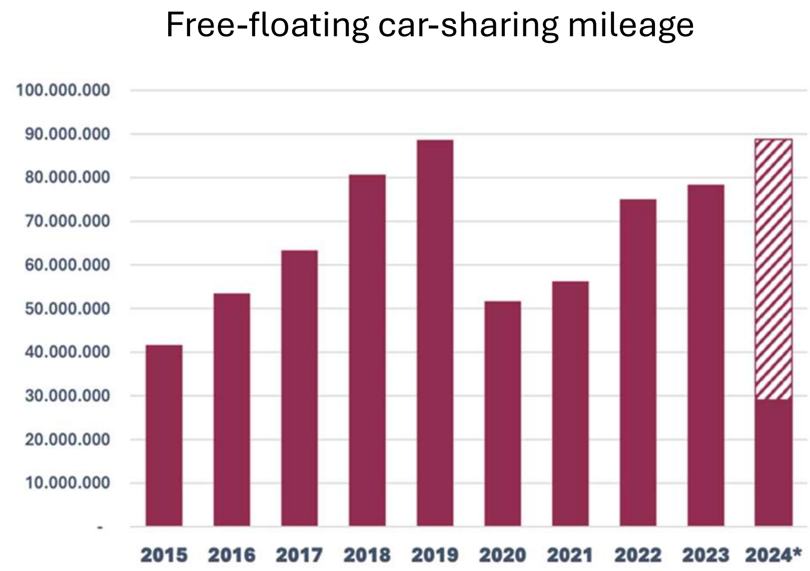
Number of vehicles in Car-Sharing: stagnation



	2019	2020	2021	2022	2023	2024
Rotation rate	4,7	2,9	2,9	**3,6**	**2,4**	**2,5**
Annual vehicle mileage	12.649	8.632	10.385	**15.995**	**11.705**	n.d.

Trend of Car-Sharing: towards long-term car rentals



	2019	2020	2021	2022	2023	2024
Rental distance (km)	7,4	8,3	9,9	**12,2**	**13,4**	**16,0**
Rental duration (min)	32,6	40,2	43,7	**72,8**	**87,7**	n.d.

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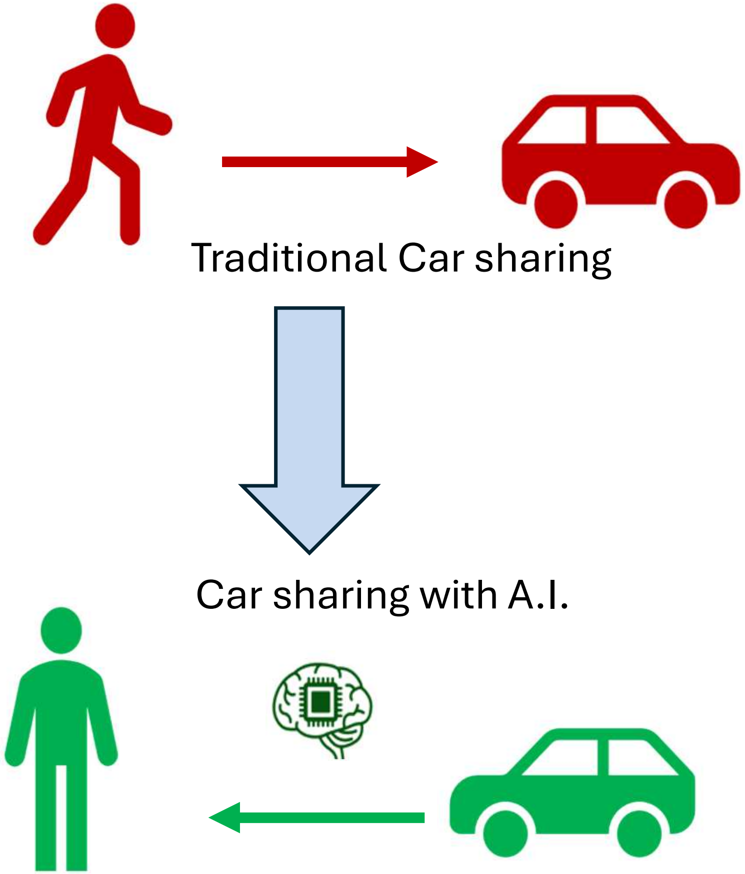
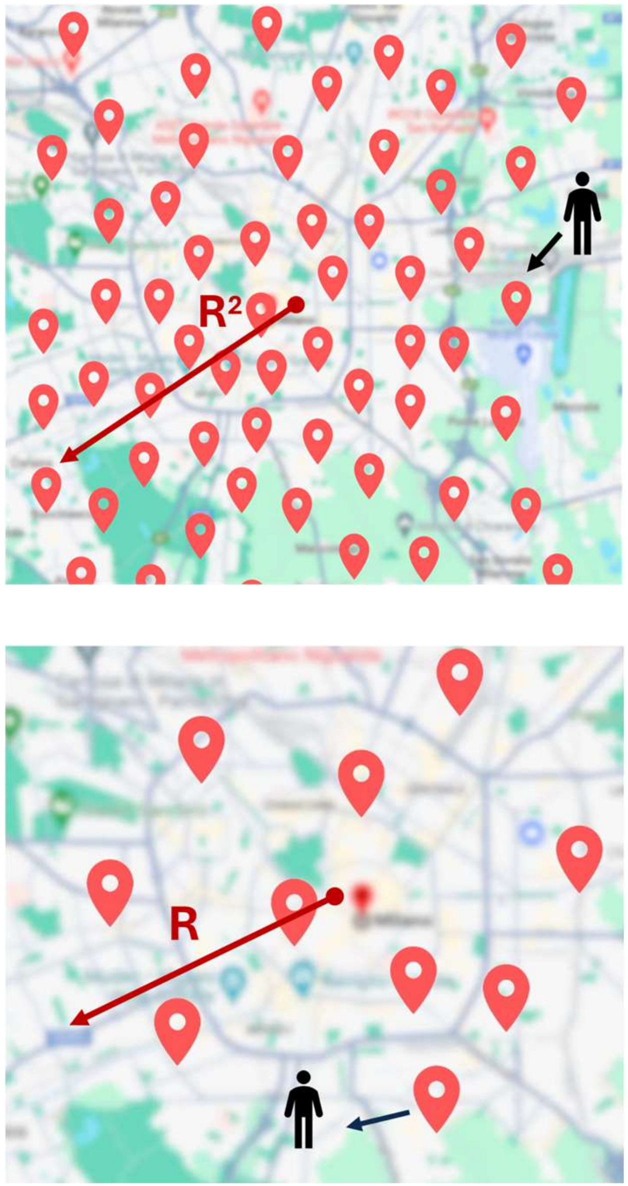
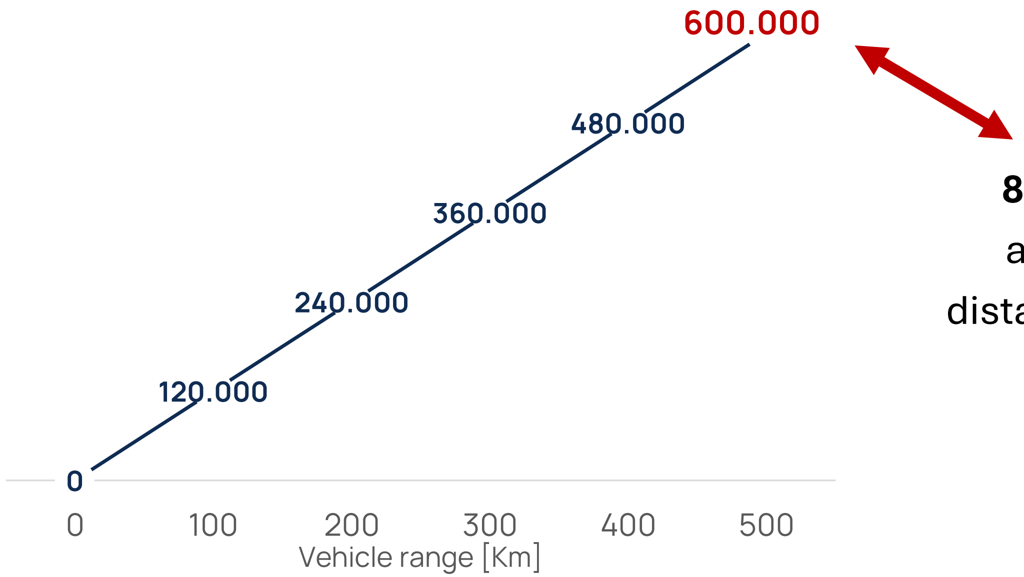
Traditional Car Sharing
Car-sharing with A.I.



Scaling factor: R and not R^2



Remark: electrification and private ownership, a difficult combination



8.000 km/year: average annual distance traveled by a car in Italy

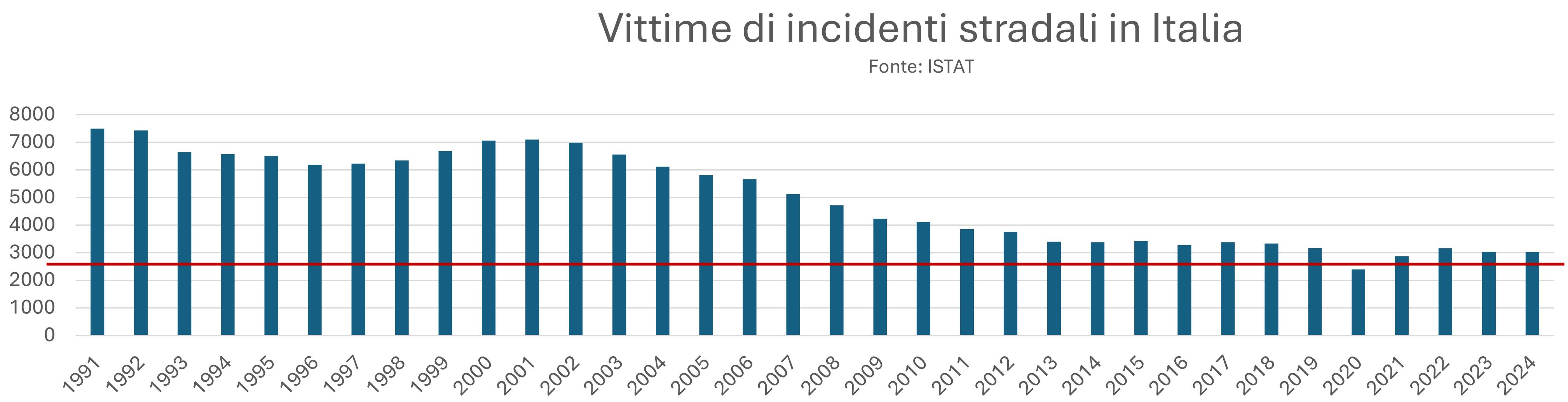
Autonomous driving: the ENABLING technology for the full roadmap towards sustainable, electric, MaaS

Personal car
(20% electric max?)

AUTONOMOUS DRIVING TECHNOLOGY

Mobility as a service
(MaaS)

MaaS,
Electric 80-90%


Vittime di incidenti stradali in Italia
Fonte: ISTAT
8000
7000
6000
5000
4000
3000
2000
1000
0
1991
1992
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1995
1996
1997
1998
1999
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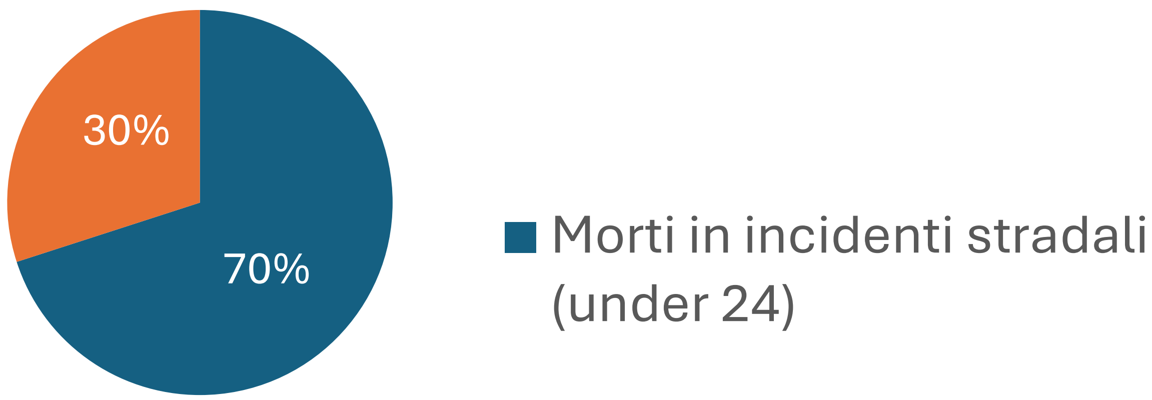
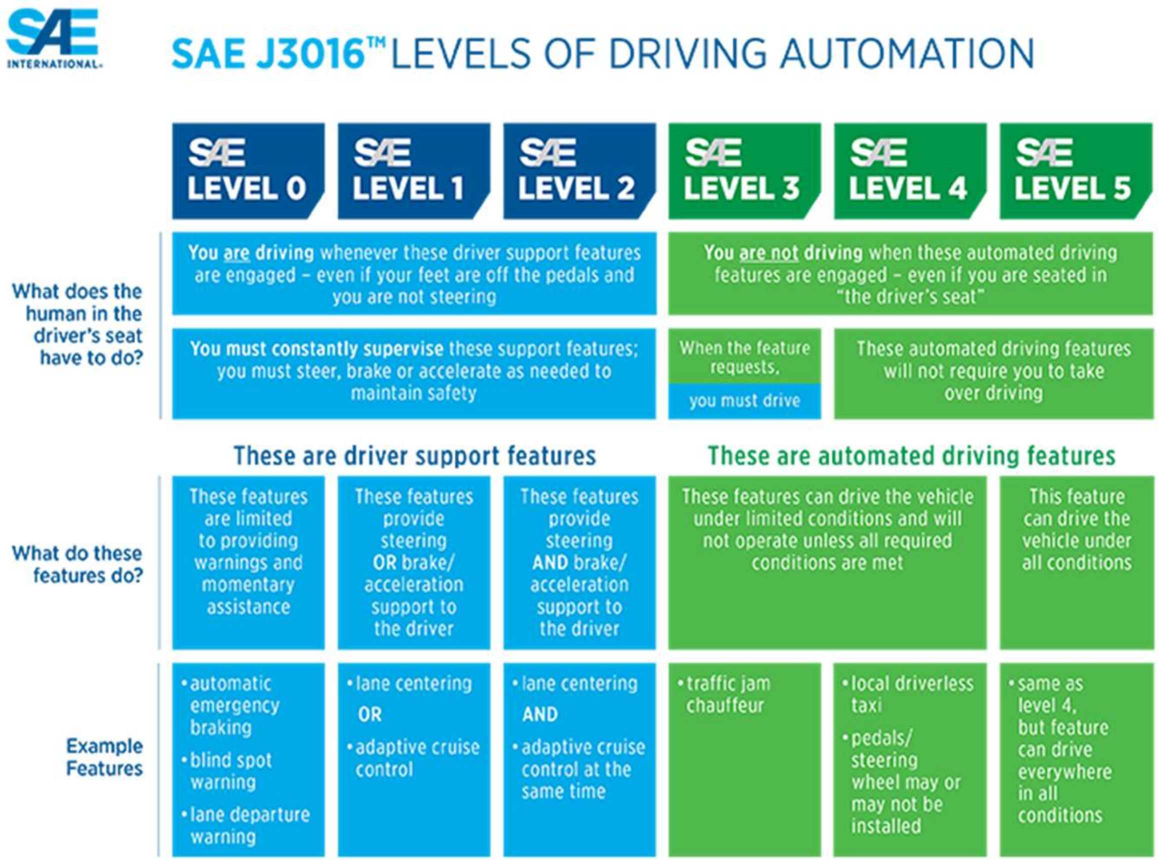

30%
70%
Morti in incidenti stradali (under 24)

Vehicle automation – a quick recap on automation levels

SAE levels define six stages of vehicle automation, from Level 0 (no automation) to Level 5 (full automation). It describes how many driving task are automated and when a human must intervene, ranging from ADAS (Levels 1-2) to fully autonomous vehicles.

L2 – Partial Automation: Car assists with steering & speed, but driver stays fully engaged (available on the market, today)

L3 – Conditional Automation: Car drives itself in some conditions (shift of liability from driver to car), but human must take over if needed (must be on the driver seat);
L4 – High Automation: Car handles most driving tasks in defined areas, no driver input required (driver seat is empty).



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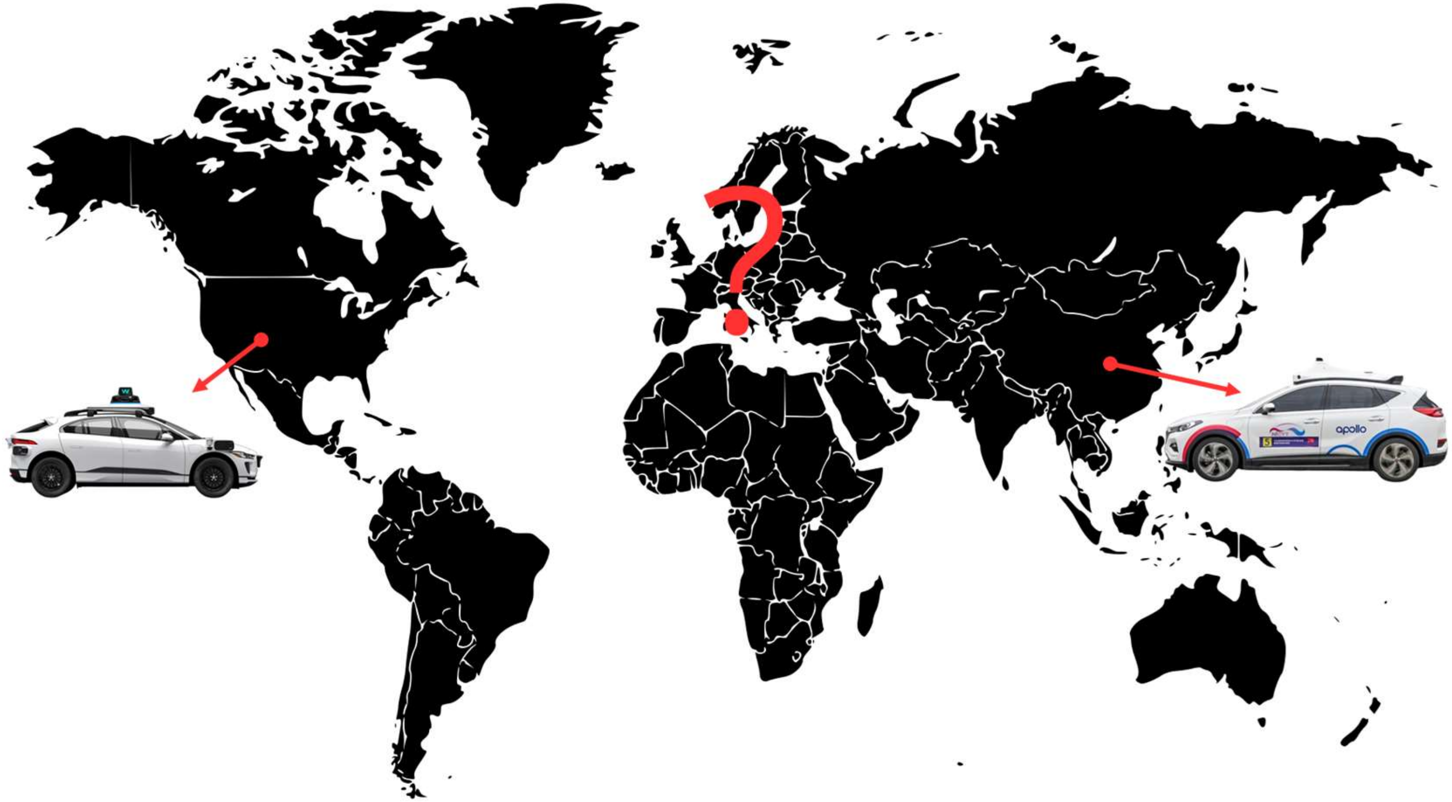
Autonomous Driving today: mainstreams

1. **Robo-Taxi (L4) – Transformational technology:**
   - U.S. and China: Advanced Development Stage
   - Focused on **complex** full-autonomy systems
   - Designed as a **long-term solution**
   - **Low acceptance** expected in the European market due to regulatory and public concerns

2. **«Gadget» for private cars (L3):**
   - Main direction taken by **traditional car-makers**
   - Available **only on high-end vehicles**
   - **No market disruption**
   - Incremental **improvements in safety**

Global Scenario



Global Scenario (“adversary countries”...)

isupport@gpo.gov>, Superintendent of Documents, certificato emesso da Symantec Class 3 Organizational Signing RSA CA.

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5360 **Federal Register** / Vol. 90, No. 10 / Thursday, January 16, 2025 / Rules and Regulations

DEPARTMENT OF COMMERCE

Bureau of Industry and Security

15 CFR Part 791

[Docket No. 250107–0005]

RIN 0694–AJ56

Securing the Information and Communications Technology and Services Supply Chain: Connected Vehicles

AGENCY: Bureau of Industry and Security, Department of Commerce.

ACTION: Final rule.

SUMMARY: This final rule, published by the Department of Commerce's (Department) Bureau of Industry and Security (BIS), sets forth regulations and procedures to address undue or unacceptable risks to national security and U.S. persons posed by classes of transactions involving information and communications technology and services (ICTS) that are designed, developed, manufactured, or supplied by persons owned by, controlled by, or subject to the jurisdiction or direction of certain foreign adversaries and that are integral to connected vehicles as defined herein.

DATES: This final rule goes into effect on March 17, 2025.

FOR FURTHER INFORMATION CONTACT: Marc Coldiron, U.S. Department of Commerce, telephone: (202) 482–3678. For media inquiries: Office of Congressional and Public Affairs, Bureau of Industry and Security, U.S. Department of Commerce: *OCPA@bis.doc.gov*.

SUPPLEMENTARY INFORMATION:

Communications Technology and Services Supply Chain,'' 84 FR 22689 (May 17, 2019), posed by a class of transactions that involve ICTS designed, developed, manufactured, or supplied by persons owned by, controlled by, or subject to the jurisdiction or direction of a foreign adversary and integral to connected vehicles. The NPRM proposed a rule to address the undue or unacceptable risks identified in the ANPRM and solicited public comment. BIS has considered the comments received during both rounds of public comment, and is making revisions, from the proposed rule, that address significant portions of that feedback.

In E.O. 13873, the President delegated to the Secretary of Commerce (Secretary), to the extent necessary to implement the Order, the authority granted under the International Emergency Economic Powers Act (IEEPA) (50 U.S.C. 1701, *et seq.*), ''to deal with any unusual and extraordinary'' foreign threat to the United States' national security, foreign policy, or economy, if the President declares a national emergency with respect to such threat. 50 U.S.C. 1701(a). In E.O. 13873, the President declared a national emergency with respect to the ''unusual and extraordinary'' foreign threat posed to the ICTS supply chain and has, in accordance with the National Emergencies Act (NEA), extended the declaration of this national emergency in each year since E.O. 13873's publication. *See Continuation of the National Emergency With Respect to Securing the Information and Communications Technology and Services Supply Chain*, 85 FR 29321 (May 14, 2020); *Continuation of the National Emergency With Respect to*

subject to the jurisdiction or direction of foreign adversaries'' as ''an unusual and extraordinary'' foreign threat to the national security, foreign policy, and economy of the United States that ''exists both in the case of individual acquisitions or uses of such technology or services, and when acquisitions or uses of such technologies are considered as a class.'' *See* E.O. 13873, *and* 50 U.S.C. 1701(a)–(b).

Once the President declares a national emergency, IEEPA empowers the President to, among other acts, investigate, regulate, prevent, or prohibit, any ''acquisition, holding, withholding, use, transfer, withdrawal, transportation, importation or exportation of, or dealing in, or exercising any right, power, or privilege with respect to, or transactions involving, any property in which any foreign country or a national thereof has any interest by any person, or with respect to any property, subject to the jurisdiction of the United States.'' 50 U.S.C. 1702(a)(1)(B).

To address the identified risks to national security from ICTS transactions, the President in E.O. 13873 imposed a prohibition on transactions that the Secretary, in consultation with relevant agency heads, has determined involve foreign adversary ICTS and pose certain risks to U.S. national security, including U.S. technology and critical infrastructure, or the security and safety of U.S. persons. Specifically, to fall within the scope of the prohibition, the Secretary must determine that a transaction: (1) ''involves [ICTS] designed, developed, manufactured, or supplied, by persons owned by, controlled by, or subject to the jurisdiction or direction of a foreign

Critical National Infrastructure
Dual use problem – Safety problem

Large fleets of shared autonomous cars will become the backbone of urban mobility. Europe's leadership in autonomous mobility is a matter of national security and these large fleets will be a **Critical National Infrastructure**. There is a risk of critical infrastructure under control of non-European players.

1. **Data collecting** – millions of sensor-equipped vehicles (cameras, LiDAR) continuously capturing information.
2. **Denial of service** – potential to disable mobility across entire cities.
3. **Physical security risk** – autonomous vehicles could be misused as weapons in public spaces.

A revolution in the Automotive Industry is expected – autonomous car technology is transformational

- **Commodization** of the classic car-making (mid&low-end cars)
- High-value HW: **sensors** for the Autonomous-Vehicle technology
- AV-technology (AI-driver SW integrated with sensors and actuators) becomes the **most valuable asset in the Automotive Industry** (e.g.: Waymo has an Enterprise Value already bigger than almost all the car makers)
- Reduction of the **NUMBER** of cars; increase the **VALUE** of each vehicle (mostly due to the AV HW&SW stack); **vehicles MORE FREQUENTLY changed**
- New large business for **Mobility Service Providers**
- The new AI-driver-based mobility will be a **Critical National Infrastructure**

EU position

Reuters

My News

EU's Von der Leyen urges European push on AI-driven cars

By **Reuters**

October 3, 2025 12:45 PM GMT+2 · Updated 8 hours ago

Aa

President of the European Commission, Ursula von der Leyen, speaks during a press conference at the end of an informal summit for the EU's heads of state and government, at Christiansborg... Purchase Licensing Rights **Read more**

TURIN, Oct 3 (Reuters) - European Commission President Ursula von der Leyen called on Friday for a continent-wide push to develop self-driving cars, saying artificial intelligence could help revive the region's struggling automotive sector and improve road safety.

Speaking at the Italian Tech Week in Turin, Italy's automotive hub, von der Leyen urged the European Union to adopt an "AI first" strategy across strategic industries, with a focus on mobility.

"Self-driving cars are already a reality in the United States and China. The same should be true here in Europe," she said, adding that "AI first" also meant "safety first".

Her remarks come as Brussels seeks to bolster industrial competitiveness, while local automakers struggle to keep up with foreign technology development, particularly by China and the United States.

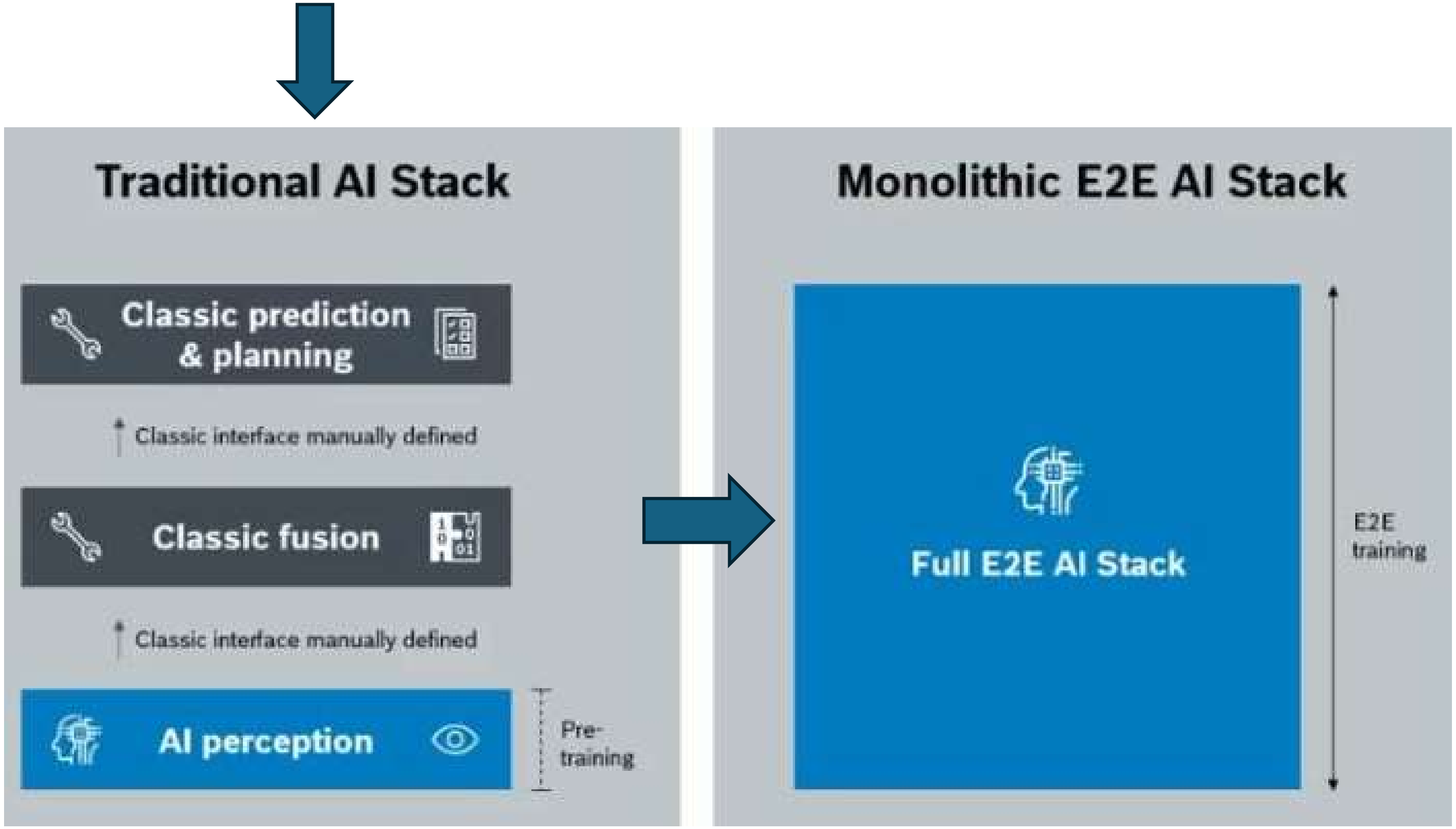
"Let us make it happen," she added.

The EU chief also pledged the bloc's support for developing vehicles "made in Europe, and made for European streets".

The automotive industry, which employs millions across Europe, is transforming rapidly amid pressure to decarbonise and digitise. Von der Leyen said AI could help reduce congestion, link remote areas to public transport, and preserve jobs.

"The future of cars – and the cars of the future – must be made in Europe," she said.

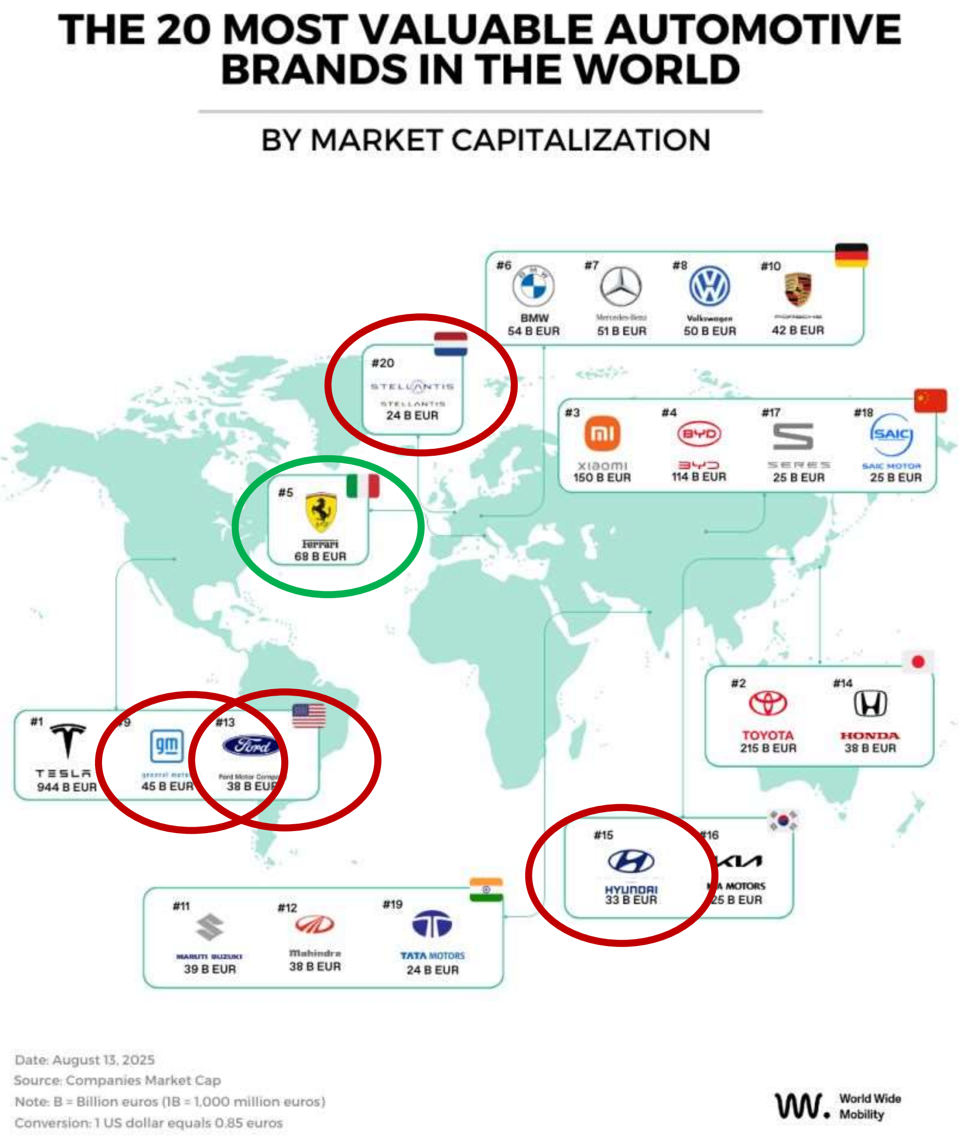
Different approaches...(performance vs. interpretability)



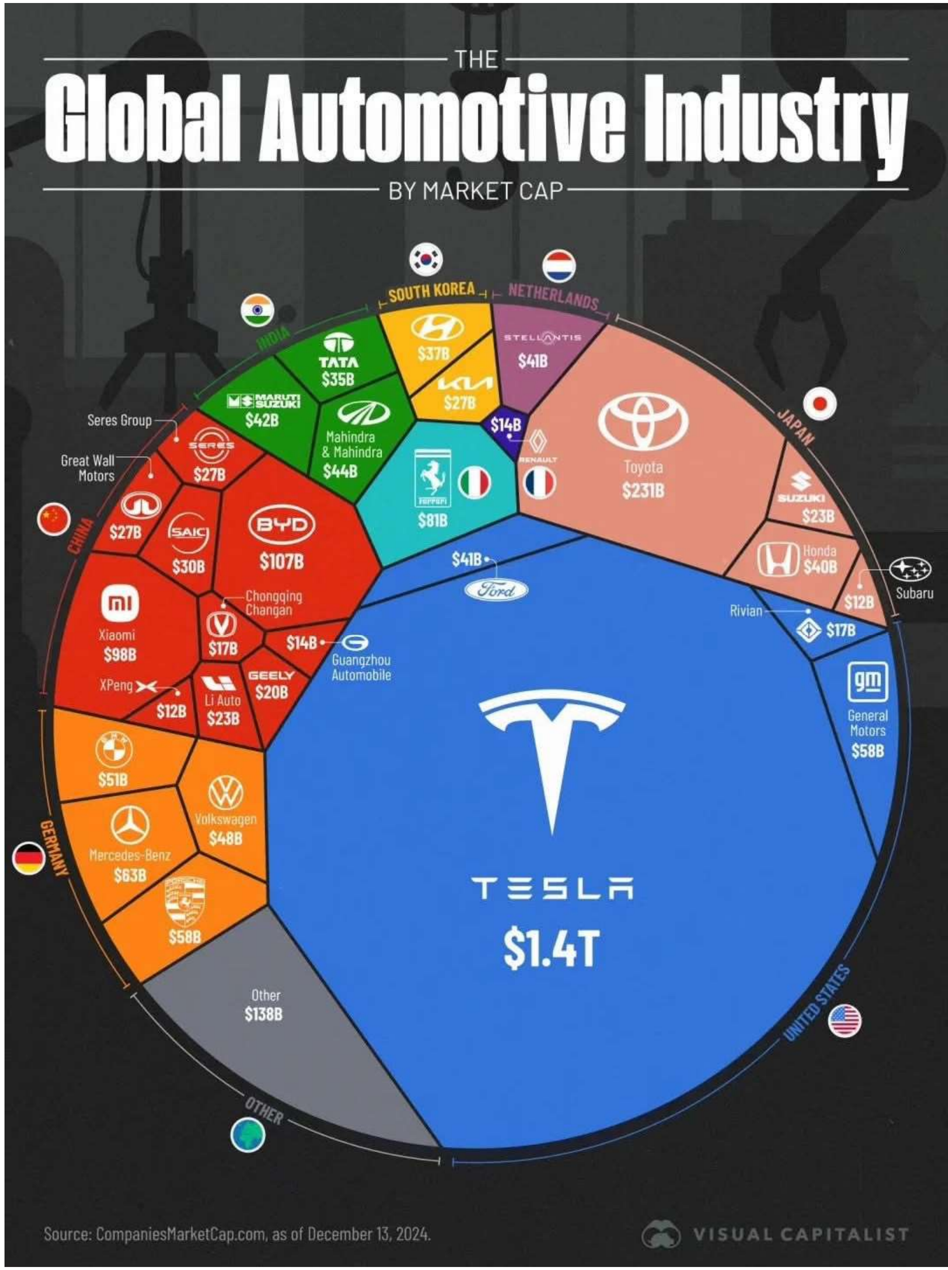
E2E AI?

Market cap of emerging AV companies vs traditional OEMs

- Current enterprise value of **Waymo (USA): $100B**
  Projected/estimated in 2040: $500B
- **Zoox (USA): $3.2B** post-money valuation
- The latest valuation of **Wayve (UK)** is **£4.43B = $6B**
- **Nuro**'s enterprise value is approximately **$6B**
- ...



AV takes it all?



UE is back in the AV-Race (and Italy has no industrial initiatives)

niulinx

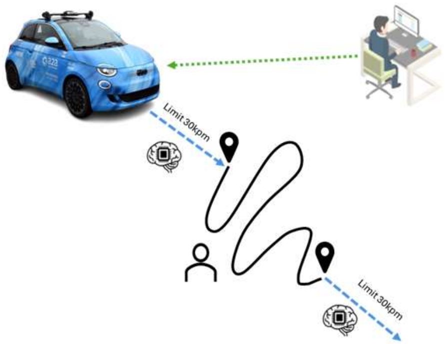
connecting points, enabling mobility

The Italian (and UE) «Champion»in AV…?

Pre-seed round closing day: **April 10 2026**

Robo-Sharing solution: the concept

1. The car-sharing client/user calls the car with an app
2. The car drives low-speed autonomously (unmanned) towards the client
3. The client takes the car and DRIVES himself/herself the car; at destination, the client quits the car (no parking problem)
4. The car drives low-speed autonomously (unmanned) towards the new client or to a parking/recharging lot

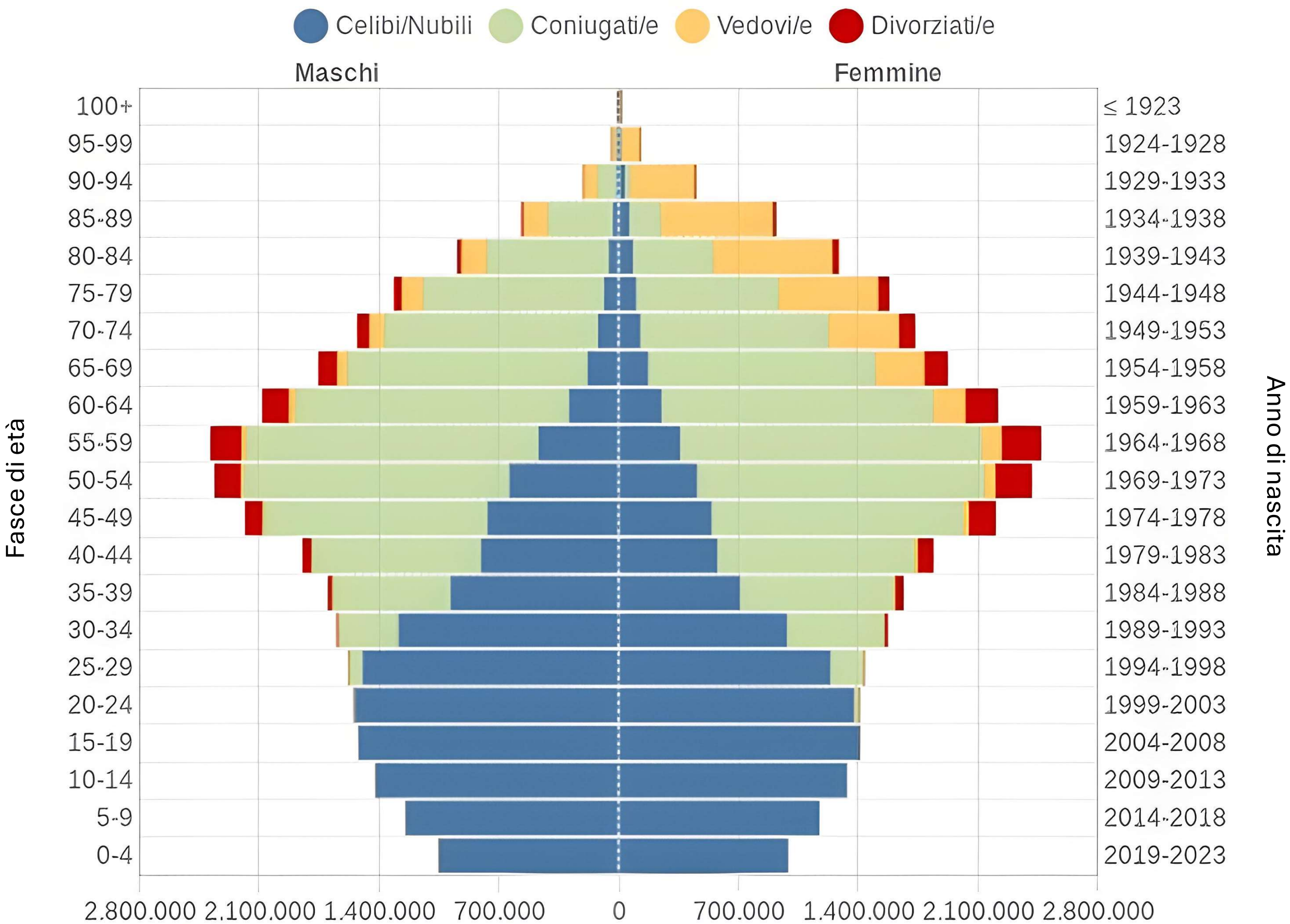


KEY features:

- Focus on the short un-manned operation (take and leave the car)
- Operations at low-speed (max 30kph)
- Active remote supervision for edge cases

Use-case #1: Robo-Sharing

Live Demo presented January 22, 2025



Popolazione per età, sesso e stato civile – 2024
ITALIA – Dati ISTAT 1 gennaio 2024 – Elaborazione TUTTITALIA.IT

Use-case #2: Robo-Caring

Live Demo presented July 18, 2025

Use-case #3: Robo-Linking

Live Demo presented May 18, 2025

Examples of use-cases based on Robo-Sharing technology (low-speed, remotely human-assisted)

The potential of Robo-Sharing extends well beyond car-sharing traditional operators. A wide range of mobility and service providers – from specialized fleet managers to public transport operators – can leverage our technology to strengthen their existing services. Similarly, industrial partners can explore new applications and revenue) streams by integrating autonomous shared vehicles into their business models.

“Robotizing” professional driving jobs with shortage of workforce is a major trend, that can straightforwardly be addressed by NEWCO technology (in urban and low-speed applications)

Multimodal shuttle service

Urban waste collection

Urban shuttle service with a fixed route

Kiss & Fly service at the airport

Internal mobility services in large hospital complexes

Urban Cleaning Vehicles

Night-time urban inspection services

Internal mobility services in large industrial plants

and many more...

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FOCUS - Example of use-cases based on Robo-Sharing technology (low-speed, remotely human-assisted)

Nighttime safety reporting to maximize vehicle utilization and enhance safety

During the day, many autonomous cars are engaged in Robo-Sharing services. At night, however, this large fleet remains largely unused. Equipped with cameras and direct communication with a remote control room, these vehicles can be repurposed for patrolling — moving through neighborhoods or designated areas to monitor surroundings, deter crime, and report unusual activity. This transforms idle resources into a smart nighttime surveillance service, enhancing safety while maximizing vehicle utilization. In this way, the system becomes a **complementary service that leverages existing assets without generating additional costs**.

Data-points:

- 5% Sharing Mobility Activity between 11pm and 6am (McKinsey 2020)
- Over 60% of violent crimes occur at night (BJS, 2018)
- 30% of EU citizens feel unsafe walking alone after dark (FRA, 2021)

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FOCUS - Examples of use-cases based on Robo-Sharing technology (low-speed, remotely human-assisted)

Robo-Sharing Technology for Last-Mile Delivery
Autonomous cars used in Robo-Sharing services spend some periods idle, especially during off-peak hours. Leveraging the same low-speed, remotely human-assisted technology, these vehicles can be repurposed as a flexible fleet for last-mile delivery, efficiently transporting goods in urban areas **without any extra costs, while making complementary use of the same resource**. This approach optimizes idle time, lowers delivery costs, and provides a sustainable alternative to traditional logistics — turning shared mobility assets into a valuable resource for the supply chain.

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Expanding Robo-Sharing features: *Robo-Fencing*

Social Impact - Human Driving Safety Enforced

Human-Driven, System-Protected

Even when driven manually, Robo-Sharing vehicles can **actively prevent driving mistakes: enforcing safety rules that private cars simply can't.**

- These safety features can be fully automated or applied with user consent, potentially offering **fee discounts**.
- While enforcement **on privately owned vehicles is extremely challenging**, it is fully feasible on shared Robo-Sharing cars.

Cause of urban accidents	%
Driving while distracted or uncertain	12,5
Failure to give way or obey traffic lights	**15,4**
Driving at excessive speed	**7,5**
Did not keep a safe distance	**5,4**
Made an irregular maneuver	7,8
Turned improperly	2,5
Drove in the wrong direction	**1,8**
Overtook improperly	1,9
Unexpected obstacle	1,5
Hit or avoided a domestic or wild animal	0,1
Avoided a stopped vehicle	0,3
Did not yield to a pedestrian on a crosswalk	**4,5**
Hit or avoided potholes, etc.	0,3
Unspecified circumstance	24,5
Hit a stopped vehicle in an irregular position	1,1
Other traffic-related behavior causes	3,6
Incorrect behavior by a pedestrian	3,5

«Robo-Fencing» has the potential to prevent **35–40%** of traffic accidents with ease.

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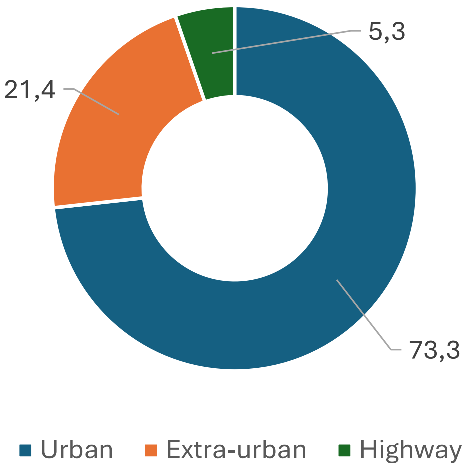
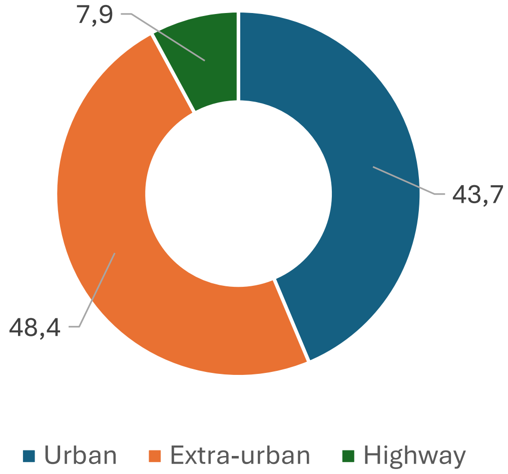
Urban Roads:
Where most accidents happen

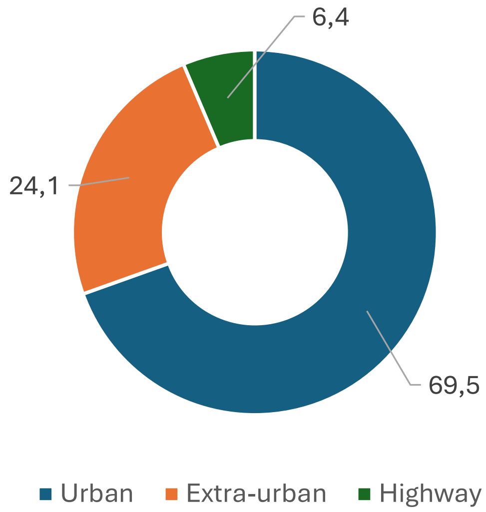
Division of **road accidents** by type of road environment



Percentage of **fatalities** by type of road environment



Percentage of **injuries** by type of road environment



Urban road are the most critical in terms of safety:

- Higher density
- Large number of non-expert drivers
- Presence of pedestrians and bicycles

EU: goto-market steps

Test authorization (with safety driver)

Homologation (L4 without safety driver)

Highway Code / Road Traffic Code update

License to operate a public service


TEST CAR4YOU NOW 4 FREE!
MUSEUM
Have a nice day!
CENTRAL
METRO
METRO
POD CAR

EU Regulation

- The EU has established a **unified regulatory framework on homologation** allowing Member States to authorize tests and real-world use cases without needing separate national regulations.
- The regulation supports **Level 3 and 4**, requiring robust safety systems, fallback mechanisms, logging, software updates, and cybersecurity.
- The Regulation leaves the governance of road use to **national authorities**, thereby allowing each Member State to establish its own legal framework for the testing and deployment of **autonomous driving technologies**.
- Global **UNECE standards** are applied, such as the ALKS regulation and cybersecurity rules
- The integrated pathway among the **Vehicle Safety Regulation**, the **AI Act**, and the **Data Act** ensures legislation addressing safety, liability, and privacy.

EU Automotive Action Plan

The automotive sector is rapidly shifting toward electric, connected, and automated vehicles, and Europe must lead this transformation.

The **EU Automotive Action Plan,** published on March 5th 2025, outlines **measures to boost global competitiveness and strengthen Europe's automotive industry across five areas: innovation, clean mobility, resilience, skills, and fair business conditions**.

https://transport.ec.europa.eu/document/download/89b3143e-09b6-4ae6-a826-932b90ed0816_en?filename=Communication%20-%20Action%20Plan.pdf

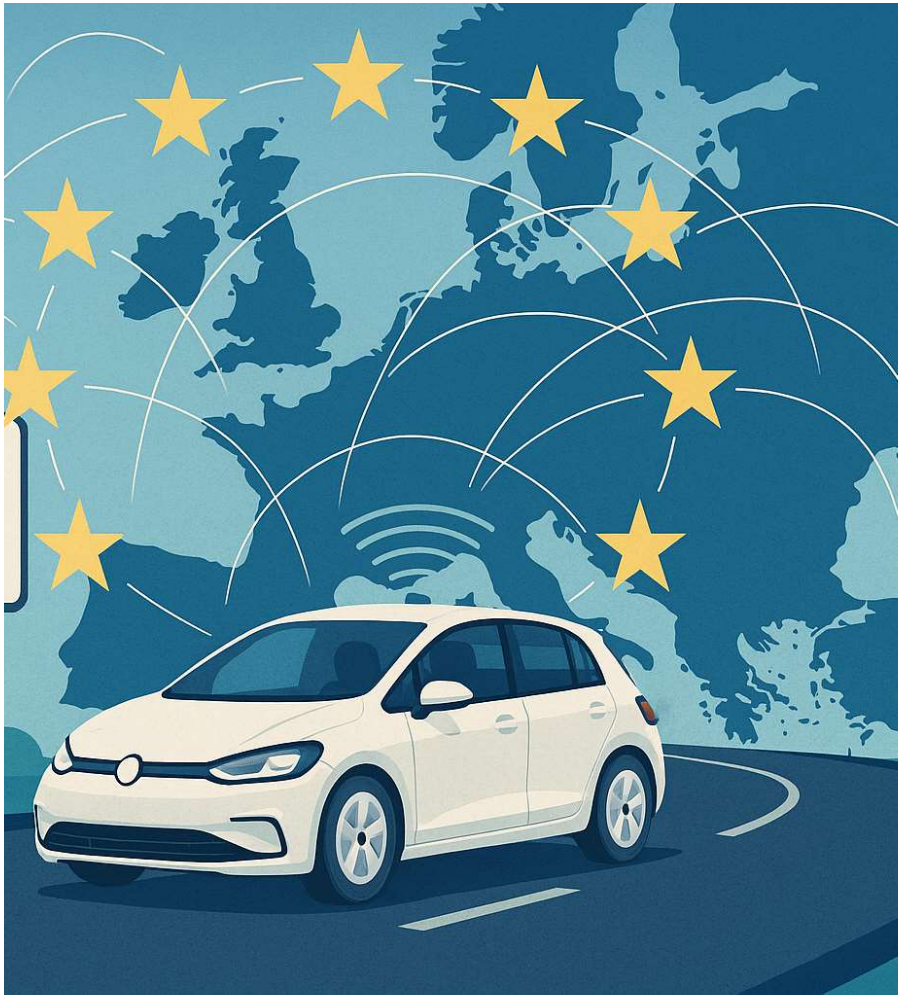
EU Automotive Action Plan – Key Points

- **Testbeds & Deployment:** Launch 3+ large-scale cross-border testbeds and regulatory sandboxes by 2026, including autonomous driving corridors and pilots in medium-sized cities.
- **Single Market Integration:** Create a harmonised EU framework by 2026 for ADAS/ADS testing and streamlined cross-border road-testing approvals.
- **Connected & Autonomous Vehicle Alliance:** Strengthen EU industrial capacity, reduce reliance on non-European tech, develop shared software platforms, and build a large pilot facility.
- **Cybersecurity:** Implement measures and guidance on vehicle data access, explore new legislation, and consider a European Automotive Data Platform to boost business opportunities.

Ruolo dei Test Beds nel settore automotive

Nel contesto automotive, i test beds servono a:

- Eseguire **test in condizioni reali** di veicoli autonomi (Automated Driving Systems), anche senza conducente per la prima volta sulle strade europee
- Provare la **sperimentazione di servizi concreti** (robotaxi, flotte logistiche e mobilità urbana)
- **Pilot su larga scala** per trasporto persone e merci per la valutazione reale dell'efficienza della tecnologia e servizio;
- **Armonizzazione normativa** tra Stati membri, che ad oggi sono completamente diverse e cambiano per ogni Stato;
- **Accelerazione del go-to-market** della guida autonoma



« *To boost market readiness and commercialisation of autonomous vehicles, the Commission will work with Member States to rapidly establish* ***at least three large-scale cross-border testbeds, related regulatory sandboxes and European Automated Driving Corridors.*** *Medium-sized cities willing to play a pioneering role could be included.* «
-Automotive Action Plan-