

Trolley90 & its sustainable future



The ATM Milano trolleybus system: features and future developments

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ATM is the operator of the transport services in the metropolitan area of Milano (96 municipalities - 3.2 million inhabitants). Since 2008, it is a reference operator of public transport in **Copenhagen** (1.4 million inhabitants). ATM operates the automated metro and soon also the new tramway line.

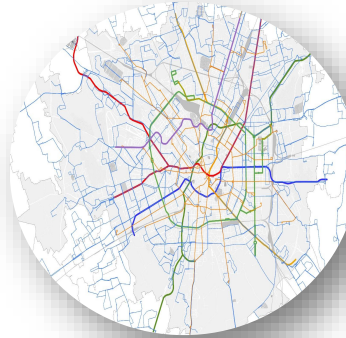
ATM operates all modes of public transport: conventional and automated metro systems, buses, trams, trolleybuses, cable cars and bikes.

ATM has been running automated metro systems for over 10 years and currently manages 6 automated lines in Milan and Copenhagen.

ATM's know-how covers the entire value chain of transport and mobility services: engineering (design, definition, optimization of transport networks), operations of all modes of transport and maintenance.



Distance covered:
185 Million km per year



Network extension:
2.200 km



Municipalities served:
96



Passengers:
800 Million per year



Fleet size:
2.300 vehicles



Mode of transport:
7

Integrated mobility provider



Urban and suburban public transport



Management of subway lines



Diagnostics and maintenance of fleet, infrastructures and technology networks



Technologies (MaaS, LEZ, access and traffic control)



On-street and off-street car parks and vehicle removal service



Bike sharing



Tourist services

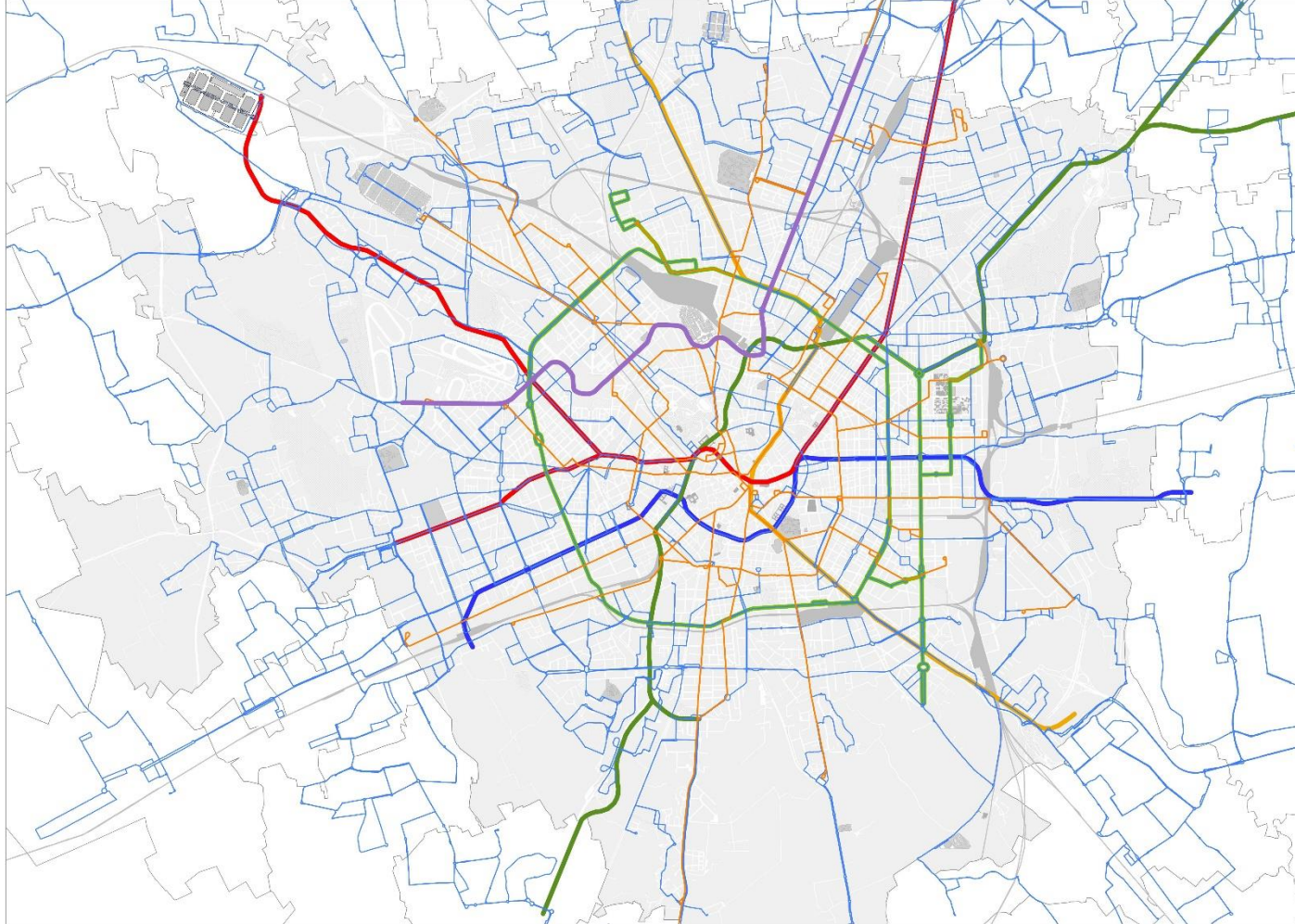
Milan's complex integrated public transport network

Metro

5 lines
136 stations
169 trains
114 km of network

Tramways

17 lines
400 vehicles
160 km of network



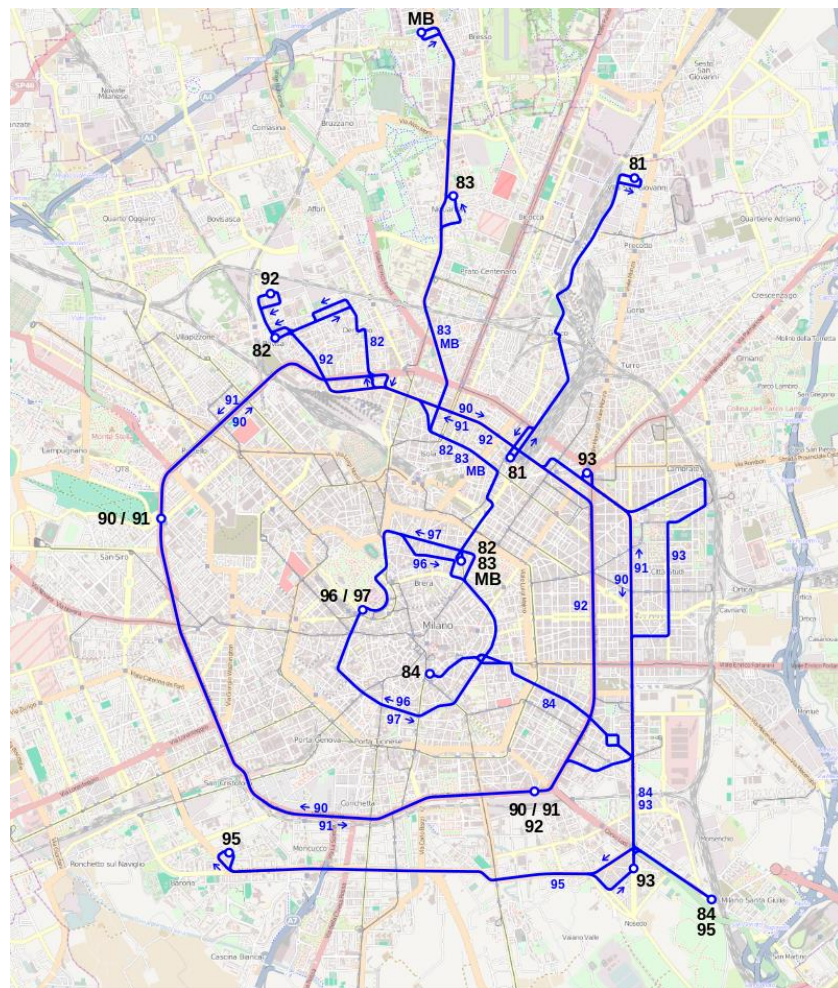
Trolleybuses

4 lines
130 vehicles
40 km of network

Buses

141 lines
1.383 vehicles
1.200 km of network

ATM trolleybus network evolution



Maximum network extension (1975)



Current network (2023)



Around **55%** of the current trolleybus network is in fully reserved lanes

| | 1975 | 2023 |
|----------------------|--|-----------------------|
| km of network | 140 km | 40 km |
| Number of lines | 12 (81, 82, 83, 84, 90, 91, 92, 93, 95, 96, 97, MB) | 4 (90, 91, 92, 93) |
| Number of trolleybus | 360 | 130 |

Many of the original trolleybus lines have become bus lines: for example, the trolleybus lines 96 and 97 have become the current bus line 94.

ATM trolleybus lines

Line 90 – Right Circular

The line moves **CLOCKWISE** between the terminus of Lotto and Isonzo.



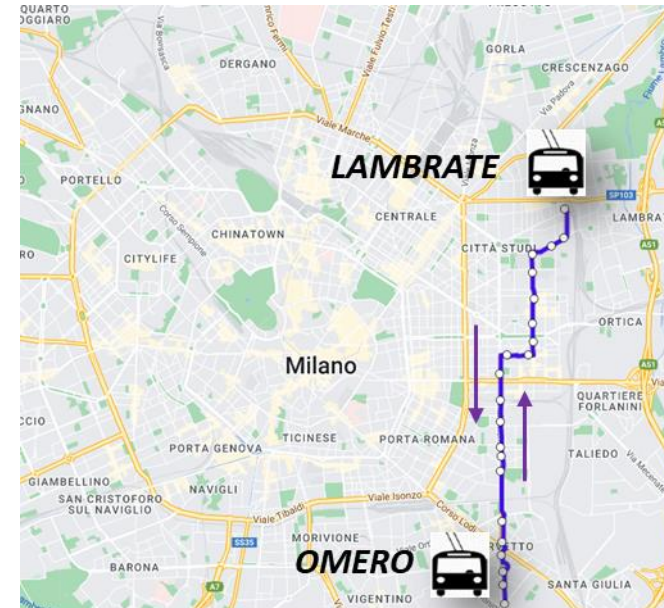
Line 91 – Left Circular

The line moves **COUNTERCLOCKWISE** between the terminus of Isonzo and Lotto.



Line 92

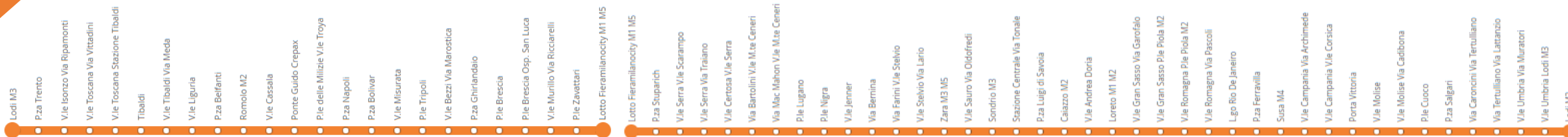
The line shares part of the route with 90 and 91 lines, reaching the north west part of the city.



Line 93

The line shares part of the route with 90 and 91 lines, reaching the north east part of the city.

Line 90

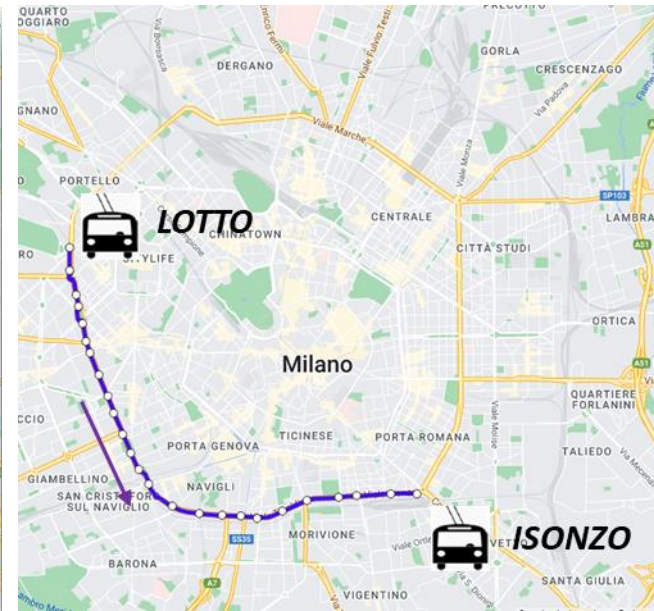


Line 90 – Right Circular

| Terminal | Isonzo - Lotto | Lotto – Isonzo |
|-------------------------------------|----------------|----------------|
| Length of the network | 8 km | 12.9 km |
| Number of stops | 24 | 40 |
| Timetable | 24 h | 24 h |
| Frequency in the peak hour | 3' | |
| Number of vehicles in the peak hour | 29 | |
| Kilometres per year (2022) | 1.400.000 km | |

Line 91

| |
|-------------------------------|
| Lotto Fieramilanocty |
| P.le Zavattari |
| V.le Murillo Via Ricciarelli |
| P.le Brescia Osp. San Luca |
| P.le Brescia |
| P.za Ghirlandale |
| V.le Bezzi Via Trivulzio |
| V.le Bezzi Via Marostica |
| P.le Tripoli |
| V.le Misurata |
| P.za Bolivar |
| P.za Napoli |
| P.le delle Milizie V.le Troya |
| Ponte Guido Crepax |
| V.le Cassala |
| Romolo M2 |
| P.za Belfanti |
| V.le Liguria |
| V.le Tibaldi Via Meda |
| Tibaldi |
| V.le Toscana Stazione Tibaldi |
| V.le Toscana Via Vittadini |
| V.le Isonzo Via Ripamonti |
| P.za Trento |
| Lodi M3 |
| Lodi M3 |
| V.le Umbria Lodi M3 |
| V.le Umbria Via Muratori |
| Via Terrullano Via Lattanzio |
| Via Terrullano Via Decembrio |
| P.za Salgari |
| P.le Cusco |
| V.le Molise Via Cadibona |
| V.le Molise |
| Porta Vittoria |
| V.le Campania V.le Corsica |
| V.le Campania Via Archimede |
| Susa M4 |
| P.za Ferravilla |
| Lgo Rio De Janeiro |
| V.le Romagna Via Pascoli |
| V.le Romagna P.le Piola M2 |
| V.le Gran Sasso P.le Piola M2 |
| V.le Gran Sasso Via Garofalo |
| Loreto M1 M2 |
| V.le Andrea Doria |
| Calazio M2 |
| P.za Luigi di Savoia |
| Stazione Centrale Via Tonale |
| Sondrio M3 |
| V.le Sauro Via Oldofredi |
| Zara M3 M5 |
| V.le Selvio Via Lario |
| Via Farni V.le Selvio |
| Via Bernina |
| V.le Jenner |
| P.le Nigra |
| P.le Lugano |
| Via Mac Mahon V.le Mte Ceneri |
| Via Bartolini V.le Mte Ceneri |
| V.le Certosa V.le Serra |
| V.le Serra Via Traiano |
| V.le Serra V.le Scarampo |
| P.za Stuparich |
| Lotto Fieramilanocty M1 M5 |



Line 91 – Left Circular

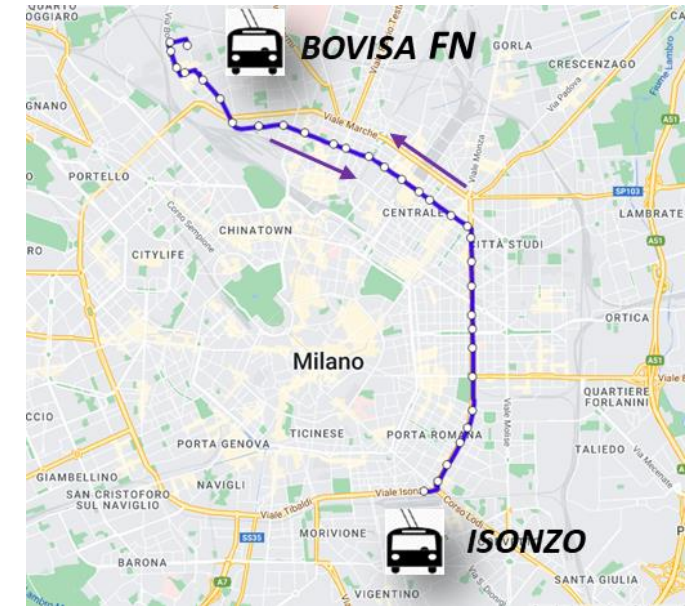
| Terminal | Isonzo – Lotto | Lotto – Isonzo |
|-------------------------------------|----------------|----------------|
| Length of the network | 13.2 km | 8 km |
| Number of stops | 40 | 25 |
| Timetable | 24 h | 24 h |
| Frequency in the peak hour | 3' | |
| Number of vehicles in the peak hour | 29 | |
| Kilometres per year (2022) | 1.420.000 km | |

Line 92



Line 92

| Terminal | Isonzo - Bovisa FN | Bovisa FN - Isonzo |
|-------------------------------|----------------------------|--------------------|
| Length of the network | 10.3 km | 11.2 km |
| Number of stops | 37 | 34 |
| Timetable | From 6:00 a.m. to 01:30 pm | |
| Frequency in the peak hour | 5' | |
| Number of vehicle (peak hour) | 23 | |
| Kilometres per year (2022) | 877.379 km | |

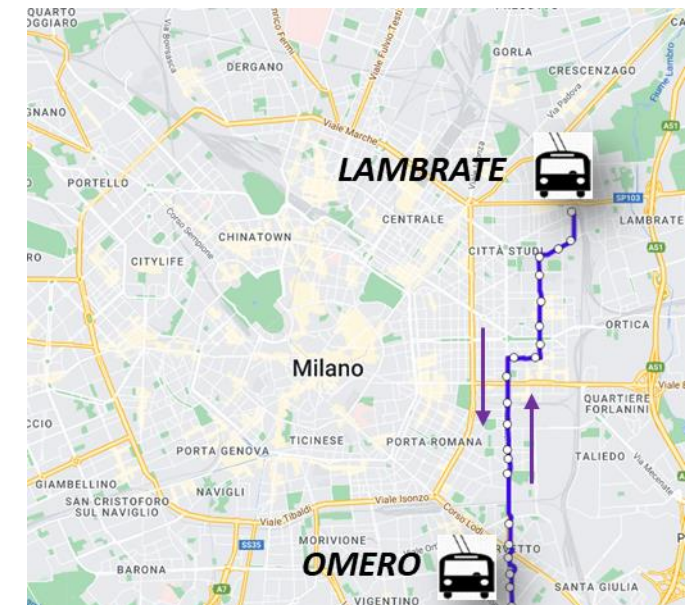


Line 93



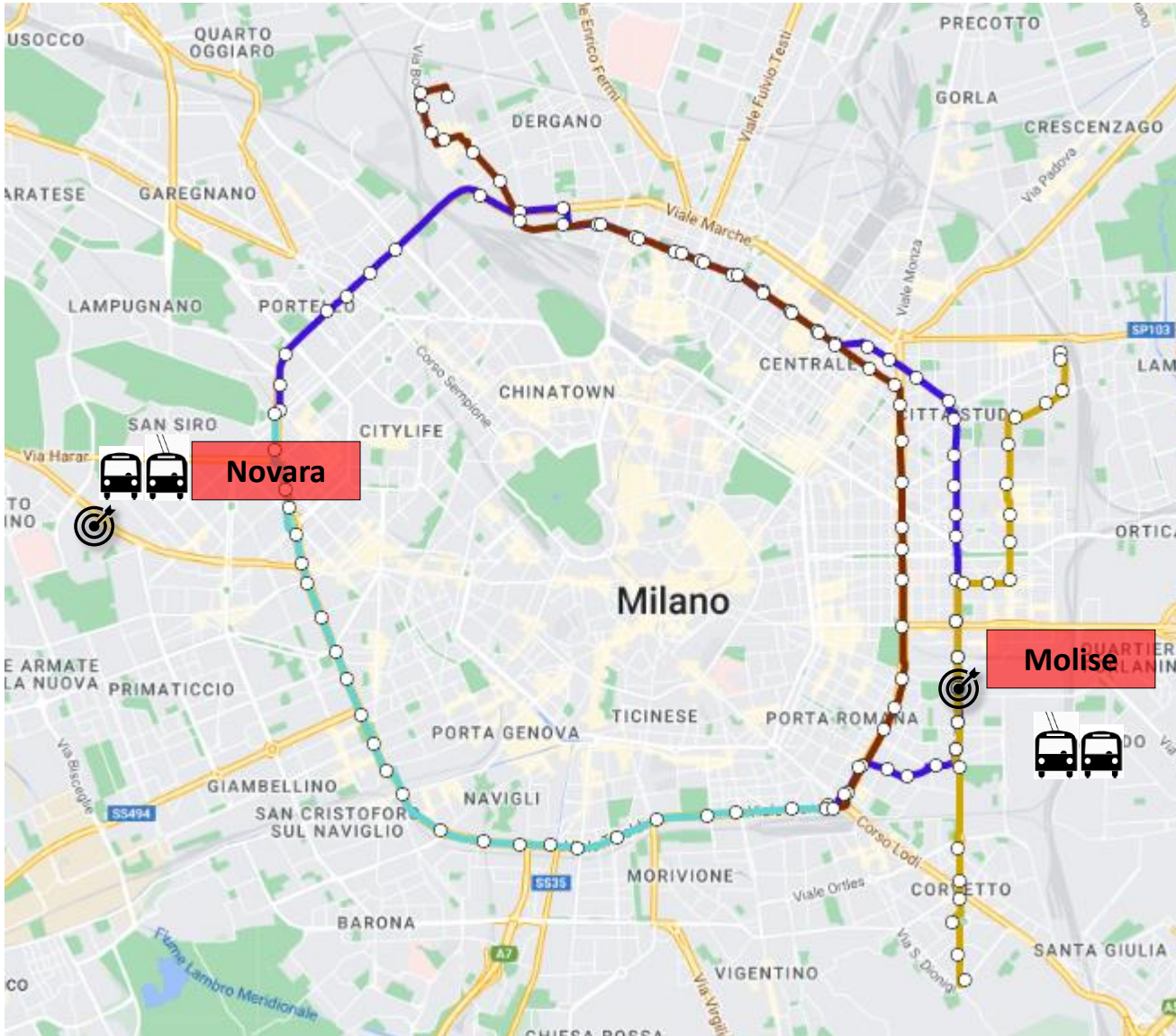
Line 93

| Terminal | Lambrate - Omero | Omero - Lambrate |
|-------------------------------|---------------------------|------------------|
| Length of the network | 7 km | 6.8 km |
| Number of stops | 24 | 22 |
| Timetable | From 06:00 am to 01:00 pm | |
| Frequency in the peak hour | 5' | |
| Number of vehicle (peak hour) | 18 | |
| Kilometres per year (2022) | 611.424 km | |

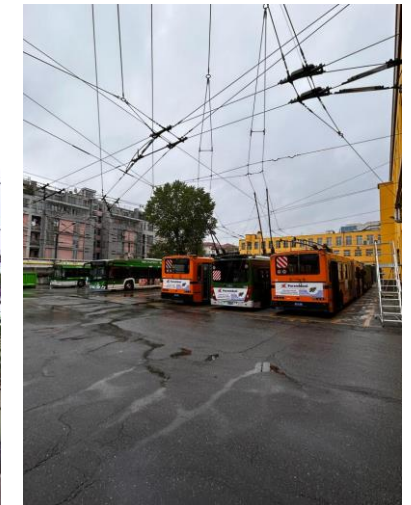


ATM trolleybus depots

Atm Trolleybus fleet is stored in two different depots: **Molise** and **Novara**.



Novara is only for the **storage** of trolleybuses. 30 trolleybus for 90 and 91 lines.



Molise is used both for **storage** and **maintenance** of trolleybus. 100 trolleybuses for 90, 91, 92 and 93 lines.

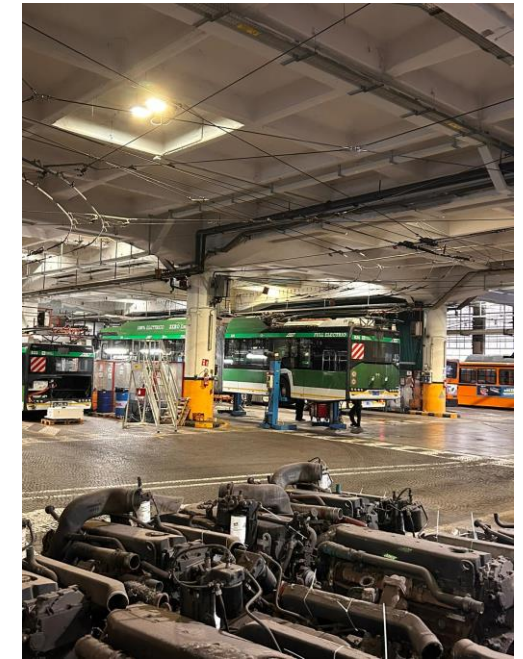
ATM trolleybus depots

Molise is the main depot used for trolleybuses. It has 2 floors and it is currently used both for trolleybus and bus fleet.

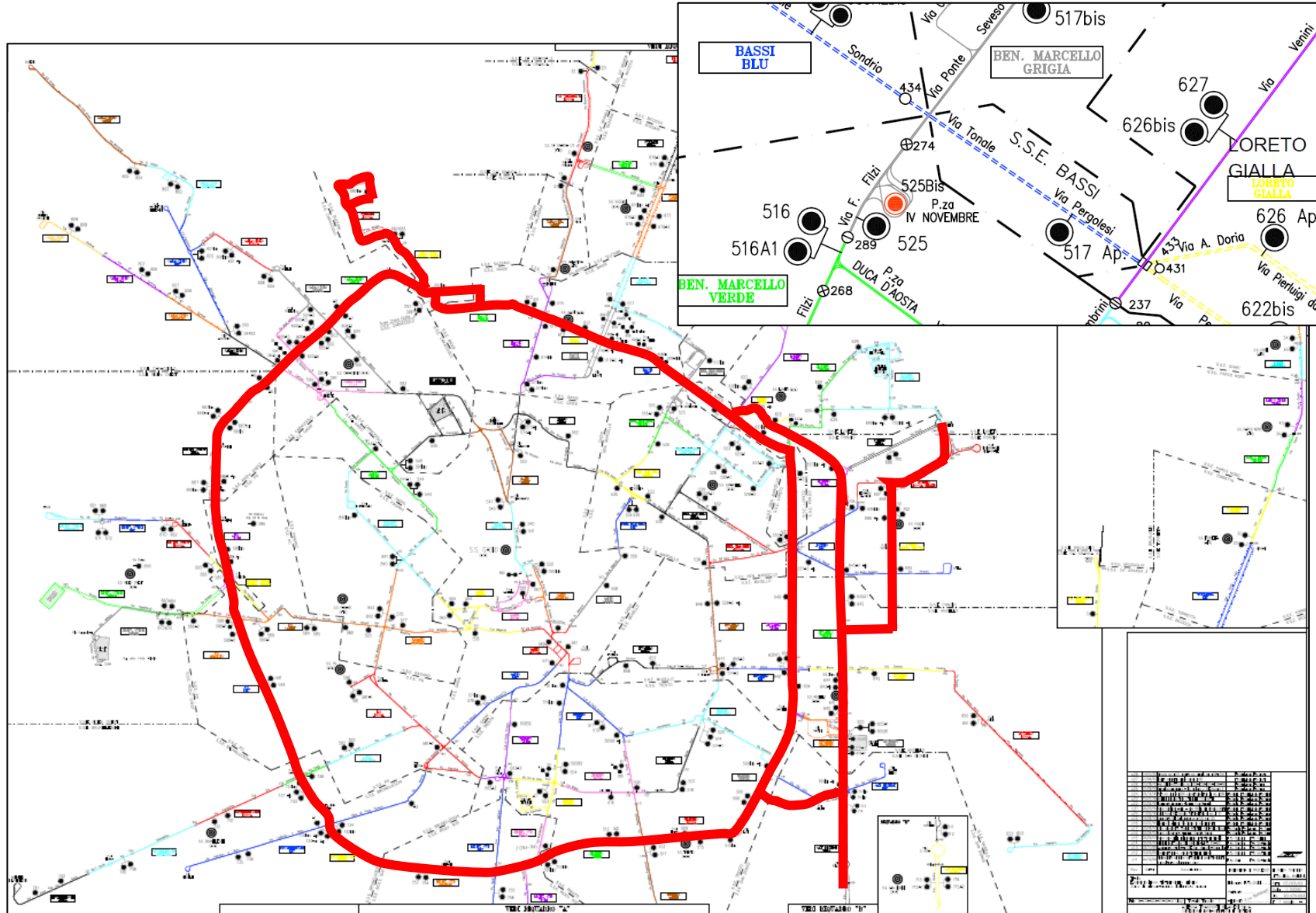
Every day trolleybuses are moved inside the depot for **maintenance** and **storage operations** (washing or cleaning). Each movement is daily **planned** between the two directions of Operation and Maintenance so that the vehicles are always available during the morning and evening peak hours.



All fleet maintenance operations are directly managed by ATM staff. At the moment the company choice is to keep the **know-how** of the entire maintenance process **in-house**. For example, the general overhauls performed on fleet vehicles with more than 100.000 km are currently underway.



ATM trolleybus network infrastructure

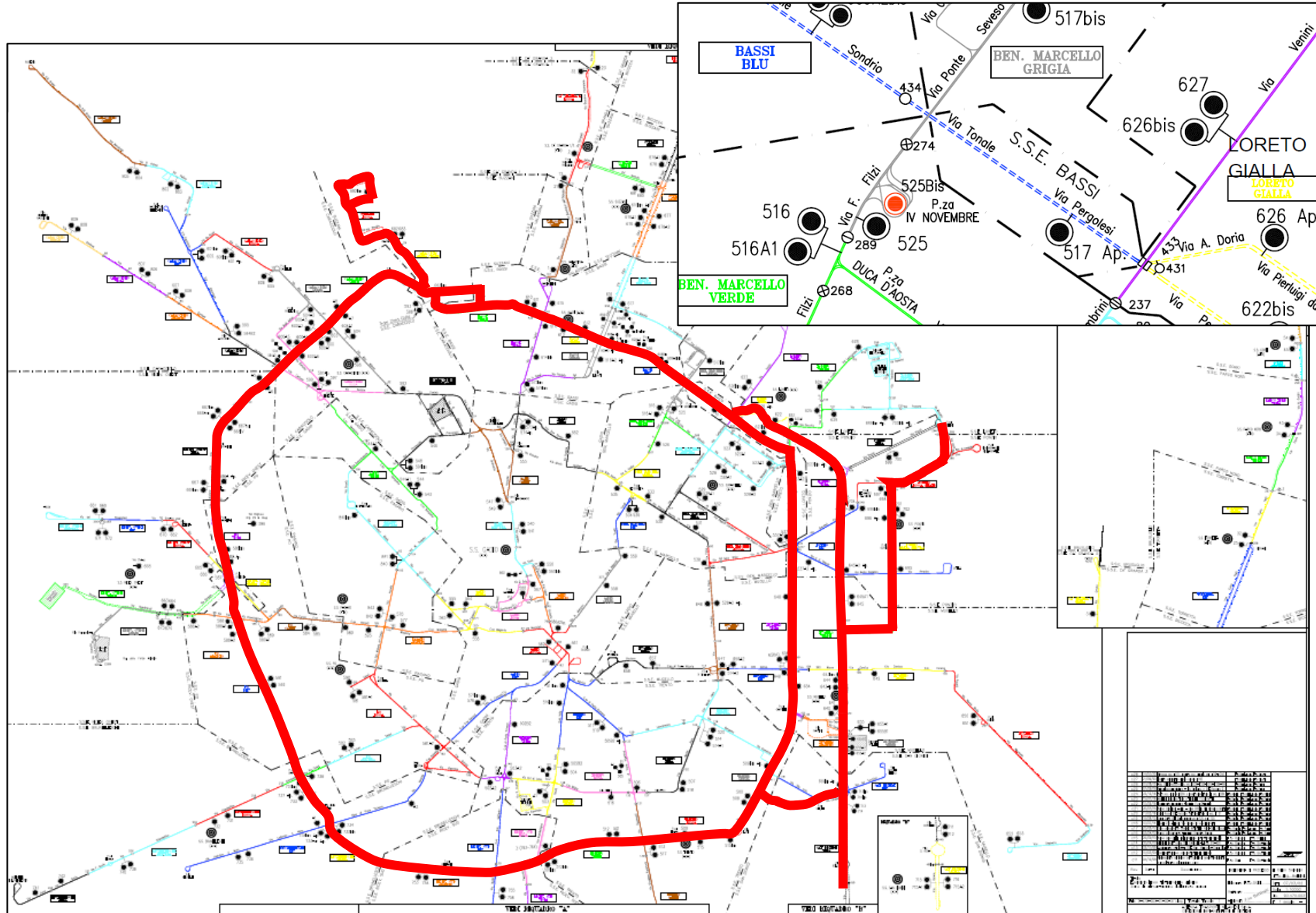


Milan's trolleybus and tramway system share the electricity power distribution network.

26 different substations: **12** of these managed directly by ATM from Operations Control Room (other 14 by Unareti).

The power supply system is designed in a flexible way, with the possibility of power redundancy and adaptability. In case of failure of the systems, or programmed needs, it is possible to carry out the reconfiguration of power supply system by de-energizing zones, merging different electrical zones.

ATM trolleybus network infrastructure



The trolleybus and tram overhead line network consists of a single mesh extending over the entire urban area of Milan, for a total length of approximately 360 km.

The height of the contact line from the street/rail level is nominally 5.60 m, with a minimum height of 4.80 m and a maximum height of 6.00 m.

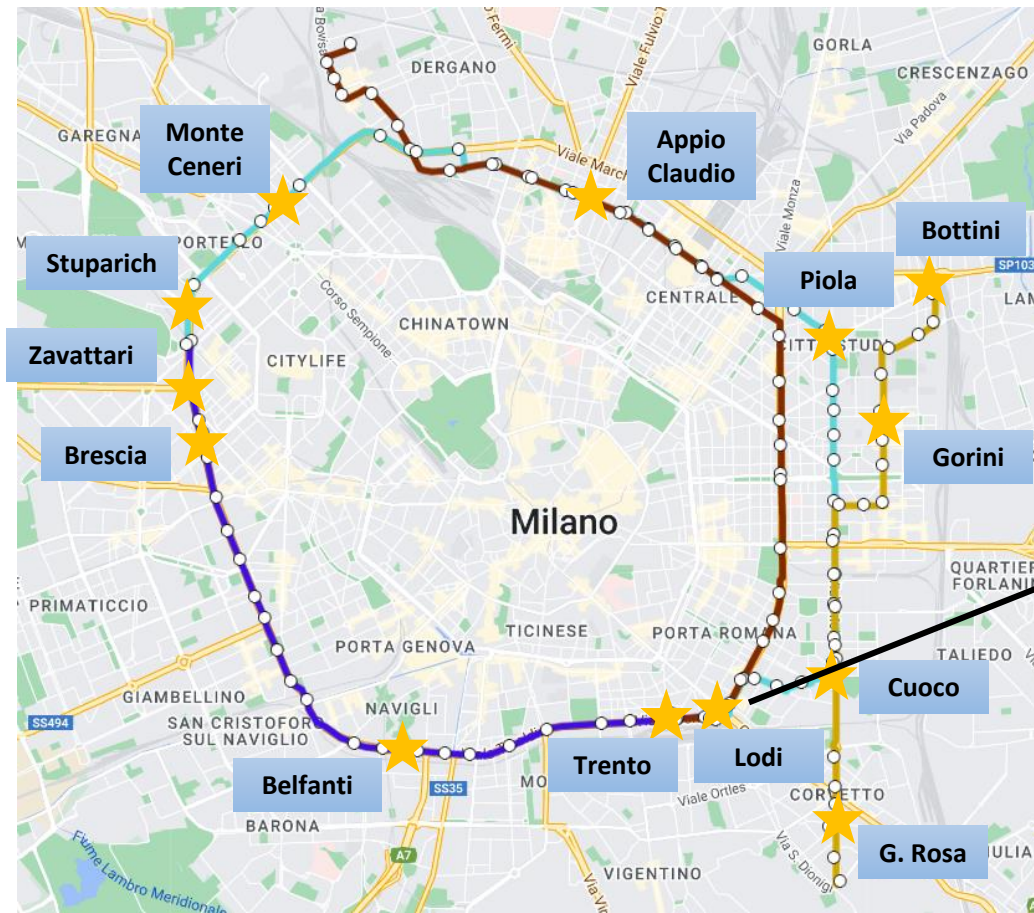
In a straight line the axis of the two-wire line is placed at a maximum of 3 - 4 m from the sidewalk.

ATM trolleybus network infrastructure



ATM trolleybus network infrastructure

Milan Trolleybus line is equipped with **turn around loops** that facilitate vehicle management by Control Room in case of emergency.



| LIN. | 90 | TAB | 1 | | | | LUNEDI VENERDI | INVERNALE | DPMOL | | | | | |
|--|-----------------------------|----------|--|------------|---------------|--------------------------------|------------------|-----------|-----------------------------|-------------|---------------|----------------------------------|-------------------------------|-------|
| CORSE | V.le_Isonzo P.le_Lodi_M3 | | V.le_Tibaldi Via_Meda | Romolo_M2 | P.za_Napoli | V.le_Bezzi P.za_Ghirlandino | | | V.le_Bodio P.le_Lugano | Via_Tonale | Staz_Centrale | V.le_Gran_Sasso P.le_Piola_M2 | V.le_Molise Via_Calvairate | CORSE |
| | arr. | partenza | | | | | P.le_Lotto_M1_M5 | | | | | | | |
| SULLA LINEA 91 (TAB. 190) | | | | | | | | | | | | | | |
| | V.le_Isonzo P.le_Lodi_M3 | | V.le_Molise Via_Calvairate V.le_Gran_Sasso | Via_Tonale | Staz_Centrale | Via_Bodio P.le_Lugano | P.le_Lotto_M1_M5 | | V.le_Bezzi Via_Trivulzio | P.za_Napoli | Romolo_M2 | V.le_Tibaldi Via_Meda | | |
| 1 | 08 | 5 10 | 18 28 | 37 | 50 | 59 | 6 02 | | 09 | 15 | 20 | 24 | 2 | |
| 3 | 32 | 6 40 | 49 | 00 | 10 | 25 | 37 | 7 39 | 49 | 59 | 05 | 10 | 4 | |
| | 20 | 8 20 | | | | | | | | | | | | |
| FUORI SERVIZIO PER Viale Isonzo-Piazzale Lodi-Viale Isonzo | | | | | | | | | | | | | | |
| REGOLARE SULLA PROPRIA LINEA | | | | | | | | | | | | | | |
| 5 | 25 | 8 26 | 36 | 40 | 46 | 57 | 07 | 9 17 | 30 | 45 | 54 | 07 | 6 | |
| 7 | 18 | 10 25 | 35 | 39 | 45 | 53 | 01 | 11 04 | 17 | 31 | 40 | 53 | 8 | |
| 9 | 04 | 12 07 | 17 | 21 | 27 | 35 | 43 | 12 46 | 59 | 13 | 22 | 35 | 10 | |
| 11 | 46 | 13 49 | 59 | 03 | 09 | 17 | 25 | 14 28 | 41 | 55 | 04 | 17 | 12 | |
| 13 | 28 | 15 32 | 42 | 46 | 52 | 00 | 08 | 16 12 | 25 | 39 | 48 | 01 | 14 | |

Two types of relegation loops:

- Line loops:** normally used during the line service to reverse the direction of travel of the trolleybus;
- Service loops:** used in particular situations when, due to vehicular blockages the trolleybus is limited and its direction of travel reversed.

ATM trolleybus Fleet



FIAT 2472 VIBERTI, 500 Series



Bredabus 4001.18 F04, 200 Series



C.A.M. Busotto MAN, 300 Series



VAN HOOL AG 300 T, 700 Series

1959-1965

1992-1994

2000-2001

2008-2012

1983-1985

1992-1995

2005-2006

2020



SOCIMI 8820, 900 Series



SOCIMI F8843, 100 Series



Irisbus Cristalis ETB 18, 400 Series



Solaris Trollino, 800 Series

ATM trolleybus Fleet

1996: represents the year of decommissioning of the oldest vehicles in ATM fleet: FIAT 2472 VIBERTI



There is currently only **one** vehicle of the 500 series in the depot of Molise. The vehicle is not used for the public transport service, but is still kept in good condition.



The doors of ATM depots are often open to citizens who are more sensitive and curious about the world of transport. The '548' vehicle is exhibited so that the most enthusiasts can appreciate the restyling work done on its bodywork.

ATM trolleybus Fleet

| Type of vehicle | Length | Series | Original Number of vehicles | Current number of vehicles | Total number of decommissioned vehicles | Self-powered type | Autonomy |
|-----------------------------|--------|--------------------|-----------------------------|----------------------------|---|----------------------------|----------|
| SOCIMI 8820 | 12 m | 901-920 921-970 | 70 | 8 | 62 | Lead acid Batteries | 200 m |
| SOCIMI F8843 | 18 m | 100-132 | 33 | 18 | 15 | Nickel – Cadmium Batteries | 200 m |
| Bredabus 4001.18 F04 | 18 m | 200-232 | 33 | 14 | 19 | Tudor lead acid Batteries | 200 m |
| C.A.M Busotto MAN NGT 204 F | 18 m | 300-307 | 8 | 0 | 8 | Diesel engine | 80 km |
| Irisbus Cristalis ETB 18 | 18 m | 400-409 | 10 | 6 | 4 | Diesel engine | 70 km |
| Van Hool AG 300 T | 18 m | 700-744 | 45 | 45 | 0 | Diesel engine | 80 km |
| Solaris Trollino | 18 m | 800-840 | 30 | 39 | 0 | Lithium titanate Batteries | 15 km |

Older vehicles with less performing batteries have few meters of autonomy. In case of problems, the vehicle cannot continue the trip and must be replaced.

Vehicles with diesel engine can continue to drive autonomously for several kilometres. The rods can remain detached from the overhead line until the fuel runs out.

Objective: vehicles with innovative and high-performance recharging batteries. In this way the vehicle can continue autonomously and when the poles reconnect to the overhead line the batteries begin to recharge again in order to guarantee a certain level of autonomy.

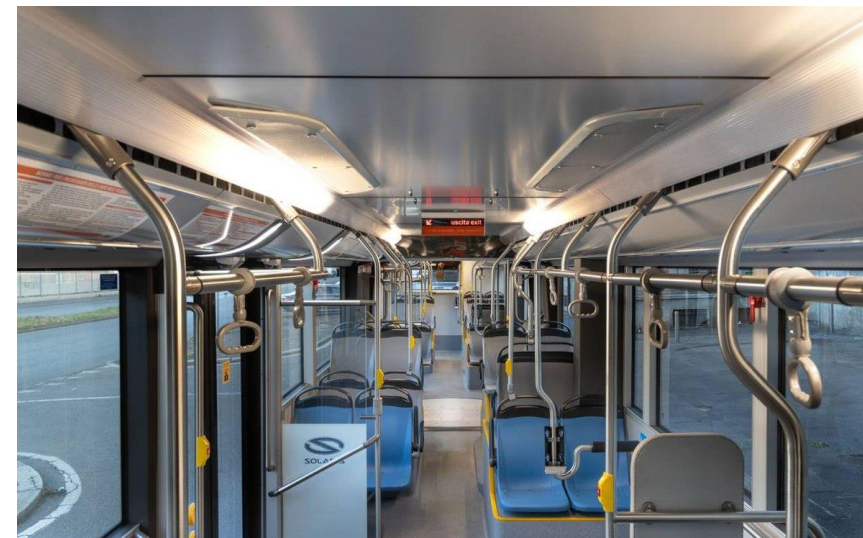
ATM future perspectives on trolleybus fleet

The future of trolleybus in ATM is represented by the introduction of the **IMC Trolleybus** into the fleet.



Differences respect to the classical bus:

1. **Source of energy:** external, coming from the overhead line;
2. **Autonomy:** potentially unlimited;
3. **Travel flexibility:** vehicle linked to the overhead line;
4. **Auditing authority:** ANSFISA.



Features of Solaris Trollino

| | |
|---------------------------|---|
| Length | 18 m |
| Width | 2.55 m |
| Height | 3.5 m |
| Total Seats | 31 |
| Total places | 136 (variable according to the presence of strollers and prams on the vehicle) |
| Air conditioning system | ✓ |
| Video surveillance system | ✓ |

ATM trolleybus fleet: potential

Trolleybuses' autonomy allows easier handling of situations where vehicles cannot run with the poles connected to the overhead line network. Some examples of possible disruptions are:

ORDINARY EVENTS: approximately **30 per day** routinely managed by Surface Control Room (*line blockages, accidents, vehicles failures, demonstrations or sick passengers...*)

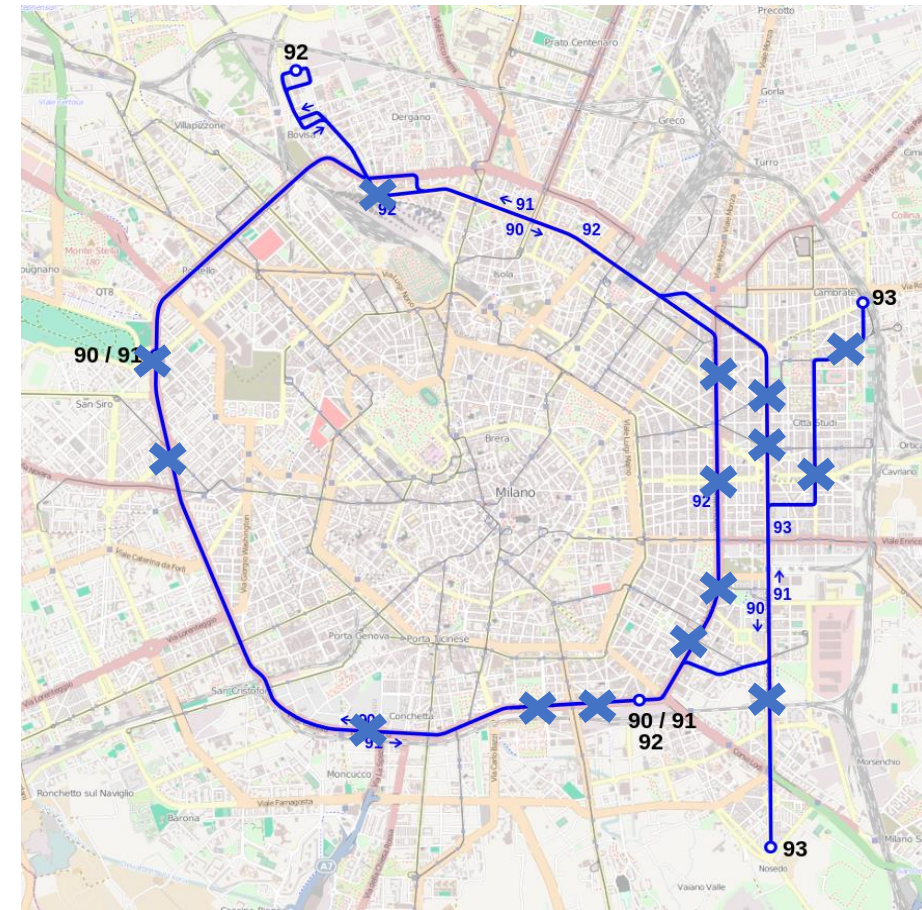
EXTRAORDINARY EVENTS: infrequent events that require the adoption of specific emergency measures.



ATM trolleybus fleet: potential

Extraordinary events, an example: Storm of 25 July 2023

- **Trolleybus lines** affected by infrastructural damage following the storm: line 90, 91, 92, 93.
- Exit and return routes to the Novara **depot**.



✕ Trolleybus Network breakpoints

ATM trolleybus fleet: potential

Extraordinary events, an example: Storm of 25 July 2023



ATM trolleybus fleet: potential

Extraordinary events, an example: Storm of 25 July 2023

Initial priorities in emergency management:

- Recovery of the usability of the routes of exit and return of isolated depots
- Recovery of axes and primary joints
- Recovery of blocked vehicles (trams and trolleybuses)

HOW?

Through the coordination by the Surface Operation Room of different teams operating directly on field and in the Municipal Operation Centre.



Operation External Control



Customer Service Team



Maintenance vehicle Team



Maintenance Infrastructure Team



Security Team and Police



ATM trolleybus fleet: potential

Two-wire gear with battery recharge

Batteries Converter

Engine



3 LTO battery packs on the vehicle

Runs on battery power

Batteries Converter

Engine

Autonomous running phase: the engines and auxiliaries are powered directly by the energy taken from the batteries.



Easier vehicle management by the Control Room in case of emergency

IMC Trolleybuses are equipped with an intelligent charging system called **IMC** (*In Motion Charging*). The batteries are mainly recharged when the poles of the vehicle are attached to the overhead line network or during the regenerative braking.



Braking phase

Batteries Converter

Engine

Regenerative braking: the electric motors act as generators that produce energy and recharge the batteries for the next phase of autonomous driving.

In case of emergency it is possible to drive the vehicle autonomously for approximately 15 km. These kilometers of autonomy are potentially infinite, since when the vehicle is reconnected to the aerial network the batteries are recharged.

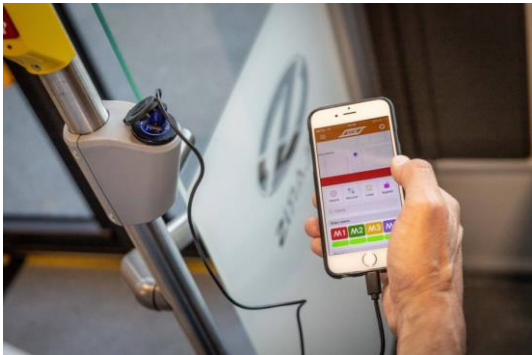
This is not possible with old generation trolleybuses since they do not use rechargeable batteries but the combustion engine.

ATM future developments on trolleybus fleet

The ATM growth plan envisages a transformation of trolley bus fleet by **2025**.

ATM goals reached during 2022:

1. Introduction in the trolleybus fleet of **6** new Solaris Trollino starting from December 2022;
2. Start of the **testing phase** of the first Trollino of the series to obtain the approval for the public transport service by the supervisory authority (ANSFISA);
3. Start of the **general revision** phase of Van Hool series (after 100.000 km).



ATM goals between 2023 and 2024:

1. Progressive addition of **3** Solaris Trollino **per month** in the fleet (fully operational);
2. Proceed with the gradual **replacement** of the old trolleybus of the series.



ATM goals by 2025:

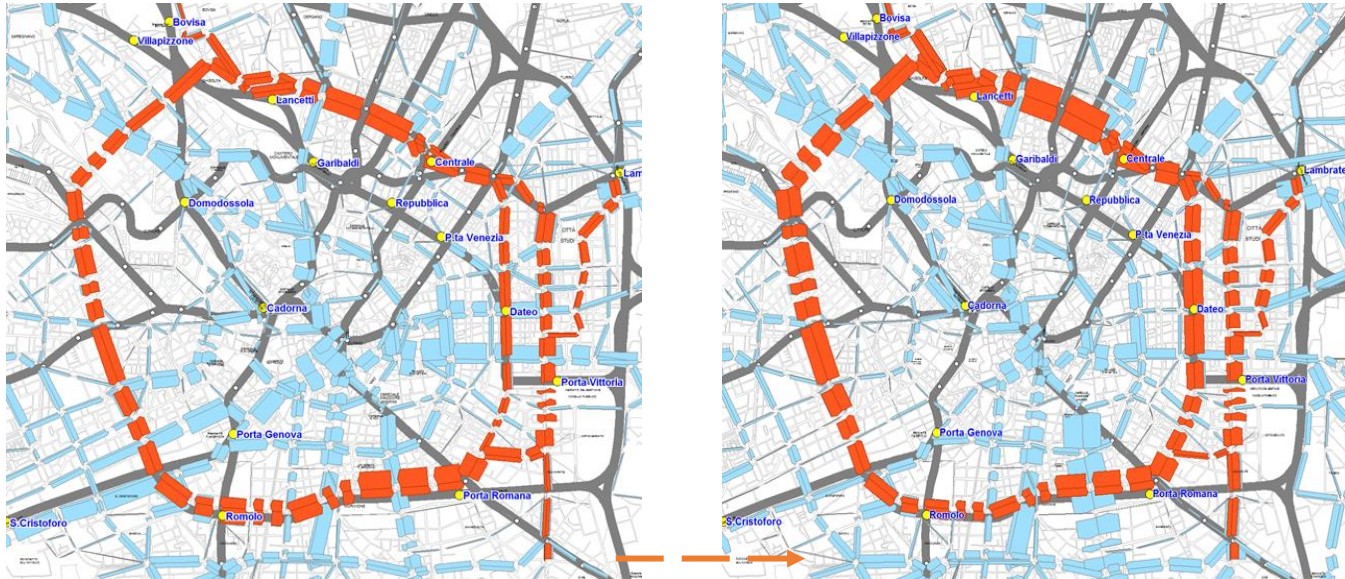
1. Fleet of 141 trolleybus splitted between the two depots of Molise and Novara;
2. Fleet composed in this way:
 - Irisbus Cristalis ETB 18 (6 vehicles);
 - Van Hool AG300 T (45 vehicles);
 - Solaris Trollino (90 vehicles)



- Trolleybus lines new routes
- Traffic light Assistance
- Autonomous driving
- Fast track
- Renovation of Novara Depot
- Tram – Trolleybus Interchange

Future developments

- **Trolleybus lines new routes**
- Traffic light Assistance
- Autonomous driving
- Fast track
- Renovation of Novara Depot
- Tram – Trolleybus Interchange



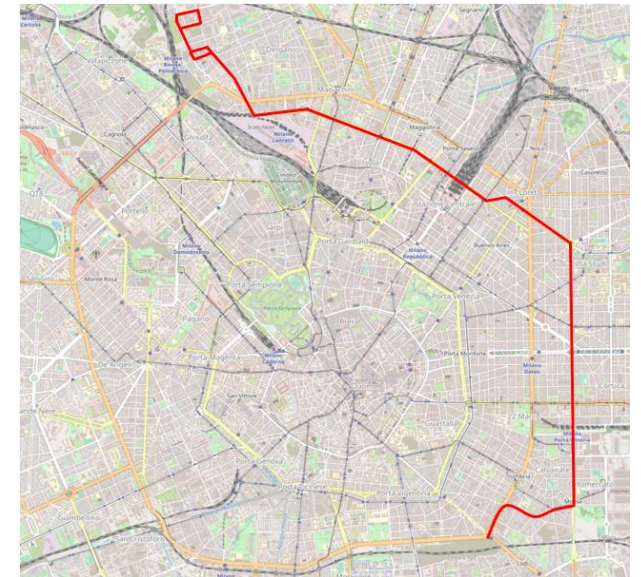
Passengers flows are changing over the years: we are facing a variation of the distribution from the one depicted in the image on the left to the one depicted on the right.

Therefore, a **new configuration** of the **routes** of 3 trolleybus lines on the eastern axis of the city has been designed: lines 90/91 will move along the inner circular ring, while 92 on the outer ring.

passengers flows



Lines 90 and 91

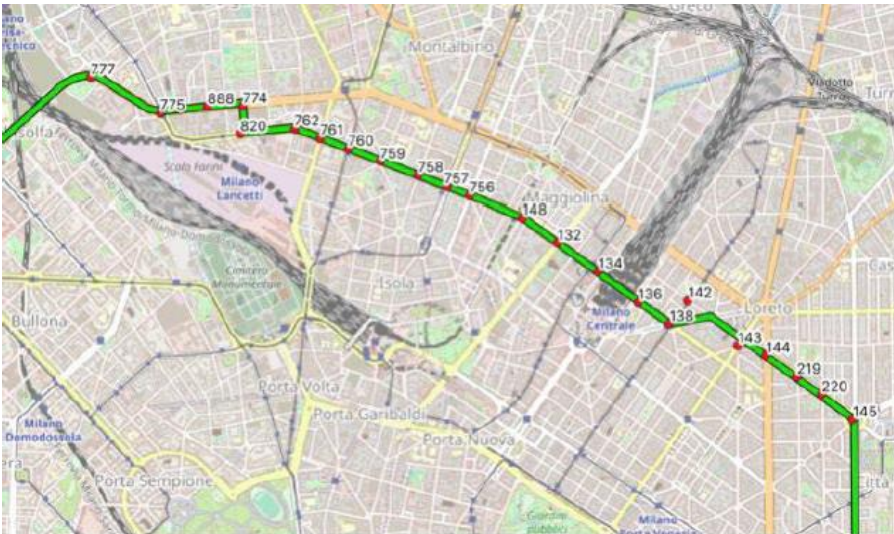


Line 92



Future developments

- Trolleybus lines new routes
- **Traffic light Assistance**
- Autonomous driving
- Fast track
- Renovation of Novara Depot
- Tram – Trolleybus Interchange



Tests for traffic light assistance are currently underway in 23 intersections in Milan.

On - vehicle data:

GPS



Traffic light:

Position

Traffic light phases

Time to red (TTR)

Time to green (TTG)



Map:

Route

Speed limit



Localization



Calculation of the optimal speed



Advantages:

- Increased road safety (warning to the driver of a red light);
- Reduction of stop and go conditions and therefore of consumptions;
- Increased passengers comfort;
- Travel time optimization;
- Optimization of traffic light control systems.



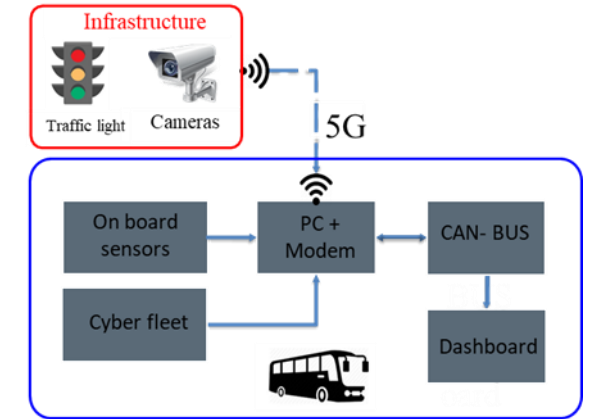
Optimal speed indication at intersections

Future developments



- Trolleybus lines new routes
- Traffic light Assistance
- **Autonomous driving**
- Fast track
- Renovation of Novara Depot
- Tram – Trolleybus Interchange

Start of the tests between ATM and Politecnico of Milan of the **Tech bus project** on the trolleybus (800 series) of 90-91 lines.



On-board sensors for vehicle-to-infrastructure communication (V2I)



First phase

Goal: Assisted guidance in managing traffic light and intersections to improve regularity and frequency of vehicles.

Second phase

Goal: Improve the reliability of the information flow given to the driver from systems and sensors on-board and on the ground .

Third phase

Goal: Create a complex system of sensors in communication with each other that transform the road infrastructure and vehicle into a traffic control center, that leads to autonomous vehicle driving.

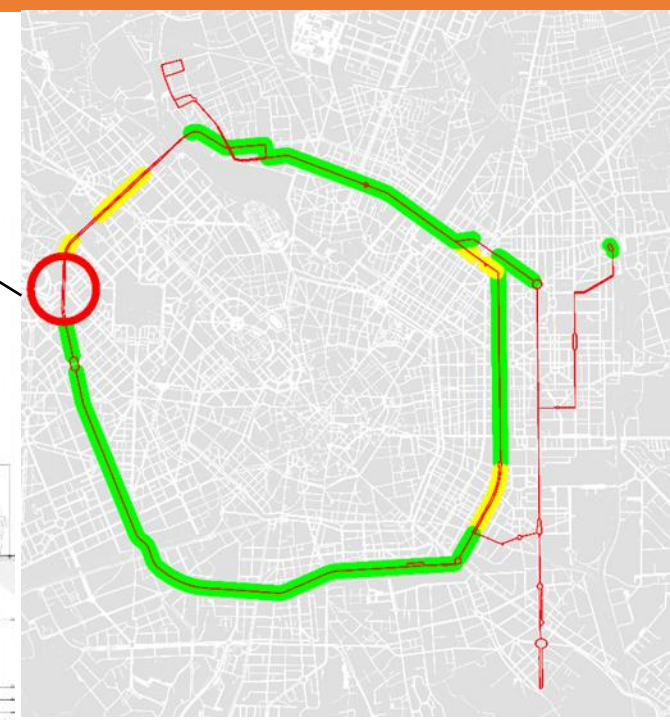
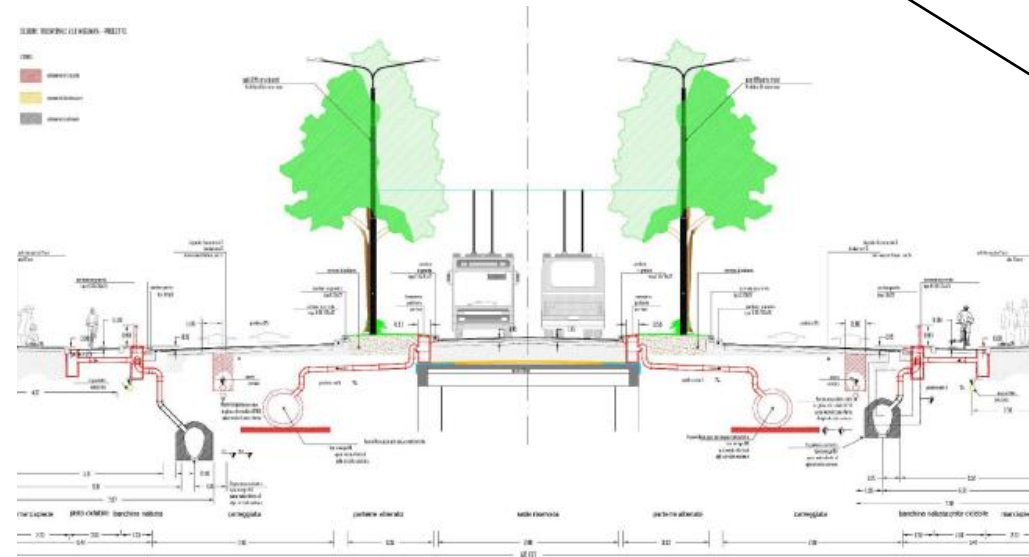
Advantages:

- Traffic light priority;
- Improved intersection management;
- More information to drivers about traffic conditions;
- Increased control of stops.

Future developments

- Trolleybus lines new routes
- Traffic light Assistance
- Autonomous driving
- **Fast track**
- Renovation of Novara Depot
- Tram – Trolleybus Interchange

It is planned to transform the section of trolleybus network between Zavattari and Stuparich.



Legend

- Promiscuous lane
- Protected lane
- Reserved lane

Advantages:

- Lower travel time and increased commercial speed;
- Urban requalification of city areas with increased green areas;
- Improved driving conditions;
- Improved road safety conditions for weak road users (cyclists and pedestrians).

Future developments

- Trolleybus lines new routes
- Traffic light Assistance
- Fast track
- Autonomous driving
- **Renovation of Novara Depot**
- Tram – Trolleybus Interchange



Novara depot, built in 1959, is a mixed depot where both trolleybuses and buses are stored.

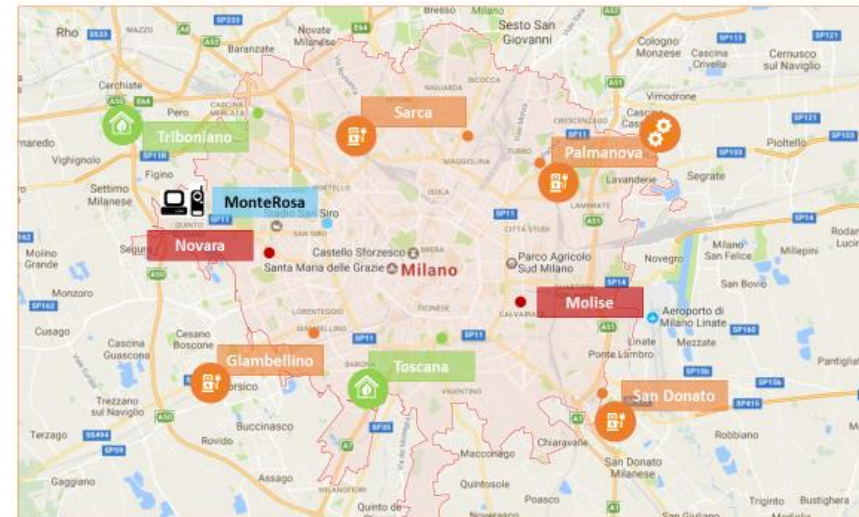


Some features of the depot:

- The only bus depot with fully indoor storage;
- Separate areas for bus and trolleybus storage.

As a part of the ATM Full electric project, a complete renovation of the depot is planned for the future, for the installation of the electric bus charging stations.

Here some examples from depots already revamped.



6 depots completely revamped

2 new depots

1200 electrical vehicles

Full electric fleet by 2031

Future developments

There are 4 parts of the network where the route of the trolleybus line runs along the route of the tramway line.

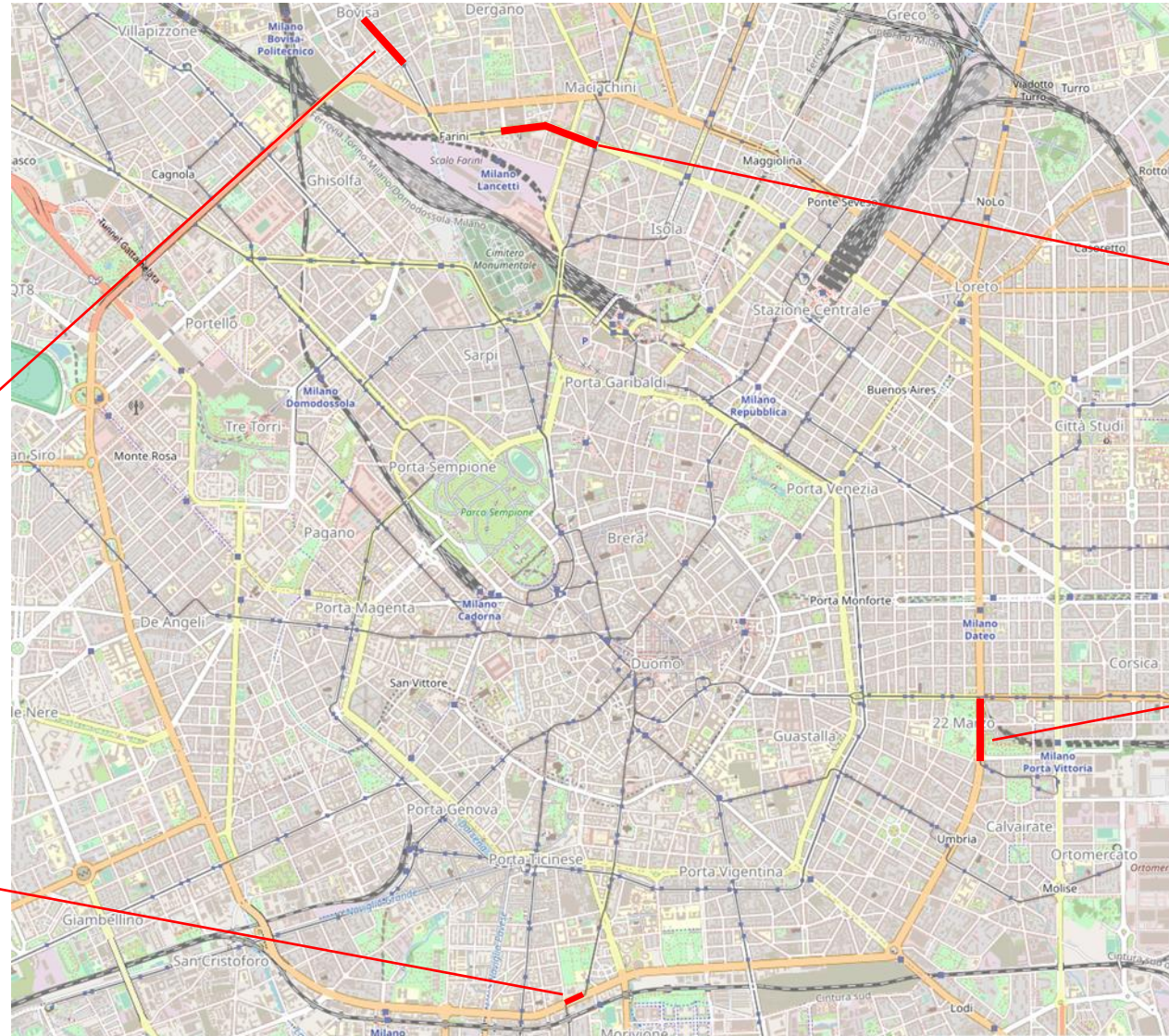
- Trolleybus lines new routes
- Traffic light Assistance
- Autonomous driving
- Fast track
- Renovation of Novara Depot
- **Tram – Trolleybus Interchange**



Line 92 (Trolley) and 2 (Tram) – Bausan



Line 90- 91 (Trolley) and 15 (Tram) – Viale Tibaldi



Line 90- 91-92 (Trolley) and 2 (Tram) – Viale Stelvio and Lancetti



Line 92 (Trolley) and 27 (Tram) – Viale Umbria

Trolley90 & its sustainable future



The ATM Milano trolleybus system: features and future developments

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