



POLITECNICO
MILANO 1863



Robo-driver: the enabler of the revolution of personal mobility

Global Software Technology Summit
Pisa, 3/7/2024



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Car-based personal mobility model

the mistake #1 (in retrospect, after 1B cars) = personal ownership



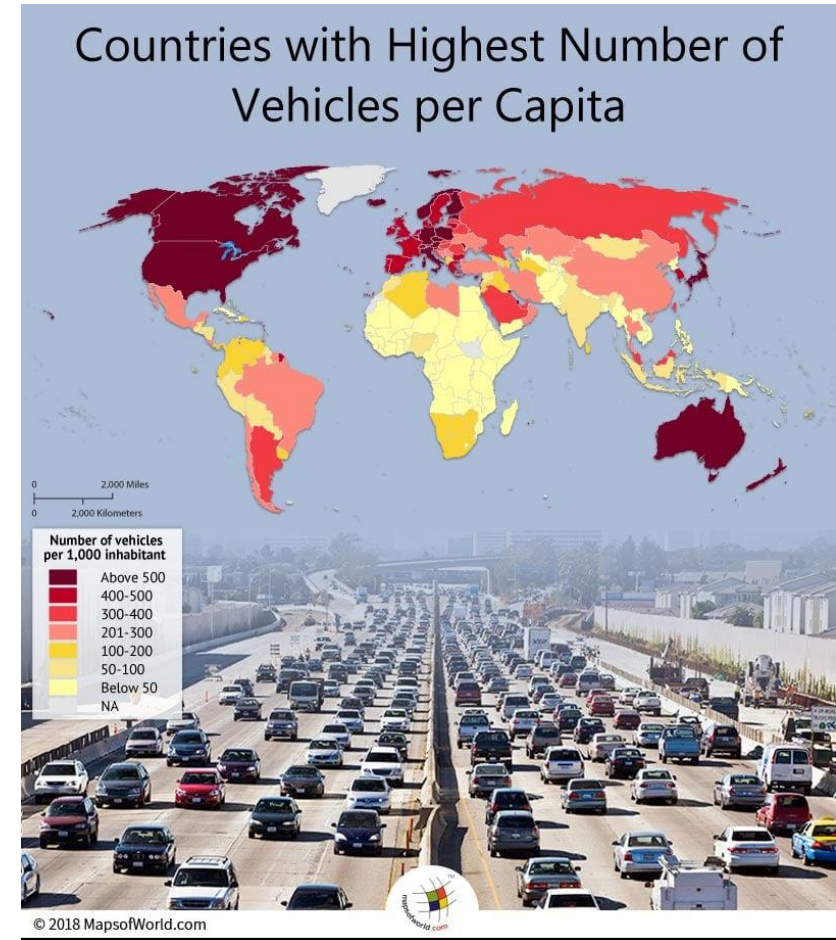
Megatrends: CONGESTION / car density

Country	cars per 1000 inhabitants	total number of cars
United States	831	275.913.237,00
Canada	790	30.754.600,00
Australia	782	20.335.000,00
Poland	771	29.369.800,00
Italy	755	45.487.900,00
France	668	45.297.000,00
Germany	628	52.275.833,00
Spain	627	29.707.581,00
Japan	624	78.461.953,00
United Kingdom	600	40.800.000,00
Netherlands	588	10.248.388,00
Malaysia	542	17.728.482,00
South Korea	485	25.167.409,00
Russia	395	58.116.046,00
Mexico	391	50.400.000,00
Argentina	373	17.000.000,00
Colombia	324	16.500.000,00
Thailand	280	19.576.630,00
Turkey	254	21.763.186,00
Ukraine	245	10.500.000,00
South Africa	232	13.570.330,00
China	226	319.000.000,00
Brazil	215	46.200.000,00
Iran	175	14.500.000,00
Indonesia	82	22.587.923,00
Nigeria	61	13.000.000,00
India	59	80.888.051,00



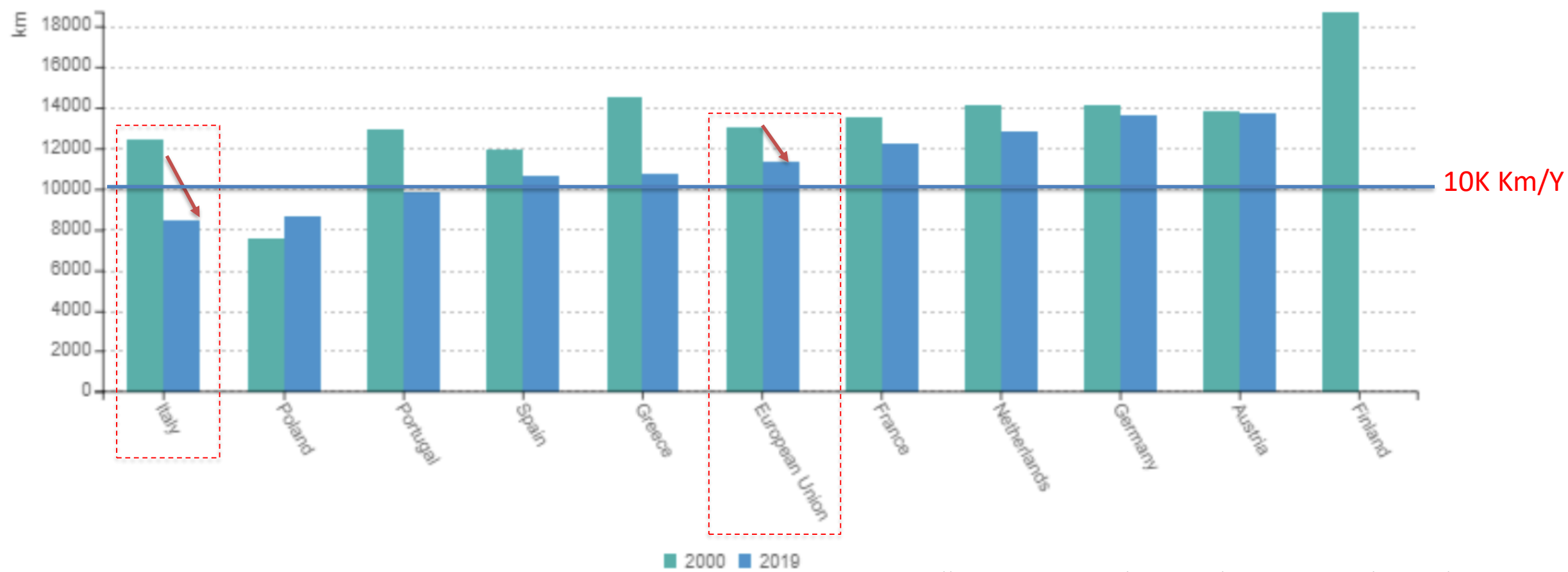
List of countries with more than 10M cars sorted by car density

Italy: 60M
people; 45M
cars)



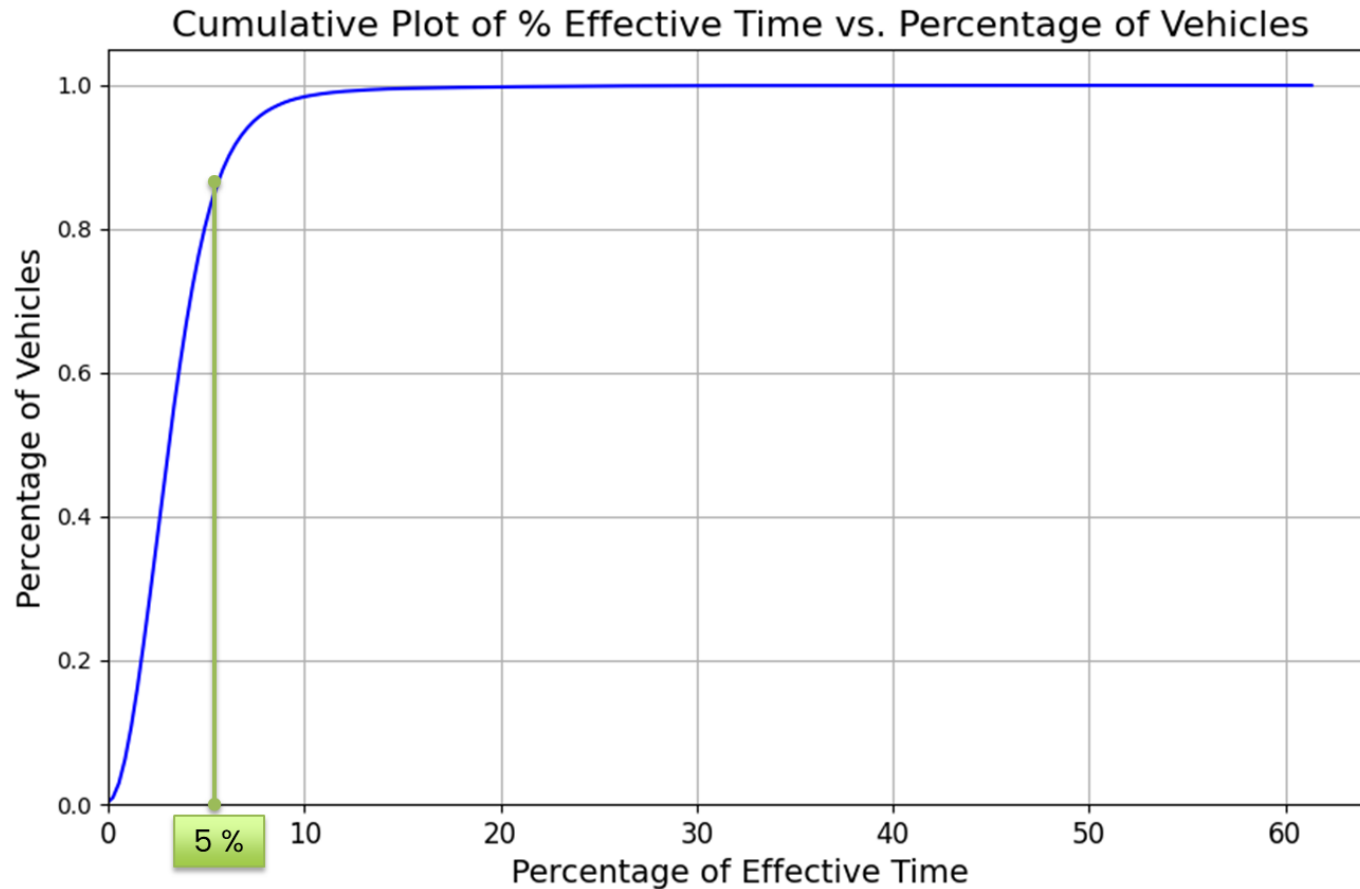
Megatrends: CONGESTION / travelled distance (EU)

Change in distance travelled by car for selected countries



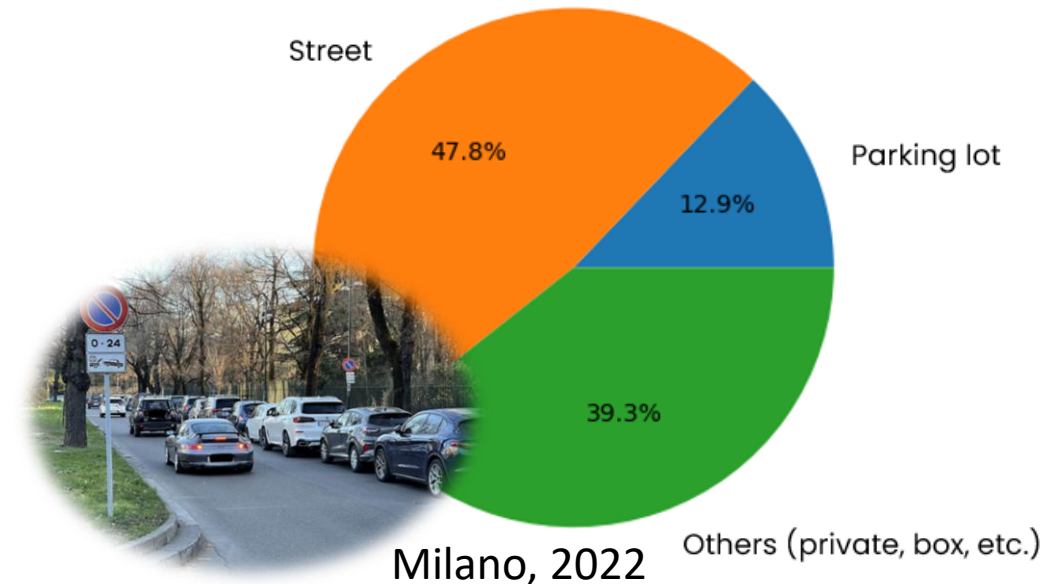
<https://www.odyssee-mure.eu/publications/efficiency-by-sector/transport/transport-eu.pdf>

Remark: car usage (Italy, 2022)



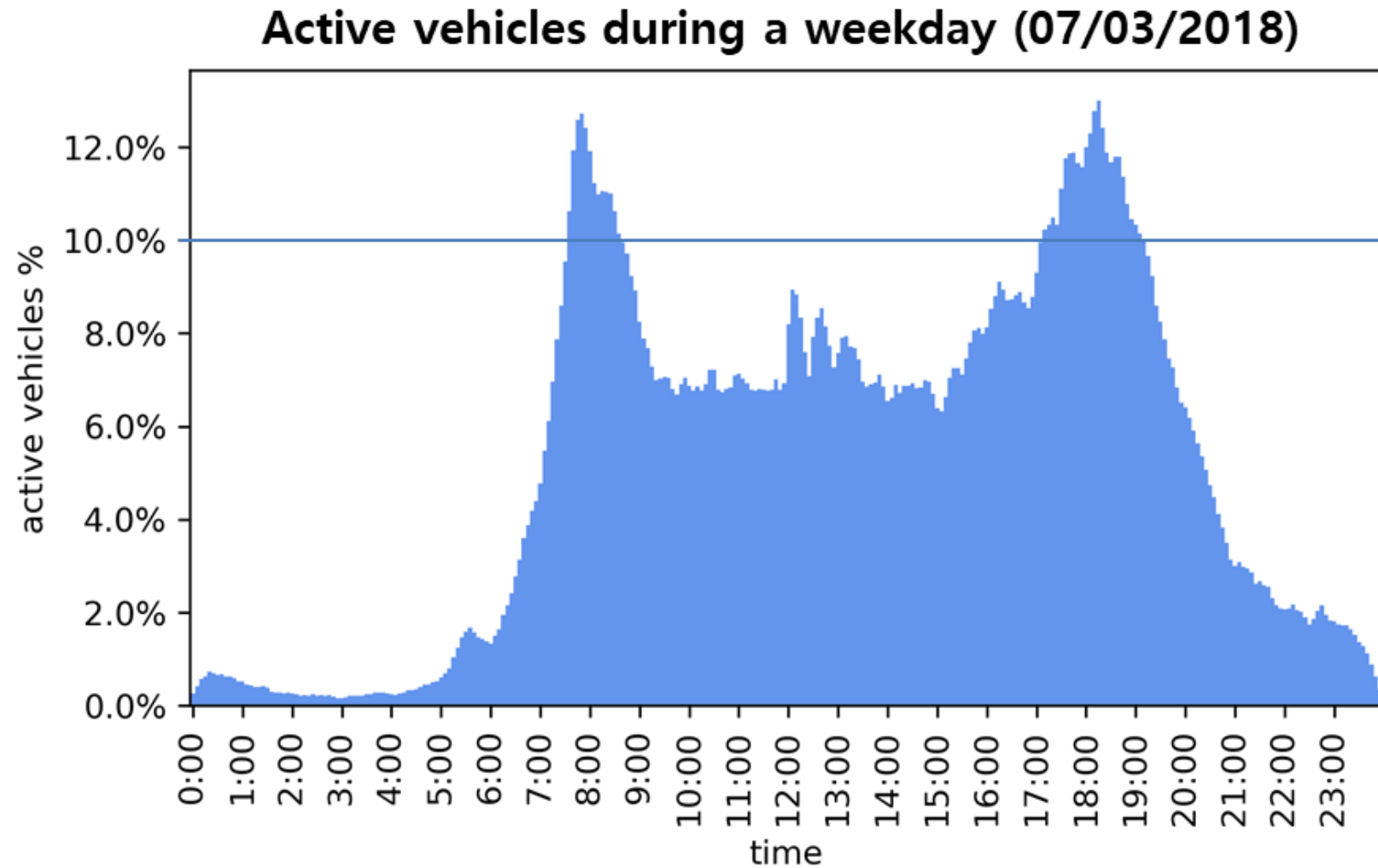
85% of the cars in Italy (2022) are used less than 5 % of time

Data source:
UnipolTech
SOLUZIONI TECNOLOGICHE



Milano, 2022

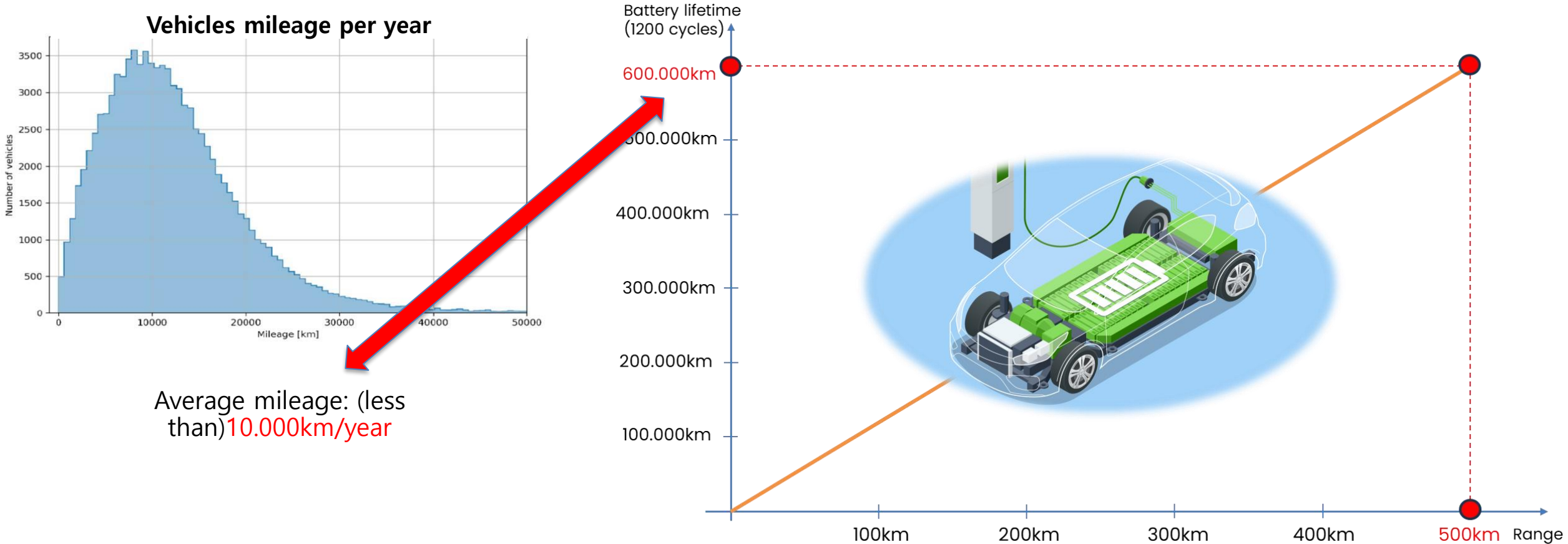
Remark: simultaneously-used cars



Data source:
UnipolTech
SOLUZIONI TECNOLOGICHE

Electric car and personal ownership: a mismatch

The longer the range, the longer the lifetime: For a 1200 cycles battery : **500Km range = 600.000+Km lifetime**



Cross-links...



Fossil fuels



Electric

«mismatch»



«perfect fit»



- large mileage
- globally-optimized recharge
- (shorter trips)
- (smaller vehicles)



Personal



Shared



Mass-market Mobility-As-A-Service: is there a cultural barrier?...NO

<https://www.smartcitiesdive.com/ex/sustainablecitiescollective/new-study-millennials-prefer-car-access-over-ownership/32723/>

New Study: Millennials Prefer Car ‘Access Over Ownership’

Author
EMBARQ
Network
@WRIncities

Low-carbon, affordable and convenient, Zipcar and other car-sharing programs are gaining popularity with Millennials. Photo by tedeytan.

The “Millennial” generation is quickly adopting car sharing as a mainstream transportation solution, according to results from Zipcar’s second annual study of the personal transportation and car ownership behavior of 18- to 34-year-olds. The study found that 55 percent of this influential generation have made an effort to drive less, which is a 10 percent rise from 2010. “Millennials are increasingly embracing access over ownership,” Zipcar explained. This is an interesting development, especially since vehicle ownership has been viewed as a “rite of passage” for many Americans.



> Nanyang Business School > News & Events > News

Millennials, Gen Z drive car-sharing boom

Car-sharing and car-leasing services in Singapore are reporting a boom in demand, fuelled by millennial and Gen Z users who are more open to using a car for hours or days instead of owning one.

Mr Toh Ting Feng, chief executive and co-founder of GetGo Technologies, expects demand for its car-sharing services “to grow more than 50 per cent from 2022 to 2023”.

This growth is driven only partly by higher certificate of entitlement (COE) prices, he says.

“Other factors driving the growth of our service include a shift in mindset away from ownership among the younger generations, a growing interest in sustainability, and the continued enhancement of our platform and service,” he adds.

<https://www.ntu.edu.sg/business/news-events/news/story-detail/millennials-gen-z-drive-car-sharing-boom>

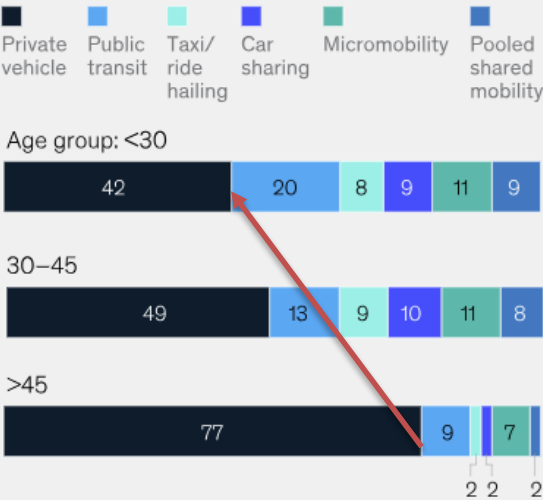
Europe’s Gen Z and the future of mobility

April 28, 2023 | Article

Younger consumers are less likely to use private cars now and plan to increase their use of public transit and micromobility.

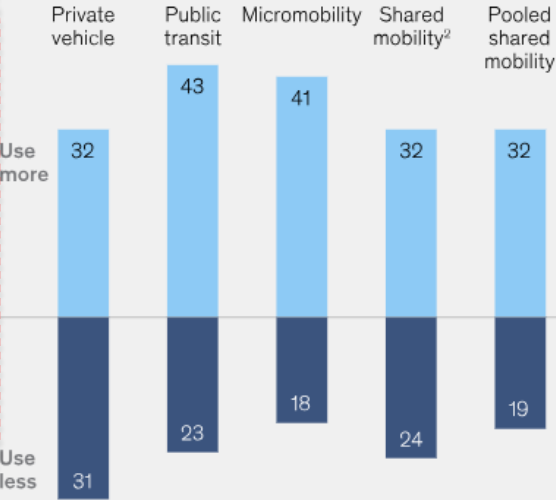
Share of respondents by age group, %

Currently use a particular mode of travel¹



Note: Figures may not sum to 100% due to rounding.
¹More than 4 times per week.
²Taxi/ride hailing/car sharing.
Source: McKinsey Mobility Consumer Pulse Survey

Planned use by mode of travel in the future, Gen Z



<https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/europes-gen-z-and-the-future-of-mobility>

Car-sharing, today (useful but limited effectiveness – hardly scalable)

High (attractive) level of services



(too) many cars



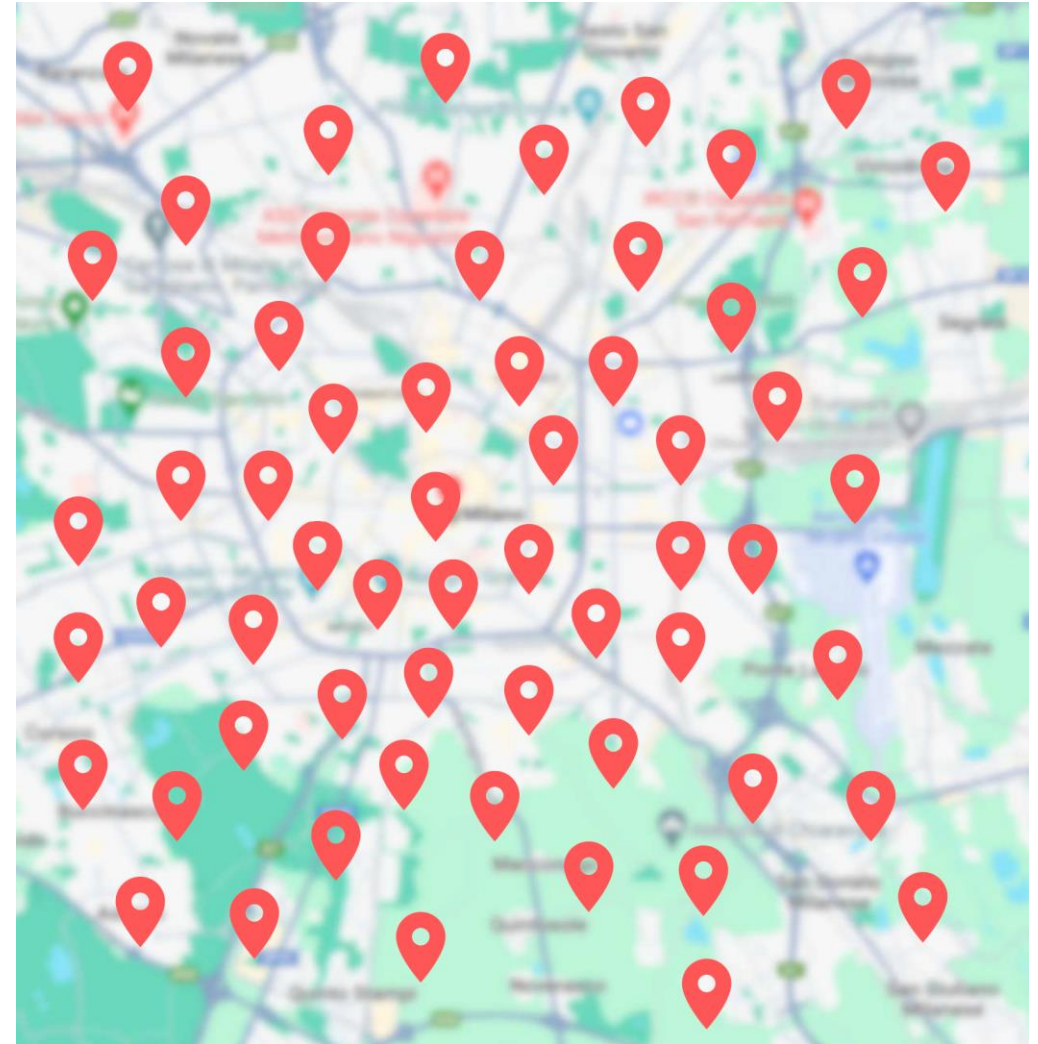
Low mileage-per-car



High cost (user) or non-profits (provider)



«deadlock»



AI(robo) driver: enabling technology for mass-market Mobility As A Service

High (attractive) level of services



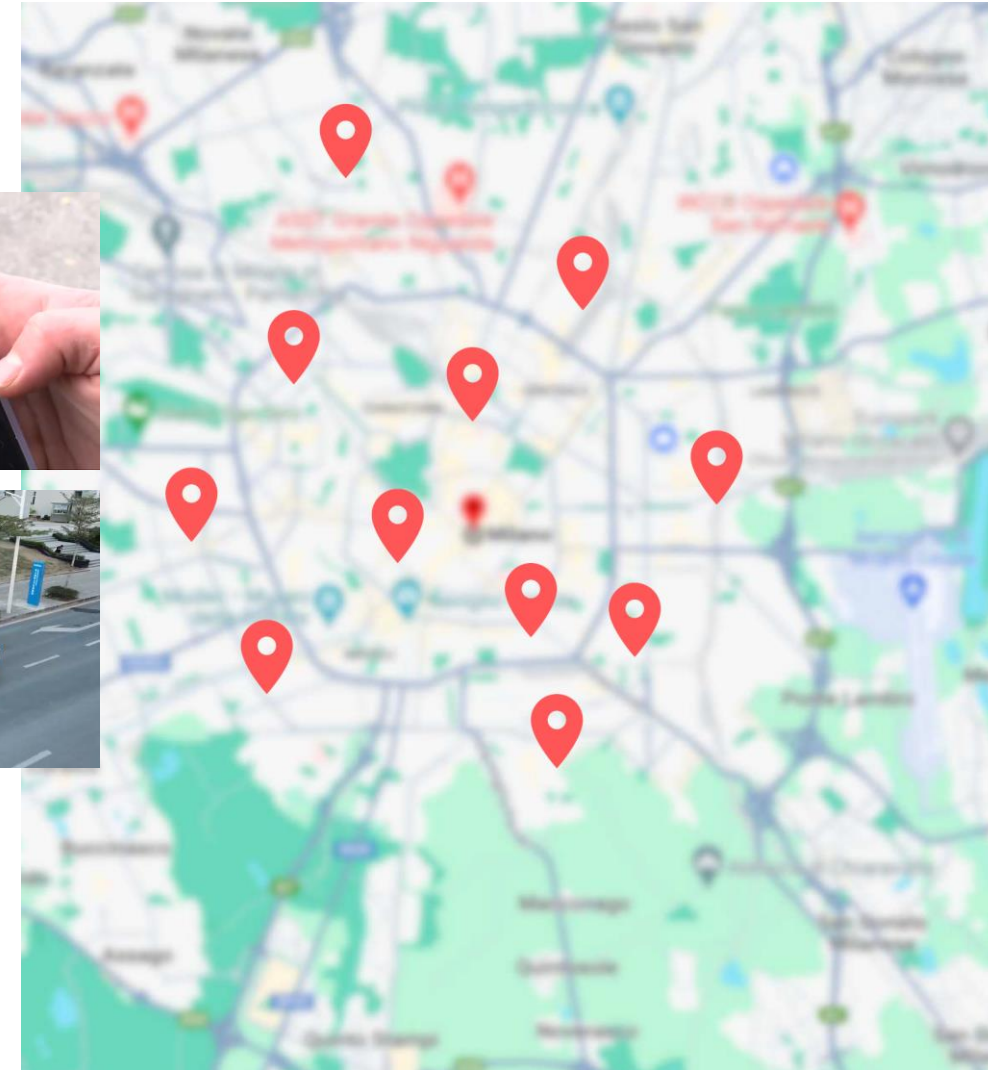
Few cars



High mileage-per-car



Low cost (user) and profits (provider)



Case study: Autonomous Mobility On Demand (MAAS) in Milano

Data source:
UnipolTech
SOLUZIONI TECNOLOGICHE

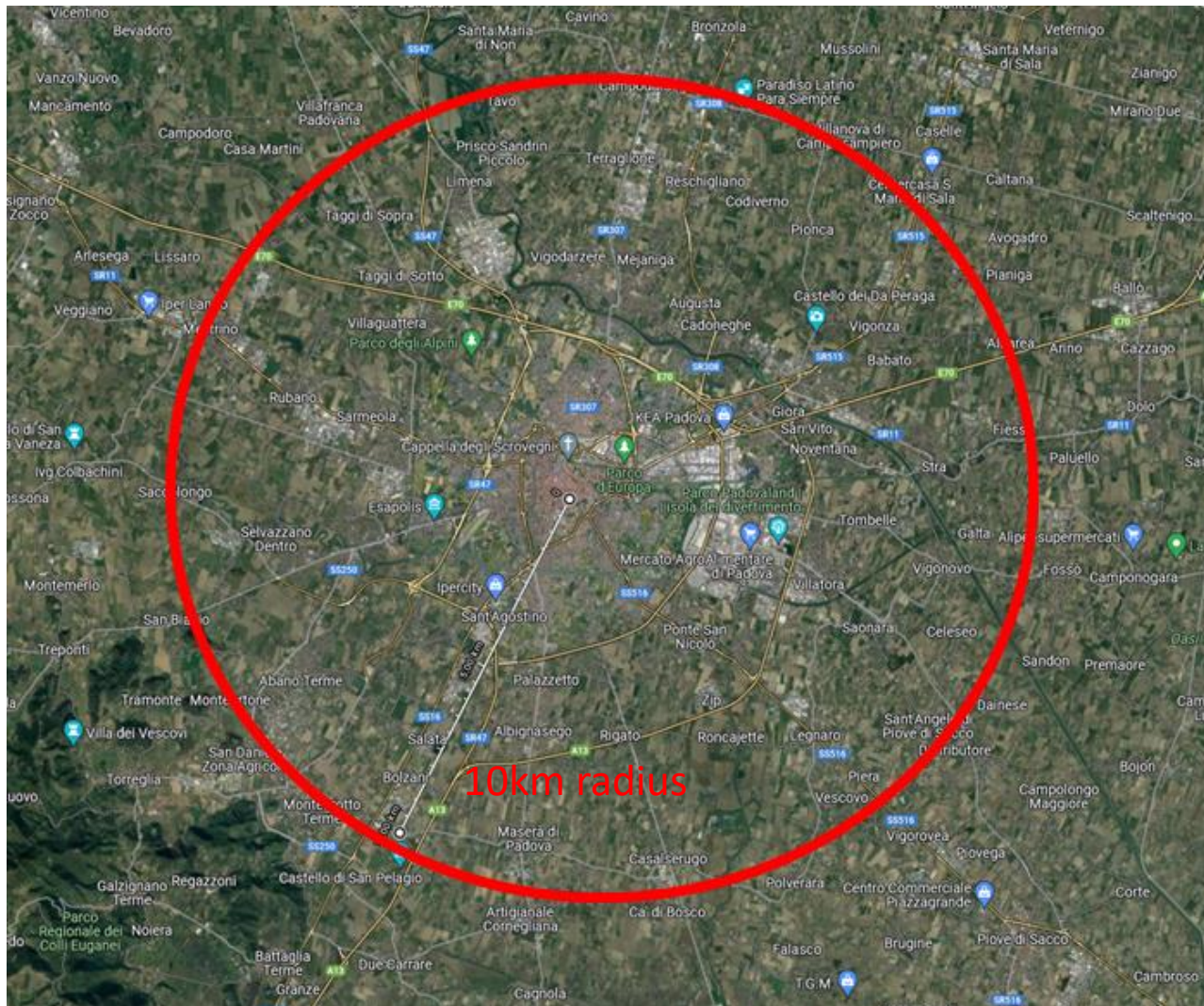
Replacement target: cars with 90% trips «in-in»

Milano	
Optimal Vehicles Number	4021
(Users) Users per car - efficiency	(43800) 10.9
Average Mileage	44.372 km/y
Average Wait Time	2min 20s

Simulation (using real data) of a **robo-taxi service with autonomous driving**



Case study: Autonomous Mobility On Demand (MAAS) in Padua



Replacement target: cars with 90% trips «in-in»

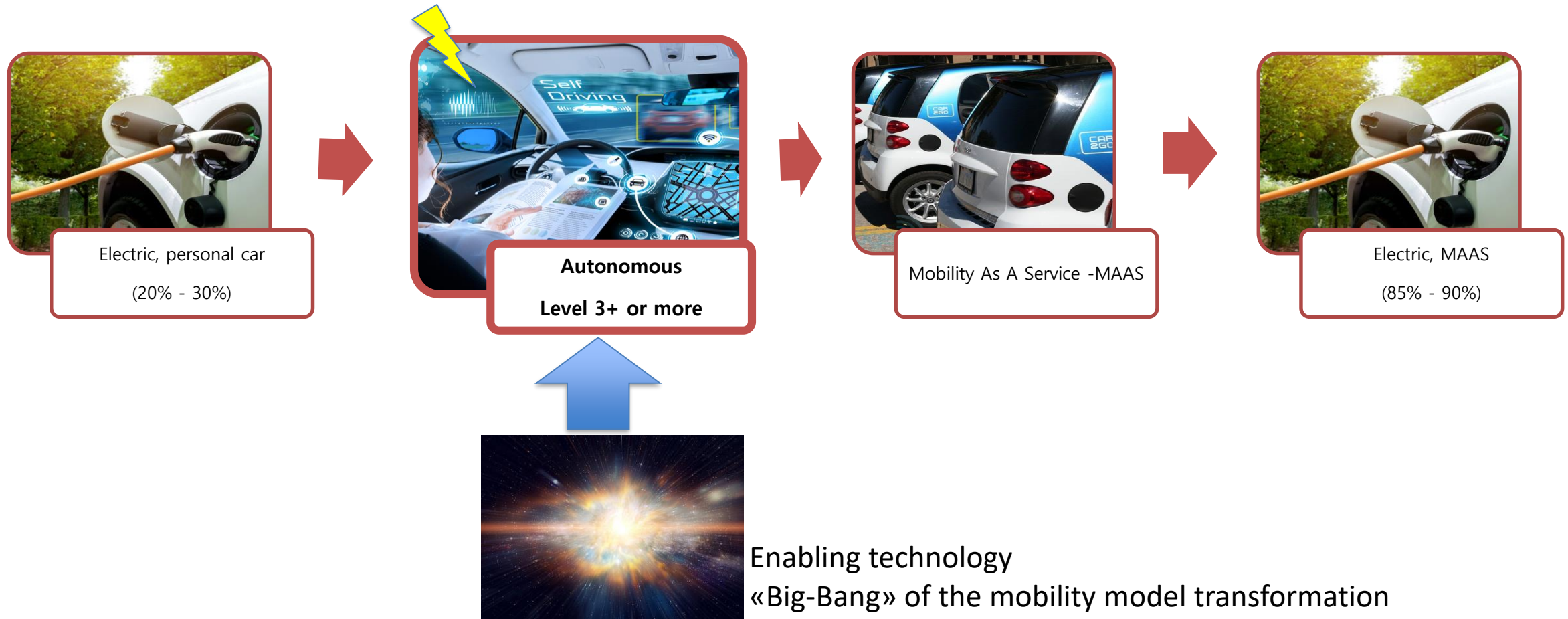
Data source:
UnipolTech
SOLUZIONI TECNOLOGICHE

Optimal Vehicles Number	4300
Users per car (efficiency)	8.0
Replaced private cars	34.500 (30%)
Average Mileage	44.000 km/y
Average Wait Time	2min 40s

Simulation (using real data) of a **robo-taxi service with autonomous driving**



Consecutio – the “right” sequence of the events



Autonomous Vehicles Technology: roadmap

Level	L0	L1	L2	L3	L4	L5
Driver	Driver only	Assisted	Partial Automation	Conditional automation	High automation	Full automation
Automation ⁽¹⁾	Driver continuously in control of speed and direction	Driver continuously performs the longitudinal or lateral dynamic driving task	Driver must monitor the dynamic driving task and the driving environment at all times	Driver does not need to monitor the dynamic driving task nor the driving environment at all times; must always be in a position to resume control	Driver is not required during defined use case	System performs the lateral and longitudinal dynamic driving task in all situations encountered during the entire journey . No driver required
	No intervening vehicle system active	The other driving task is performed by the system	System performs longitudinal and lateral driving task in a defined use case	System performs longitudinal and lateral driving task in a defined use case. Recognises its performance limits and requests driver to resume the dynamic driving task with sufficient time margin	System performs the lateral and longitudinal dynamic driving task in all situations in a defined use case	
Example	N/A	Park Assist	Traffic Jam Assist	Highway Patrol	Urban Automated Driving	Full end-to-end journey



Autonomous robo-driver: a massive technical problem, still to be fully solved (in mixed human-AI traffic)

The autonomous car: the «ultimate challenge» in «robotization» of a human task



High speed

Complex and fast vehicle dynamics

High safety issues (humans on-board; humans in dynamic obstacles)

Extremely-variable environmental conditions (grip, weather, type of roads, visibility, etc.)

High mapping uncertainties

Massive localization issues (GNSS not enough; canyoning, tunnels, etc)

Extreme multi-agent environment

Hybrid robot-humans environment

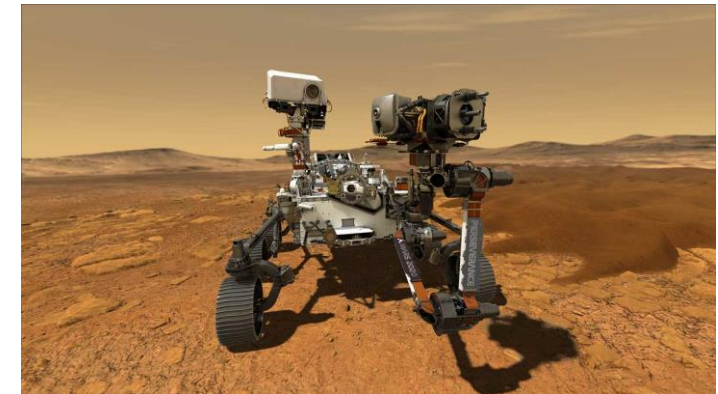
Gray-zones in engagement rules

Extreme variety (type, speed, behaviors) of dynamic obstacles

Extreme dynamic obstacles density

...

Other «Robotization» domains: difficult to find a similar complexity

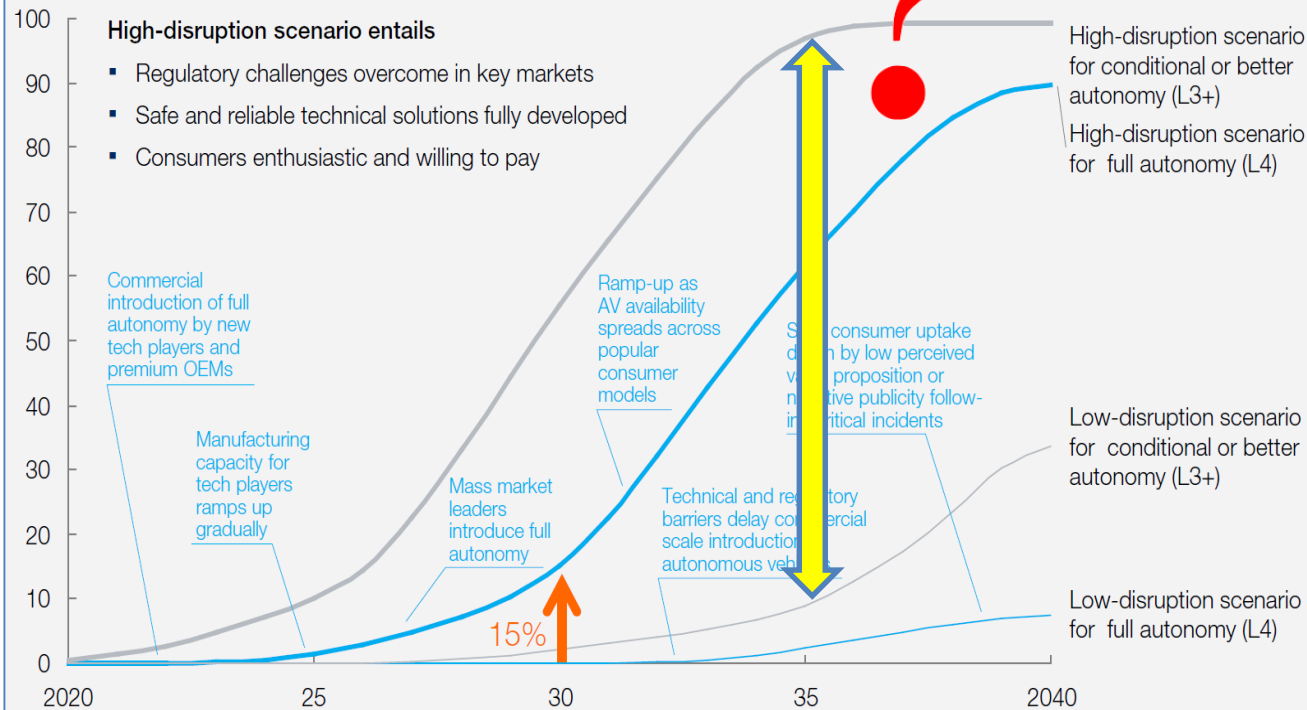


Roadmap to Autonomous Vehicles: timing?

Subject to progress on the technical, infrastructure, and regulatory challenges, up to 15% of all new vehicles sold in 2030 could be fully autonomous

New vehicle market share of fully autonomous vehicles

Percent



SOURCE: McKinsey

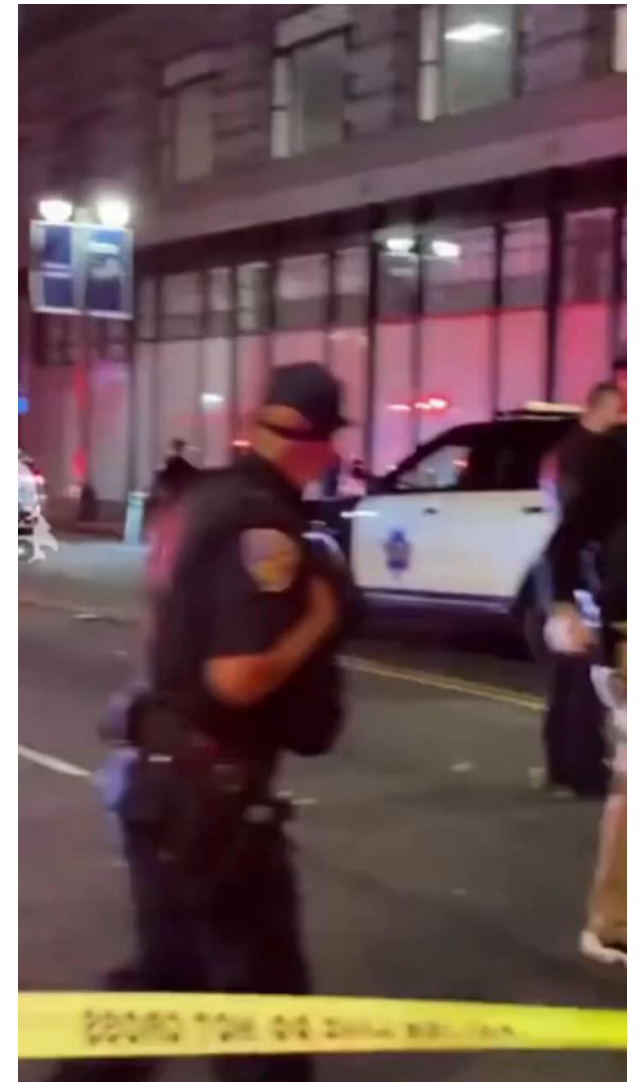
L3, 2035 prediction:
10%-95% range...



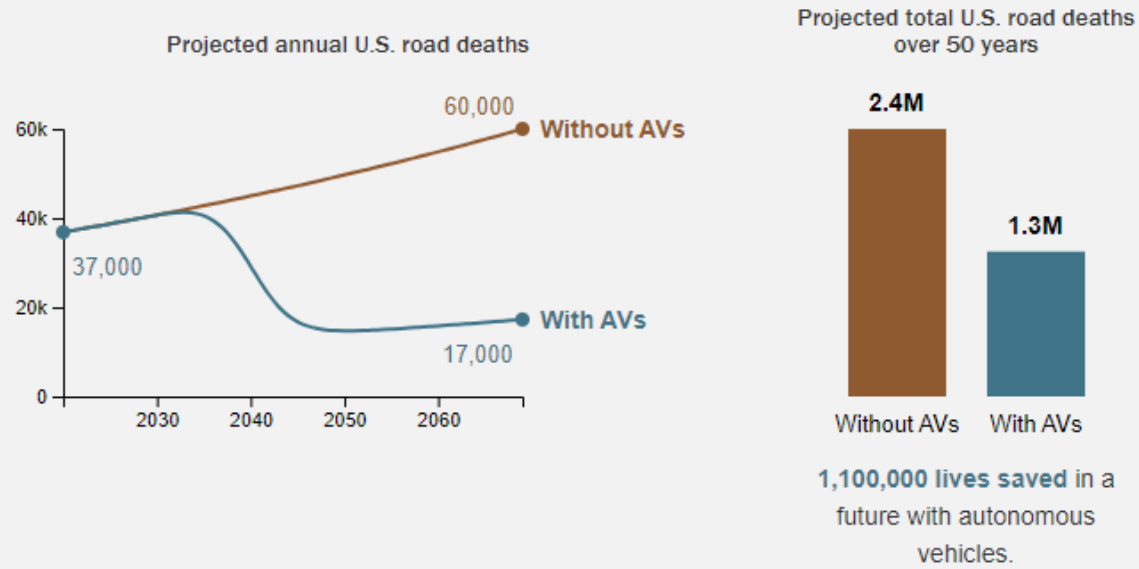
A political dilemma...



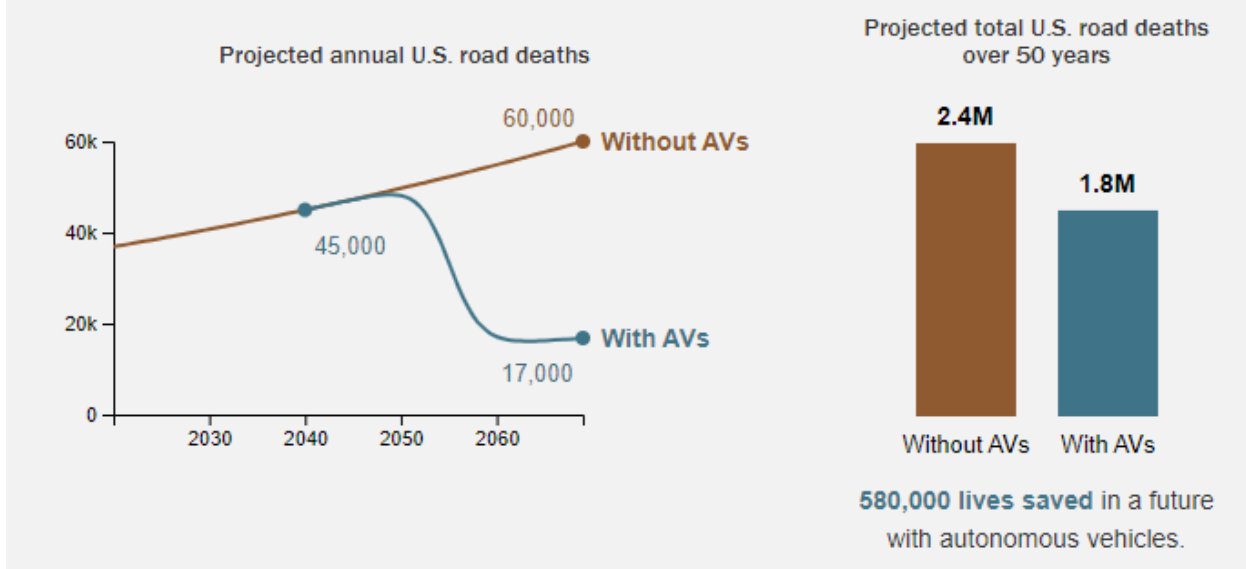
San Francisco,
October 2023



A political dilemma...



Scenario 1: Introduce when slightly safer (10%) than humans



Scenario 2: Delay AV introduction until nearly perfect

The «good for the individual» is playing against the «good for all»?

Are we ready to accept the errors of technology?

A long-term vision of our cities... (a dream?)



car-based personal mobility model

the mistake #2 (in retrospect, after 1B cars) = mixing function&fun



Bifurcation | landing point

Today: function & fun



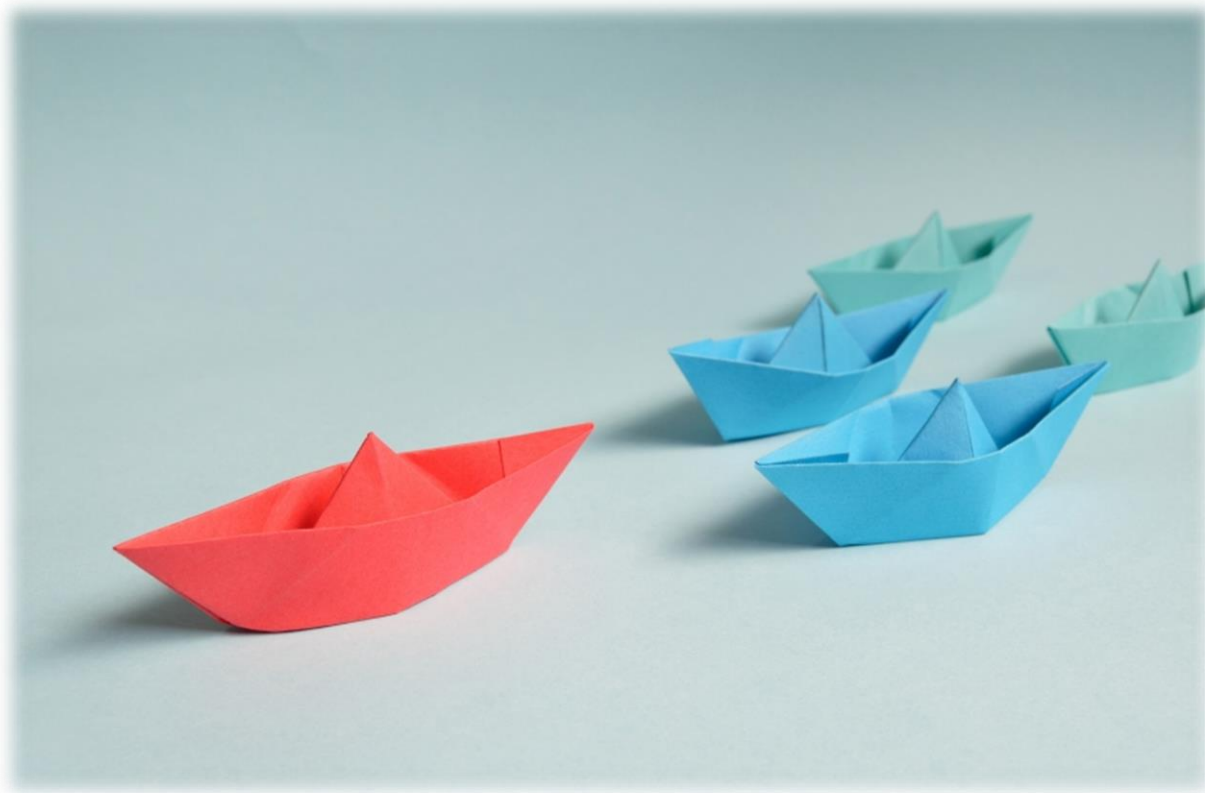
MaaS/MoD = public transport



Emotional ("red") vehicles (private owner or "service")



Appendix - “flagship” projects



Autonomous motorsport

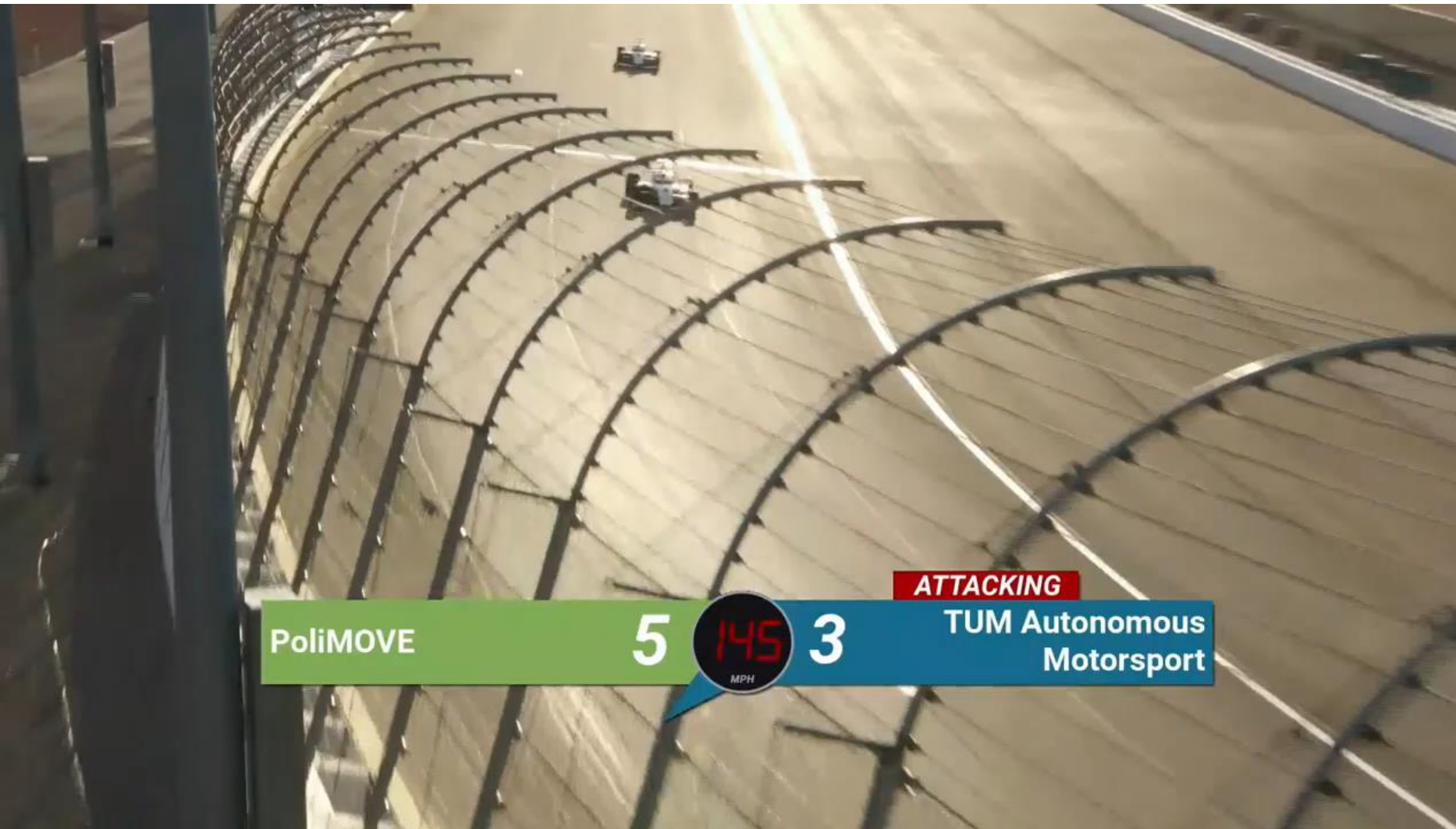


Indy Autonomous challenge: 1st example of autonomous motorsport



(9 **IDENTICAL** Indylight cars) – Race of AI-DRIVERS (not CARS)

Autonomous Challenge @ CES (Las Vegas) 1/7/22: the birth of Autonomous racing



First ever competition:


- **fully autonomous**
- **multi-agent** (head-to-head)
- **high-speed (up to 280kmh)**

Winner: Polimove,
Politecnico di Milano



Autonomous Challenge @ CES (Las Vegas) 7/1/2023 (winners) [current speed record on an autonomous car on an oval circuit: 290.0 KPH / 180.2 MPH]




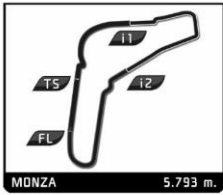
Winner: Polimove,  Politecnico di Milano



Autonomous Challenge @ Monza 18/6/2023 (winners: 2:05:87) [current speed record on an autonomous car on a road course circuit: 273.4 KPH / 169.8 MPH]



Winner: Polimove,  Politecnico di Milano



Indy Autonomous Challenge
Monza, 16-17-18.06.2023
Final Classification 16-17-18.06.2023
Official Classification

No Driver		Nat Team	Class	Time
1	2	PoliMOVE	PoliMOVE	2:05.873
2	3	TUM Autonomous Motorspo	TUM Autonomous Motorsport	2:08.662
3	6	TII Unimore Racing	TII Unimore Racing	2:11.242
4	4	KAIST	KAIST	2:44.239
5	8	MIT-PITT-RW	MIT-PITT-RW	3:07.738

World record- (27/4/2022) - Space Florida launch&landing facility, at NASA Kennedy Space Center in Cape Canaveral, FL



New world record holder for a fully-autonomous car: **309.3kph=192.2mph** (two-ways average, average over 1Km); 310.4kph=192.8mph (two-ways average, average over 100m); 311.9kph=193.8mph (top speed). The previous record was held by Roborace since 2019 (282,4kph=175,5mph, two-ways average, average over 100m).



Record holder:
PoliMOVE,
Politecnico
di Milano



New competition: Abu Dhabi Autonomous Racing League (A2RL) 25-26-27 April, 2024



🏆 1st place in the Attack-Defense Competition

🏆 1st place in the Time-Trial Competition

🏎️ special performance prize, lap time of Time Trial 2:00.653 within the 114% of the lap time of an F1 driver

🕒 best officially-timed lap time of all: 1:57.854 (112% of the lap time of an F1 driver)

4th place in the final 4-cars race

Empowering the human: the AS.CAR.I technology



AS.CAR.I



The logo for ASCARI is displayed in a stylized, yellow-outlined font. The letters are interconnected, with the 'A' and 'S' forming a continuous shape, and the 'C' and 'A' also connected. The 'R' and 'I' are more distinct but still integrated into the overall design.

A S C A R I D R I V E R



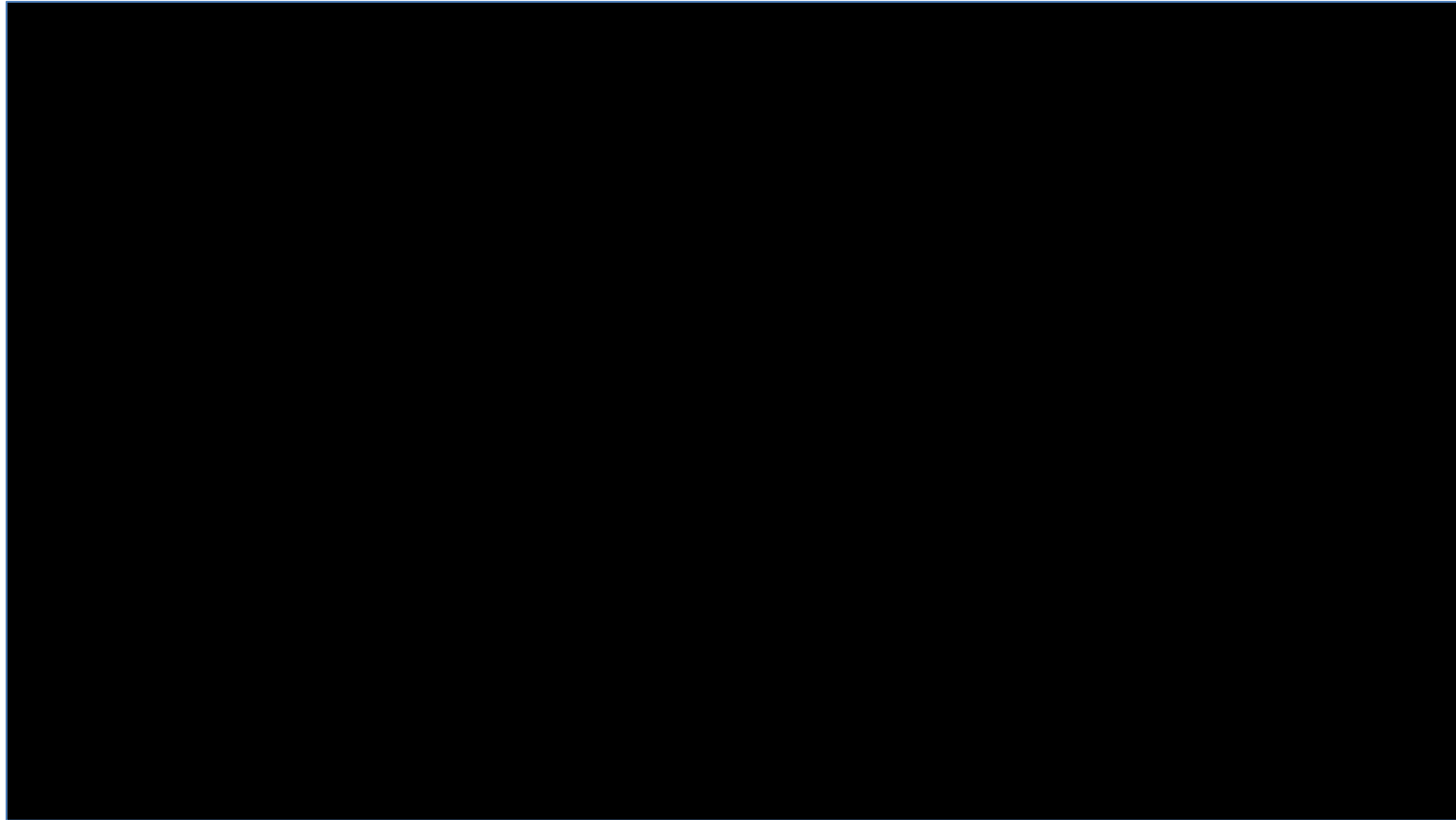
ASCARI

V I R T U A L F E N C E

“demo” test starting 15/7/2024 – Vairano circuit (Pavia)

Car-makers (large)
Car-makers (atelier)
Track-experience managers
Circuit managers
Track-events managers
Non-professional racers
Private sport-car owners

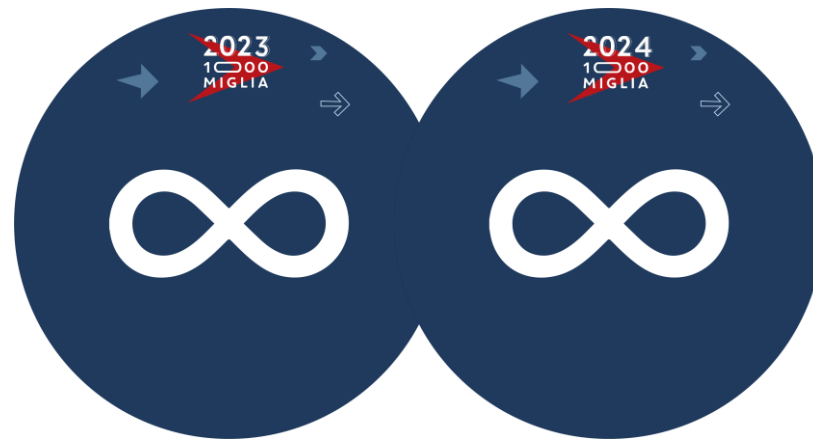
...



Remark: : an enabling technology for hybrid-racing (co-botics...)



1000 Miglia Autonomous Drive (1000-MAD)



The challenge: high road diversity and public engagement

Brescia-Rome-Brescia (1000 Miles)



High road
diversity



Low time-extension

Long time-extension

Low road
diversity



**1000
MIGLIA** ➤

Mille Miglia: “the most wonderful race in the world” [Enzo Ferrari]



BIGGEST Achievement: Authorization to test on public road (D.M.70/2018 «smart road»)

Full-crossings of:

- BRESCIA
- FERRARA
- MODENA
- PARMA
- MILANO
- BERGAMO



M INF.MOT.REGISTRO DECRETI.I.0000226.01-06-2023



Ministero delle infrastrutture e dei trasporti
Dipartimento per la mobilità sostenibile
Direzione generale per la motorizzazione e per i servizi ai cittadini e alle imprese in materia di trasporti e navigazione
DIVISIONE 3

DECRETO DIRIGENZIALE

"Autorizzazione alla Sperimentazione di veicoli a guida automatica ai sensi dell'art. 9 del Decreto del Ministro delle infrastrutture e dei trasporti del 28 febbraio 2018 n. 70"

Il Direttore Generale della Direzione Generale per la motorizzazione e per i servizi ai cittadini e alle imprese in materia di trasporti e navigazione

VISTO il decreto legislativo 30 aprile 1992, n. 285 e successive modifiche ed integrazioni, istitutivo del Codice della Strada;
VISTA la legge 27 dicembre 2017, n. 205, e in particolare l'art. 1, comma 72, che autorizza la Sperimentazione su strada delle soluzioni di Smart Road e di guida connessa e automatica;
VISTO il decreto del Ministro delle infrastrutture e dei trasporti del 28 febbraio 2018 n. 70 recante le modalità attuative e strumenti operativi della sperimentazione su strada delle soluzioni di Smart Road e di guida connessa ed automatica;

2nd permission grant in the 5-years history of DM70/2018 – with the largest mileage

1000 Miglia 2023

"Unveil" (Brescia, 11/6/2023)



1000 Miglia 2023

Siena, 15/6/2023



POLITECNICO MILANO 1863

1000 Miglia 2023

Milano 16/6/2023



POLITECNICO MILANO 1863

1000 Miglia 2023

The "Avatar" (to boost public engagement)



1000 Miglia 2024



1000+ Km of authorized road!

GranCabrio Folgore



















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MILANO 1863

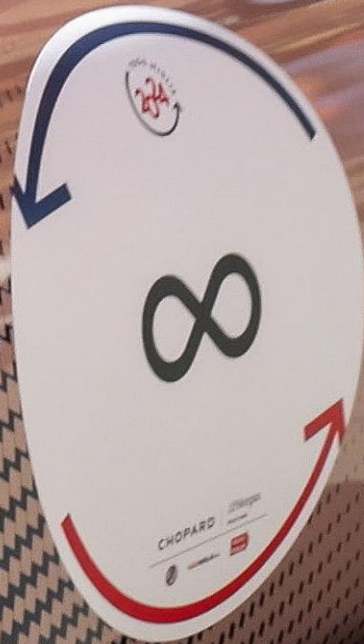








1000
MIGLIA











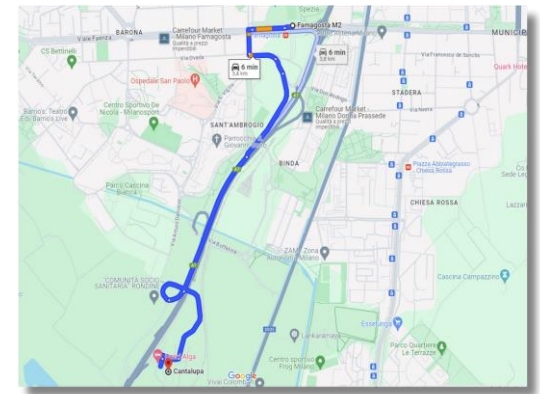


The AIDA project

The screenshot shows the Facebook profile of AIDA - Artificial Intelligence Driving Autonomous - Politecnico di Milano. The profile picture is a blue circle with the AIDA logo. The cover photo is a blue banner with the AIDA logo and the text 'Artificial Intelligence Driving Autonomous'. The page name is 'AIDA - Artificial Intelligence Driving Autonomous - Politecnico di Milano'. Below the name, it says 'Politecnico di Milano' and 'Research Services · 384 followers · 11-50 employees'. There are buttons for 'Message' and 'Following'. The 'Posts' tab is selected, showing a post from 3 days ago about the #1000Miglia2024 event. The post text says: 'Anche quest'anno la sperimentazione su strada pubblica condotta da AIDA durante #1000Miglia2024 è stata il frutto di un'intensa collaborazione con MOYON, centro di eccellenza per la ricerca e l'innovazione leader nei servizi di Intelligent ...more'. Below the text is a 'See translation' link and a grid of images showing the autonomous car driving on a road, with a rainbow in the background.

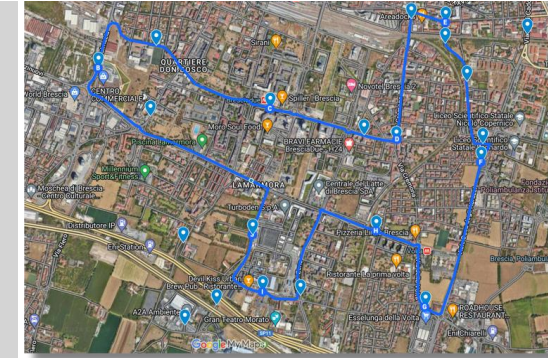
The screenshot shows the Instagram profile of aida.polimi. The profile picture is a blue circle with the AIDA logo. The bio says: 'AIDA - Artificial Intelligence Driving Autonomous - Polimi', 'Politecnico di Milano, a project powered by @polimi', 'The journey of a completely autonomous car @millemigliaofficial...', and '1000mad.deib.polimi.it'. There are buttons for 'Segui già', 'Messaggio', and a menu icon. The page shows 30 posts, 747 followers, and 53 followed. Below the bio, there are tabs for 'POST', 'REELS', and 'POST IN CUI TI HANNO TAGGATO'. A grid of 12 images is displayed, showing the autonomous car driving on a road, with a rainbow in the background, and people celebrating the event.

Urban-mobility projects (spinoff projects of 1000MAD)



Low-speed with
human-remote
supervising for edge
cases

Urban-mobility projects (spinoff projects of 1000MAD)



Low-speed with
human-remote
supervising for edge
cases

Special-mobility projects (spinoff projects of 1000MAD)



Focus on a mid-size village («Borgo») without public transportation

Focus on: Elderly / medical services

Low-speed with human-remote supervising for edge cases

Conclusions

A.I.(robo)-driver will revolutionize the mobility model

A.I.(robo)-driver car will be the enabler of full-scale electrification

Technology still immature for large-scale deployment

Pushing the limit of this technology will speed up the development and acceptance process

EU: need to speed-up the testing and development in open-roads of the A.I.(robo)-driver – better compromise risk vs. opportunity?

