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## Living and Walking in Cities

New challenges for sustainable urban mobility

This Special Issue intended to wonder about the new challenges for sustainable urban mobility, aligning with the European Sustainable & Smart Mobility Strategy. Contributions come from selected papers of the XXVI International Conference "Living and Walking in Cities" and have been collected around two main topics: the relationship between transport systems and pedestrian mobility and the transformative potential of temporary urban changes. Reflections and suggestions elaborated underline a collective great leap forward to reshaping urban mobility paradigms.

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# TeMA

Journal of  
Land Use, Mobility and Environment

*Special Issue 3.2024*

## Living and walking in cities: new challenges for sustainable urban mobility

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Cover photo: Herrengasse street in Graz (Austria), baroque pedestrian avenue and centre of public life, provided by Michela Tiboni (June, 2024)

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*Special Issue 3.2024*

## Living and walking in cities: new challenges for sustainable urban mobility

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## Urban and transport planning integration. A case study in a mid-size city in Italy

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### Abstract

Integrating urban and transport planning requires a well-defined approach structured across various planning and strategic levels. This emphasizes the necessity to explore the matter within the frameworks of territorial government processes. The paper aims to address the issue by examining the case of the city of Brescia, Lombardy, a mid-size city which is pioneer in Italy in the development of innovative transport systems. Brescia is equipped with a metro line and is on the final stages of in the design of the new tram line "T2 Pendolina-Fiera". The paper is developed as follow: (1) significance of the integration between urban and transport planning; (2) narration of precedents where Brescia has been at the forefront in this domain; (3) reconstruction of administrative steps that led to the design of the tram; (4) assessment of the role of the new tram line in the urban context; (5) final considerations. The research verified that it was possible for a medium size Italian city to apply the desired integrated approach, as well as the effectiveness of the local planning tool in Lombardy region (the PGT) to hold together strategic and design layers to target such goal.

### Keywords

Urban planning; Transport planning; Public transport stop; Mid-size city; Tram.

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## 1. Integration of urban and transportation planning for sustainable cities

### 1.1 The crucial role of public transportation stops

The integration of transport and urban planning has long been recognized as crucial for sustainable development (Bertolini et al., 2005). Achieving climate neutrality objectives through strategies focused on mobility in urban areas is an emerging topic in the international debate (Pezzagno & Richiedei, 2022). Such awareness has been simultaneously accompanied, in the field of transportation, from a progressive focus shift from mobility planning to accessibility planning (Handy, 2002). This transition reflects the acknowledgment that the ultimate goal of transportation systems is not merely to facilitate movement but to ensure access for individuals (Handy, 2020), as much that accessibility concept has taken the place of mobility in the contemporary literature (for a review see Guida & Caglioni, 2020). This new paradigm emerged as contemporary cities face challenges such as rising motorization and urban sprawl (Cervero, 2001). The surge in the demand for (especially private motorized) mobility can be attributed to changes in habits which have led, as a result, to changes in the temporal organization of human activities and consequently, to changes in transportation behaviour. Many authors recognize time barriers as barriers to accessing public transportation and thus their use (see for example Ahsan et al., 2023; Curl, 2013; Ollson et al., 2021). In fact, nowadays it's very common to organize personal days through a multi-purpose trip, such as accompanying a child to school before heading to work. This topic is particularly relevant in Italy, where an increase in demand for mobility is observable despite a demographic decline (ISFORT, 2021).

Careful integration of urban and transport planning is essential to minimise car dependency and rationalise travel. A critical aspect of this integration is the location and design of public transport stops, which is shared by both disciplines. The stop is a crucial element of a transport network, being the interface between the user and the transport system (Maternini & Foini, 2009), but it is also an element of public space (Vitale Brovarone, 2021). Moreover, the location of a public transport stop is a decision that involves very relevant urban planning issues, such as the structure of the settlement and the location of attractor poles (Tira, 2011). Its correct insertion in the urban context can have positive effects both in terms of transport and urban planning, establishing a direct correlation between public transport accessibility and public transport attractiveness (Guglielmetti Mugion et al., 2018). In order to increase attractiveness, accessibility must be geared towards as many modes of transport as possible, with particular attention to vulnerable users such as children and the elderly (Tiboni & Rossetti, 2012). To make this possible, the public space must be appropriately redesigned, subtracting the space dedicated to private cars (Boglietti & Tiboni, 2022). The urban regeneration processes that take place in places already served by public transport must also aim to improve the walkability of the area (Carra et al., 2022). Designing a public transport system to reduce car dependency in cities requires consideration of both transport and urban planning factors. This integrated approach not only benefits transport efficiency, but also addresses urban planning concerns (Spadaro et al., 2023). Research shows a link between public transport accessibility and social inclusion, highlighting the importance of this integration in promoting an equitable urban environment (Mackett & Thoreau, 2015).

### 1.2 Three approaches to the integration of urban and transportation planning

Tira and Lombardi (2009) outline three approaches by which this integration can take place: by optimizing existing routes; by creating new routes; and by developing neighborhoods based on Transit Oriented Development (TOD) principles. In all three approaches, the stop is a crucial topic. In the first case, the issue is the rethinking of existing stops, in relation to their context. In the second case, it is important to locate the stops in the most appropriate places. In the third case, the design of the stop is inseparable by the design of the neighborhood that will be built around and will use it. The aim of this paper is to understand whether this integrated approach has been successfully applied in the Municipality of Brescia, a city of

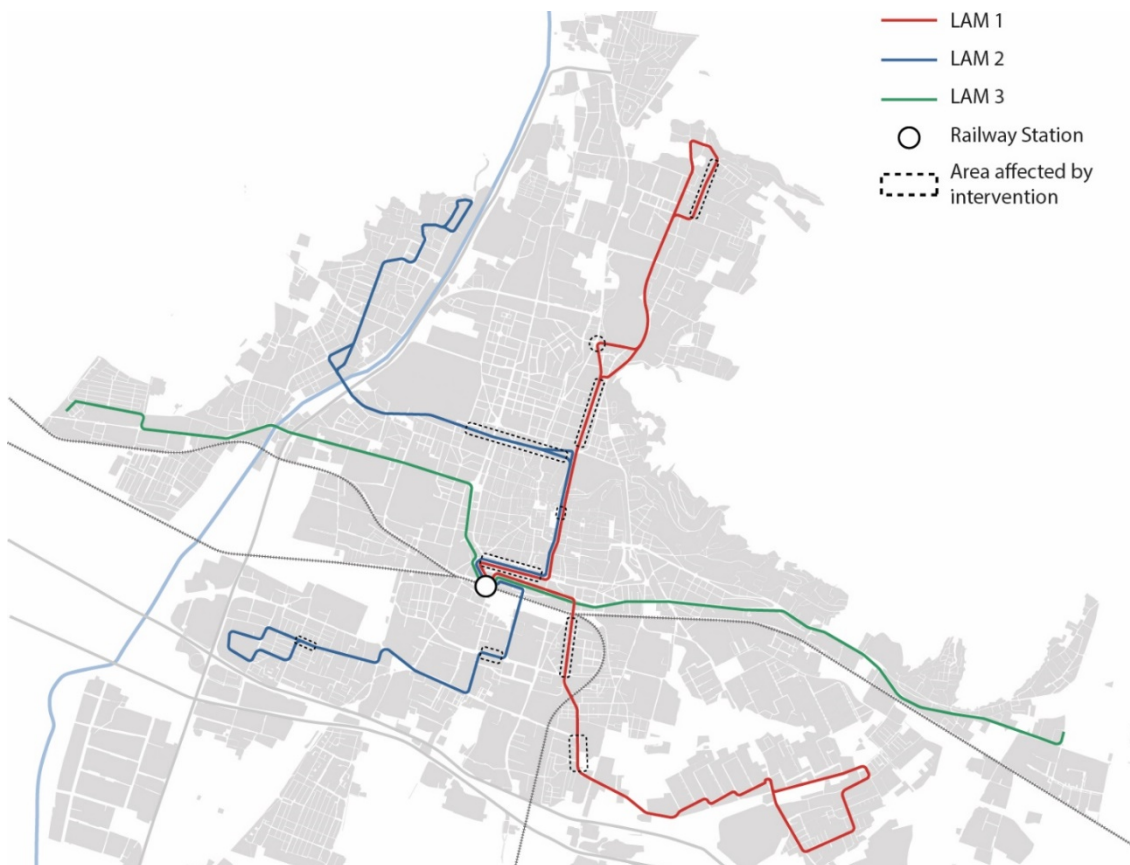


198,617 inhabitants (DEMO.ISTAT, 2023) in Lombardy Region, Italy. According to the different quantitative criteria of the Union of Italian Municipalities (Tortorella, 2008), the European Union (OECD, 2022) and the OECD (OECD, 2012 & 2024), Brescia is considered a medium-sized city. In the Italian context, Brescia is recognized as a best practice in various public service sectors including urban waste management (Di Vita, 2020) and public transport, boasting the fourth highest public transport capacity among Italian cities (Euromobility, 2023). Brescia has indeed implemented significant transport projects over recent years, including the high mobility bus line "LAM" in 2004, the development of the Sanpolino TOD district in 2008, and the opening of an automatic light metro line in 2013. Additionally, a new tram line project (known as "T2") is currently in the final design phase. These projects align with the three approaches outlined by Tira and Lombardi. The research employs both qualitative and quantitative methodologies, involving narrative analysis of project histories and GIS-based evaluation of existing and future transport routes in relation to the urban context. Data for the first research were sourced from documentation available on the website of the Municipality of Brescia and local publications, while data for the second research has been obtained from the Lombardy Region Geoportal and ISTAT websites.

## 2. Three transport projects in Brescia: a critical review

### 2.1 Optimization of existing lines: the High Mobility Line "LAM" 1

An example of the optimization of existing lines in Brescia is the High Mobility Lines (LAM, Linee ad Alta Mobilità) project, which combined the upgrading of important urban areas with a radical renovation of the public transport system. Launched in Brescia in the late 1990s and early 2000s, the LAM project involved the transformation of three local public transport lines (D, E, G) (Belotti & Baldoli, 1999) into three main lines (renamed 1, 2, 3), which formed the backbone of Brescia's public road transport network (Fig.1).



**Fig.1 The three LAM lines originally planned in Brescia**

The project aimed to distinguish these three lines from other bus routes, both in terms of transport performance and in terms of urban design. From a transport perspective, the LAM lines were characterized by the use of spacious 18-metre buses, as opposed to the standard 12-metre buses, and by high frequencies up to 12 vehicles per hour. In terms of urban design, the streets served by the LAM routes were slated for specific public space reorganization. These interventions, which lasted between 2004 and 2008, did not only concern aspects strictly related to the vehicle's mobility such as the creation of bus dedicated lanes, but they also concerned the redevelopment of public space with new flooring and street furniture. The last aspect was perhaps the most relevant. The use, along the roads crossed by LAM buses, of street furniture elements with a coordinated design, guaranteed visibility and recognition of the lines themselves. For this reason, the design of the public spaces crossed by the Lam and all the waiting shelters was entrusted to the Italo Rota and Partner studio. However, the implementation of the project entailed many critical issues, referred first to the flooring, which was considered noisy and continually being restored (ANCE Brescia, 2004).



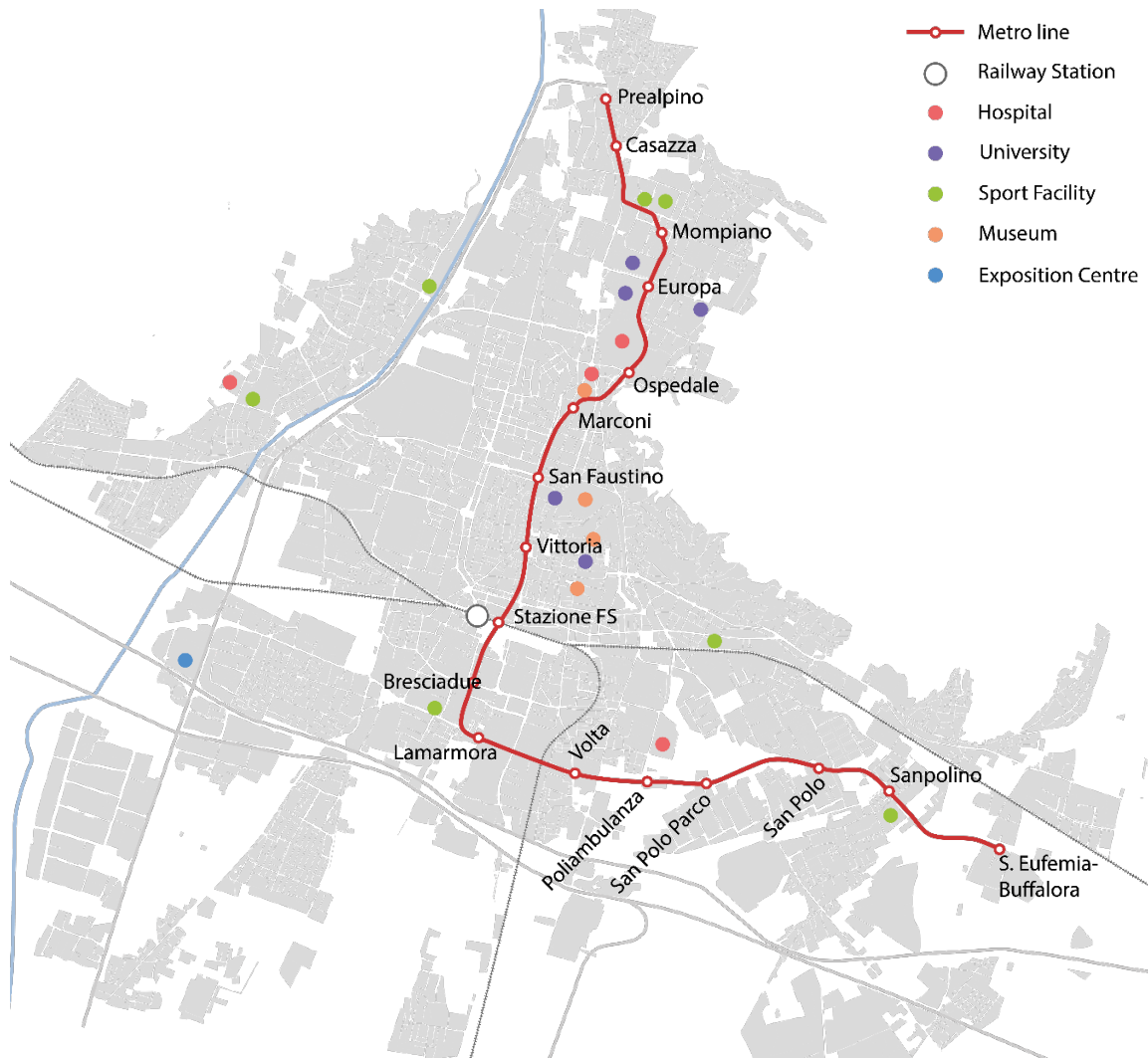
**Fig.2 A LAM stop in Cremona Street**

Eventually, a change in the political administration in 2008 led to the abandonment of the project: at that point ten public spaces were redeveloped, along the routes of the lines 1 and 2, but only the first line was

activated with the transport standards initially requested. Line 2 effectively remained a normal bus line, as did line 3. Nevertheless, the projects had positive effects, even if partial, both in terms of transport and urban design aspects. On the one hand, between 2002 and 2008 there was a 37% increase in local public transport users (Comune di Brescia, 2018c, p. 24). On the other hand, contexts previously characterized by a poor public environment such as Crocifissa di Rosa Street and Cremona Street have been redesigned (Fig.2). The last chapter of the LAM story definitively occurred in March 2013: with the opening of the new metro line, which partly overlapped the route of LAM 1, that line was finally abolished (Galesi, 2013).

## 2.2 Creation of a new line: the automatic light metro

The automatic light metro line constitutes the second example in this brief overview. The placement of stops, a pivotal aspect as previously mentioned (section 1.1), assumes an even more significant role when dealing with the construction of a substantial infrastructure like a metro line. The history of the Brescia metro project is intricately tied to the positioning of its stops and urban planning decisions made by the municipal administration since the early 20th century.



**Fig.3 The metro line of Brescia in relationship with the majors' urban polarities**

The concept of introducing an underground metro line to the city took shape in 1985, envisioning the creation of an automatic shuttle to connect the then-under-construction Brescia Due business centre with the railway station and the historic centre (Zanirato, 2010). Over the subsequent two years, this concept underwent further development, progressively extending the route to encompass key destinations across the

city. To the north of the historic centre, the route was extended to include significant sites such as the main city hospital, the university, and the football stadium. South of the Brescia Due district, it was extended to densely populated neighbourhoods like Lamarmora and Volta, along with the large public housing district of San Polo. Following the completion of this design phase, the initial shuttle evolved into an automatic light metro. It resulted a 13-kilometer line connecting nearly all major urban attractions (Fig.3), inaugurated in 2013 after works that lasted ten years ("La nuova metropolitana di Brescia", 2013).

The design of the metro was therefore supported by two considerations linked to urban planning domain. The first is the optimal localization of the main attractor poles, arranged along a single route which has made it possible to connect (almost) all of them with a single rapid mass transit line. The second is the design of the Brescia Due business centre, which gave the first impetus to the metro project. Such aspects are linked to morphological factors of the city of Brescia which have influenced its urban planning choices (Fusi, 2023). The expansion of Brescia was in fact limited by the presence of Mount Maddalena to the east, the Cidneo hill to the north, and starting from the 19th century by the railway to the south. For millennia, the city gradually developed along the east-west direction, along the ancient road that connects Milan with Verona. A series of urban planning decision then shifted the developing axis to the north-south orientation: the opening of the tunnel under Cidneo hill and the viaduct over the railway opened the possibility of developing the plains located to the north and the south. This met the need of new large urban facilities, such as the hospital and the stadium, that has been located north of the Cidneo hill, driving a further development of the area. The area south of the railway was instead designated, starting from the 1961 PRG, to host the city's new business district: a new centre opposed to the old one, beyond the railway, to decongest the historic city. Idea then developed between the 80s and 90s through specific masterplans<sup>1</sup>. However, the modernist idea of a new city separated from the old city soon clashed with the need to make it easily accessible with the railway station and with that same historic centre, which was considered obsolete. The integration of urban and transport planning criteria is evident when examining the placement of the Brescia metro stops. Several stops are strategically positioned to effectively serve the mentioned urban polarities. For instance, the Ospedale station is precisely situated in front of the main entrance of the city's largest hospital, while the Europa station is in proximity to the university. On the other hand, stops serving purely residential areas are strategically located at pre-existing communal spaces. This is the case of the Mompiano station in Kossuth Square, the life centre of the working class Villaggio Valotti district. Further examples include the San Polo and San Polo Parco stations, located near two multifunctional centres in the San Polo neighbourhood. Thus, the metro stops not only fulfil the purpose of serving certain functions or populations but contribute to reinforcing already established meeting and service points.

### 2.3 Transit Oriented Development: the Sanpolino neighbourhood

A TOD is "mixed-use community that encourages people to live near transit services" (Still, 2002, as cited in Carlton, 2009, p. 1). This approach has experienced a flourishing period, especially in the post-war period and since the 1990s (Papa & Bertolini, 2015). It has been applied mainly in large metropolitan areas in Europe and North America (Tira & Lombardi, 2009), but also in low- and middle-income countries (World Bank Group, 2021). In the context of Brescia, the district that comes closest to the principles of Transit Oriented Development is the Sanpolino district, located in the south-eastern periphery of the city: a district that, at the end of the 1990s, was involved in two different projects, the metro line and a new public residential district. The metro line was to end near the S. Eufemia locality, while the new district, Sanpolino,

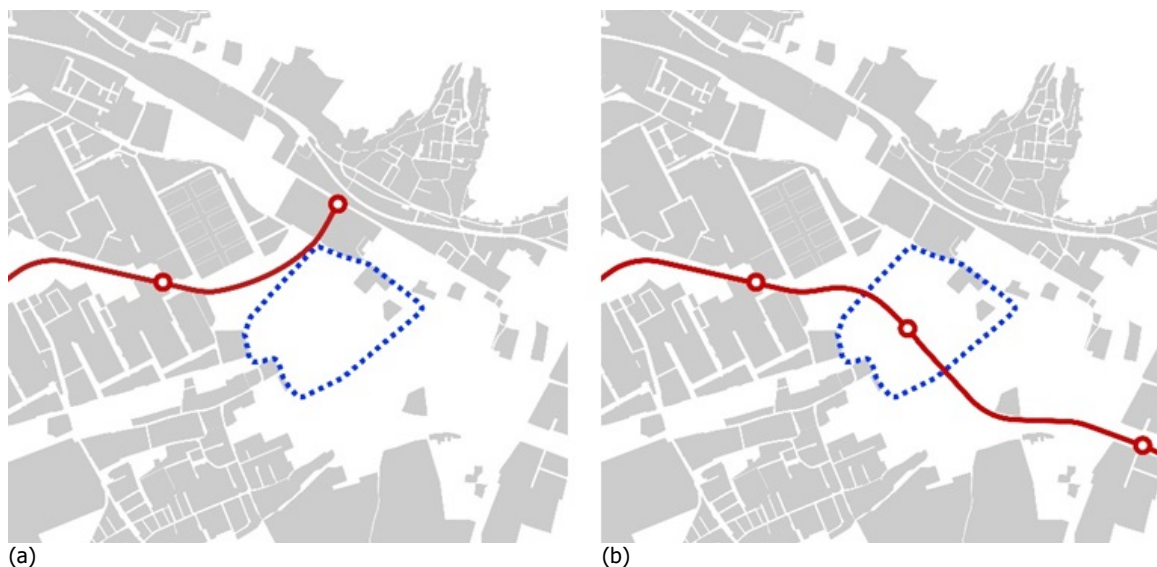
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<sup>1</sup> Specifically, Brescia Due has been developed through a *Piano Particolareggiato*, a planning tool provided by Italian urban planning law to implement large private urban interventions with public input and coordination.



was designed by the urban planner Bernardo Secchi on behalf of the city council. The district was conceived as a PEEP<sup>2</sup> area to extend the large San Polo public housing estate.

While the metro project received the first state's funds in 1995, the first Sanpolino masterplan was approved in 1998. The destiny of the two project intersects in 2000: on one hand, the environmental impact assessment prescribes to move the metro depot further east. On the other hand, the Sanpolino masterplan had to be modified to meet prescription by Lombardy region who asked to increase the density. Consequently, the development of the neighbourhood paralleled the development of the metro, producing a commendable example of Transport Oriented Development (Tiboni & Rossetti, 2013). The entire neighbourhood falls within a 600-metre radius from the metro stop, devoid of functions necessitating exclusive car access. The area with the highest population density is positioned in close proximity to the station, fostering numerous neighbourhood activities and forming a genuine hub of community life. According to a survey conducted by Brescia Mobilità in 2015, the Sanpolino station is more used than the two stations located in the much bigger and populated San Polo neighbourhood (Comune di Brescia, 2018a). However, the Sanpolino overall density is not comparable to that of TOD applications found in large North American cities (Tiboni & Rossetti, 2013). In addition, the district remained partly unfinished, with some areas originally planned that were never developed, and despite being more used by others, the metro stop remains one of the less used of the entire line, ranking only in thirteenth place. To tackle these challenges, the 2016 PGT envisioned the implementation of new city-scale services and facilities in the Sanpolino area (Comune di Brescia, 2016, p. 97). This prediction materialized with the construction of an athletics track and a gym for indoor artistic gymnastics in the undeveloped areas. The objective of these interventions is to introduce city-scale functions, leveraging the accessibility facilitated by the metro station, and infusing vitality into the neighbourhood.



**Fig.4 (a) The original metro project. (b) The definitive metro project. Sanpolino's boundaries are marked by the blue dotted line**

### 3. The return of the tram in the Brescia's streets

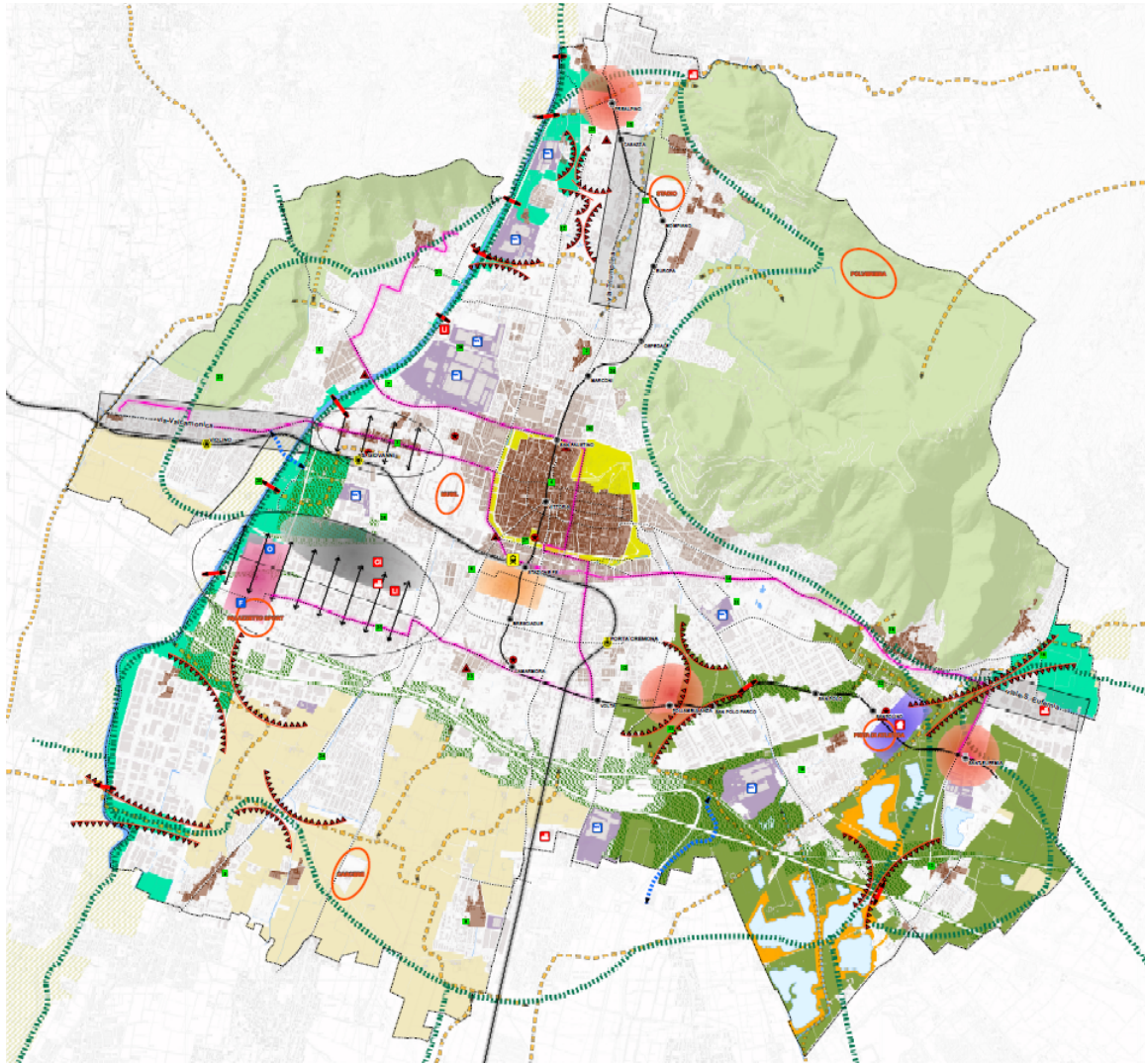
#### 3.1 Setting the strategy: the 2016 Territorial Government Plan (PGT)

Over the past two decades, the city of Brescia has experimented with three different approaches to integrating transport and urban planning. The LAM project involved rethinking public spaces, while the light

<sup>2</sup> *Piano per l'Edilizia Economica e Popolare*, a planning tool provided by Italian urban planning law to develop public housing districts.



metro line route is the result of decades of urban planning decisions. The Sanpolino TOD, on the other hand, is the result of merging two independent public projects. Nevertheless, a more comprehensive coordination was achieved in 2013 and 2014, when the new PGT (8 October 2013) and SUMP (16 December 2014) were formally launched. The PGT (Piano di Governo del Territorio, or Territorial Government Plan) is the instrument that defines the policies and regulations for land use and development in a given municipality in the Lombardy region.



**Fig.5 The Document Plan (Documento di Piano) of the Brescia 2016 PGT, which constitute the strategic element of the PGT. The lines of force are the two in purple**

With the aim of improving the quality of life in Brescia (Comune di Brescia, 2016), a general variant of the PGT was approved in 2016. The three strategic pillars that support this intention are "starting from the unbuilt" (protection of non-urbanised areas), "renewing and redeveloping the already urbanised territory" (renewal of the already urbanised territory) and "accessibility as a strategy for a friendly city" (offering competitive public transport). These pillars are linked throughout by the theme of sustainability. Based on these three themes, the PGT presents a series of actions included in the document plan (Fig.5), one of which is the designation of two "lines of force" for public transport to cover the regions not served by the metro:

*"The new overall network will have to represent a rapid, direct and efficient system, which identifies high-performance services along the lines of greatest traffic and potential demand external to the metro corridor.*

*(...) For the corridors concerned (...) of the lines of force, the increase in transit frequencies will necessarily have to be accompanied by a planning of technological and infrastructural interventions aimed at significantly increasing the regularity and commercial speed of the service offer. In particular, (...) taking up the consolidated itinerary represented by the current bus lines 2 and 3, it highlights the opportunity to achieve a further development of these east-west crossing services of the city through the possible use of innovative guided systems (bus-ways, tramways...)' (Comune di Brescia, 2016, p. 86).*

The PGT acknowledges the need for better public transport in areas not served by the metro, and therefore identifies two potential corridors to upgrade - the existing bus lines 2 and 3 - and proposes the use of two technologies: the bus rapid transit and tramway.

### 3.2 Addressing the topic: the 2018 Sustainable Urban Mobility Plan (SUMP)

After the PGT established the theme, the SUMP, which was approved by the Brescia municipality in 2018. The SUMP objectives align perfectly with the PGT pillar "accessibility as a strategy for a friendly city" and were established in accordance with the municipal council's directive. These include goals like reducing the danger of an accident, developing shared mobility solutions, enhancing the quality of public transportation, and integrating the transportation system. Based on these goals, the SUMP compiled several potential courses of action into three scenarios (Fig.6), named B, T and M (Comune di Brescia, 2018b).

In Scenario B, three public transport lines (designated B2, B3 and B4) are implemented, modelled on the city's former LAM line, with separate lanes and traffic light priority. Line B4 is a completely new design, while lines B2 and B3 largely follow the 'lines of force' defined in the PGT, i.e. the current bus lines 2 and 3. According to the SUMP, these two routes account for 25% of all passengers on the city bus network, making them the most heavily used.

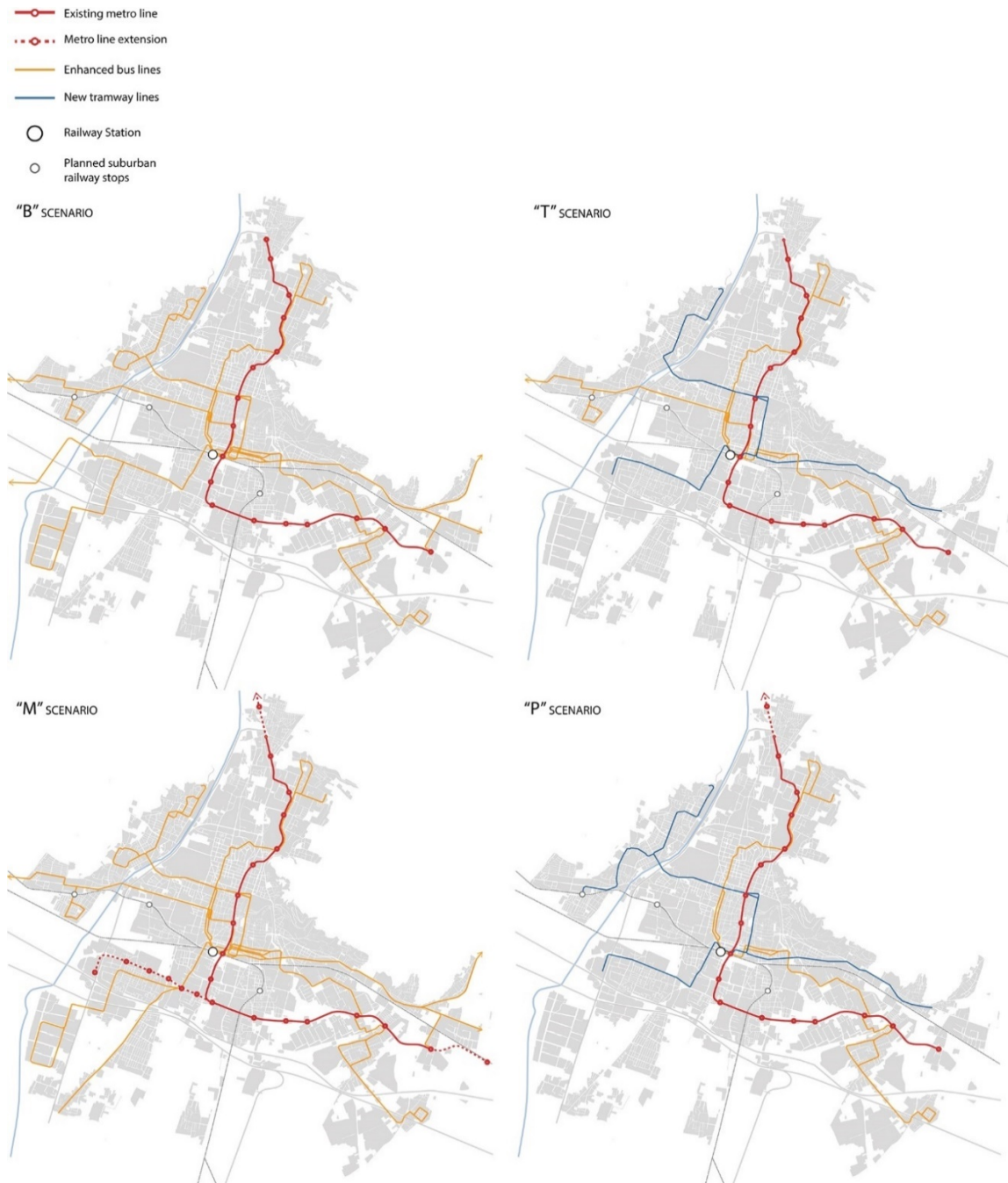
The Scenario T calls for the building of the bus line B4 as well as two tramway lines, designated T2 and T3. This is an improvement on scenario B, in which the two "lines of force" - as proposed by the PGT - become tramway lines.

The M scenario envisages an extension of the metro line in three directions: west to the Exhibition Centre, east to Rezzato and north to the Trompia Valley. All three hypotheses are based on concepts, plans and initiatives developed in previous years (Comune di Brescia, 2018c, p. 65), in particular those directed towards the north and west. The Provincial Territorial Coordination Plan of the Province of Brescia describes the extension to the north, and the initial idea even included a westward extension by using the Lamarmora station as an interchange stop.

All three options were then evaluated using a model developed by the research office of Brescia Mobilità, the local public transport operator (Comune di Brescia, 2018c, pp. 72, 76, 80). Comparing the results of the assessments, it is clear that the T scenario is the most effective in shifting people from private to public transport, and that the northern extension of the metro line is the most efficient (Comune di Brescia, 2018c, p. 82). Based on these considerations, a fourth scenario was created, called P, or the plan scenario, which included the new BRT line B4 (derived from the B scenario), the new tram lines T2 and T3 (derived from the T scenario), and the northern extension of the metro line (derived from the M scenario). Using the transport model, the scenario plan was evaluated and found to be more effective than the three scenarios alone. According to the model, the modal share of public transport in metropolitan areas could increase by up to 34%, carrying an estimated 65 million passengers per year (Comune di Brescia, 2018c, pp. 86-87).

The two system the SUMP provides as an integration of the metro line are not a total novelty for the city of Brescia. The B4 line revives the LAM idea, while the T2 and T3 lines reintroduce a system that was already present in the city of Brescia between 1882 and 1949 (Robecchi, 2009). The reintroduction of the tram

system in Brescia is part of a wider "tram renaissance" trend that has affected Western Europe since the 1980s and which has seen many mid-size cities rethinking the use of this mean of transport (Spinosa, 2013).

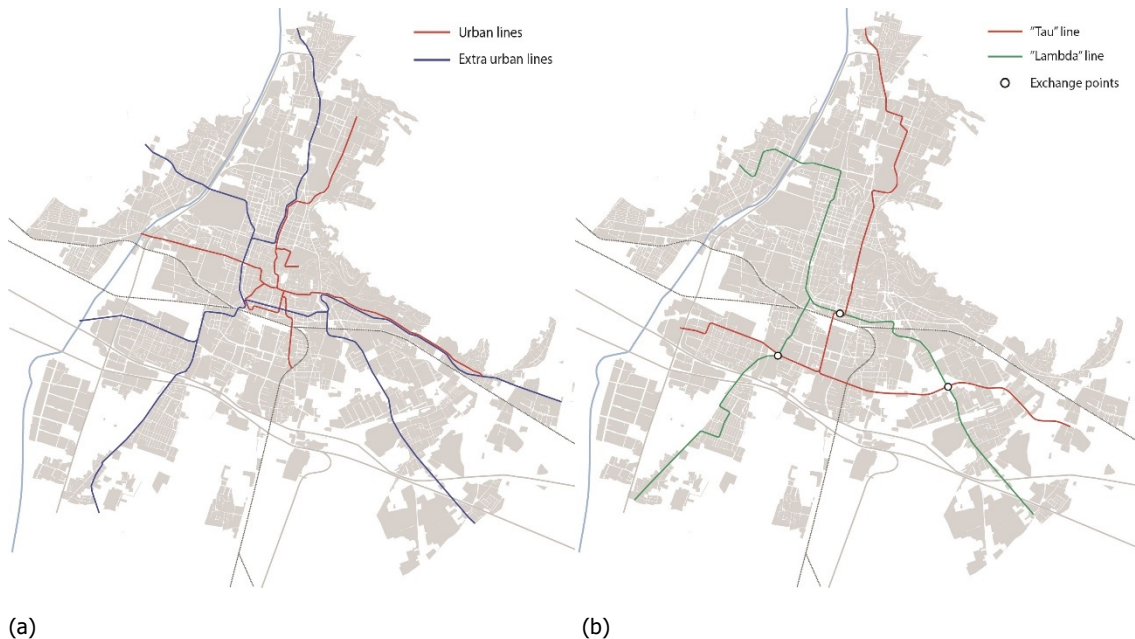


**Fig.6 The four scenarios in the Brescia's SUMP**

Actually, a first tram reintroduction proposal in Brescia already occurred in the 1990s and deserves a brief mention. In 1994 the municipality of Brescia relied on the consultancy of Bernardo Secchi to design the new PRG (*Piano Regolatore Generale*, General Master Plan), which was the Italian municipal urban planning tool before that Lombardy region replaced it by the PGT in 2005. At the time the municipality was detailing the metro project, but Secchi proposed instead the development of two tram lines, named 'tau' and 'lambda', thought to serve two different urban contexts. The "tau" line should link together the areas characterized by major urban polarities, while the "lambda" line should serve residential areas and schools. The interchange between the two lines was thought to take place in the areas where these two urban systems met (Secchi &



Viganò, 1998). Such plan was cancelled in 2001 by a TAR (Regional Administrative Court) ruling (Lupo & Badiani, 2009). Consequently, the tram idea was abandoned in favor of continuing the metro project.



**Fig.7 (a) Brescia's historical tram network at his peak in 1935, overlapped to the current urbanized areas; (b) The tram network designed by Bernardo Secchi**

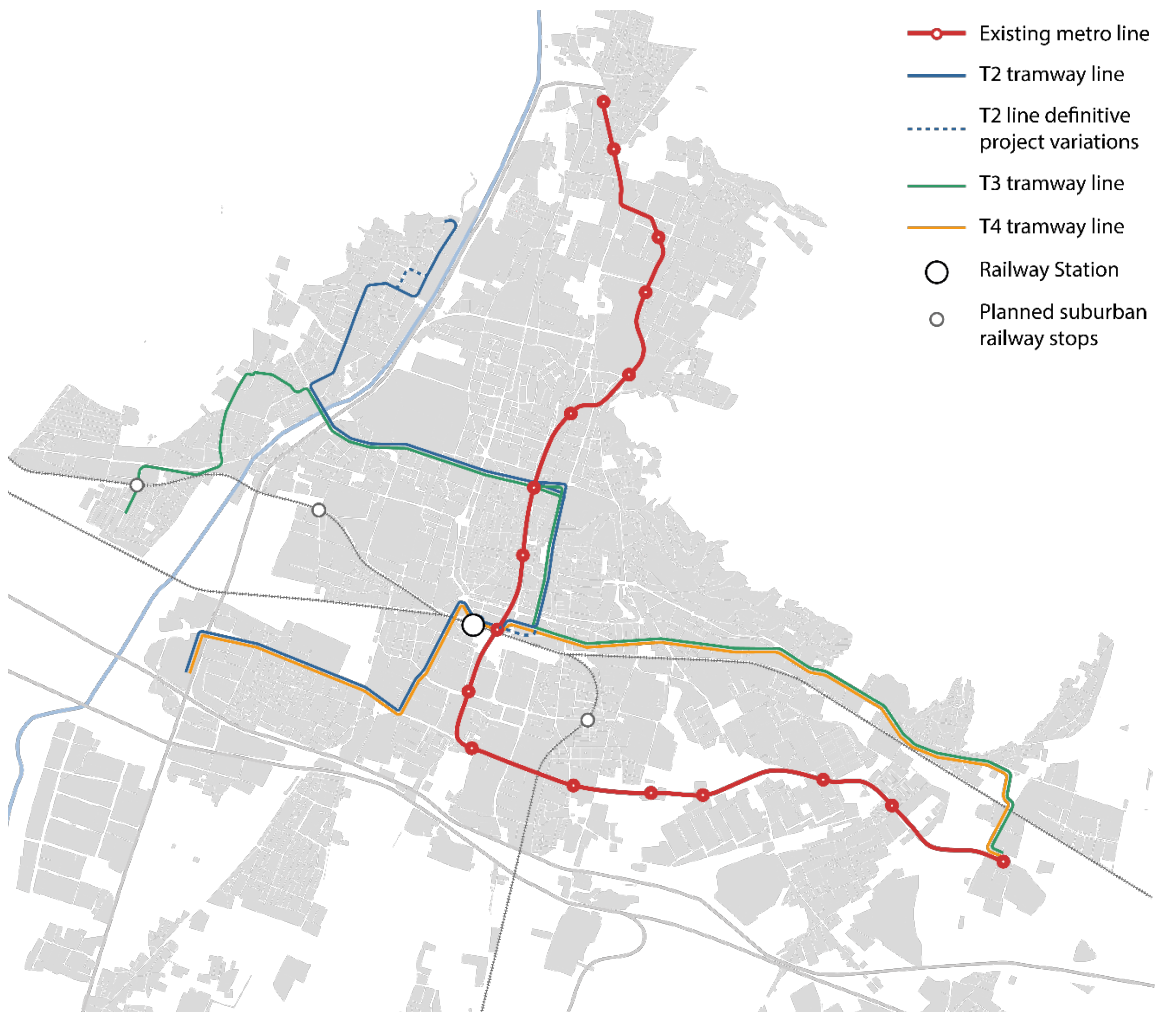
### 3.3 Turning the strategy in action: the "T2" design process

Following the approval of the SUMP on 5 February 2018, an opportunity for implementation has arisen. As mandated by the 2018 Budget Law (Law 205/2017), the Ministry of Infrastructure and Transport launched a public tender process to allocate funds for the mass rapid transport system. This fund covered expenses such as new vehicles, the construction of trolleybus, tram and metro lines, and the renovation of existing lines. Brescia Mobilità partnered with the Italian State Railways to submit the required documents by the tender deadline of 31 December 2018 (Ferrovie dello Stato Italiane, 2018). The partnership aimed to design, build and manage two tram lines outlined in the SUMP. They proposed a project financing model with majority private investment totalling €400 million, with the aim of being operational by 2027.

In a joint effort, they conducted a feasibility study (PFTE, Progetto di Fattibilità Tecnico- Ecomica) over the following months, aligning the project with the SUMP tram lines: T2 from the Pendolina district to Expo, connecting to metro stations; and T3 from Violino to S. Eufemia metro station, sharing the central route with T2. In addition, a third line connecting Expo to S. Eufemia was proposed. The total length of the system was approximately 23 km, 35% of which was in dedicated lanes. An alternative, less costly plan proposed building only the T2 line for 11.75 kilometres. The project was submitted to the ministry on 31 December 2018, seeking €252 million, or 51% of the total funding required. The rest was expected to come from project financing. However, when the Ministry published the ranking on 18 December 2019, the project was ranked 19th and did not receive funding. This raised concerns about the sustainability of the funding. The Ministry's decision to fully fund seventeen other projects suggested a preference for state funding over public-private partnerships, contrary to Brescia's expectations.

After the rejection, the Municipality of Brescia made the decision to review the project with the aim of participating in a second tender. In fact, the 2019 budget law (Law 145/2018) allocated new funds for rapid mass transport and set new deadline for 15 January 2021. To this end, the Municipality gave a mandate to Brescia Mobilità to prepare a new feasibility project on 30 September 2020 and withdrew from the

cooperation agreement with the Italian State Railways on 1 July 2020. The instance presented to the Ministry was very different from the old one.



**Fig.8 Brescia's tramway line projects. The T2, T3, and T4 lines were a part of the initial feasibility project, which was rejected by the ministry. Only the T2 line was included in the second feasibility project, which has been approved**

Firstly, it included the T2 line alone, which had been prioritised in the SUMP. Secondly, in order to improve service efficiency and meet increased demand, the percentage of dedicated lanes was increased from 35% to 70% of the total route. Thirdly, the project funding approach was abandoned in favour of public funding for the whole project, with the Ministerial's funding request covering 99% of the projected costs. Specifically, €359 million were requested, of which 254 for rolling stock and infrastructure, 12 for safety fees, 9 for environmental monitoring, 44.7 for VAT and 39.3 for expropriation and redesign of public spaces crossed by the tram. The projected 12.4 million annual passengers by 2032 is in line with the SUMP projection, with a projected 3.3% annual reduction in private transport passengers. The expected commercial speed was 18 km/h, slightly faster than the 17 km/h of Brescia's buses and slower than the 28 km/h of the Brescia metro. The expected passenger capacity of the vehicles was 250, which is more than a 100-seater bus but less than the metro vehicles, which have a capacity of 440 passengers per vehicle. The expected frequency during peak hours was 12 vehicles/h in each direction. This is more than the current frequency of 6 vehicles/h on the main bus routes, but less than the Metro frequency of 15 vehicles/h (Comune di Brescia, 2018c).

The second instance was successful; on 22 November 2021, the Ministry issued Ministerial Decree 464/2021, allocating the full €359 million euros for the Brescia projects. To continue with the design process, on 2 February 2022, the Municipality of Brescia mandates Brescia Mobilità S.p.A. to proceed with the



development of the definitive project (Municipal council resolution 35/2022). The municipal company called for a tender which closed on 4 April 2022, that was seen as a winner the French engineering firm Systra Sotecnici SPA. At the request of the municipality, Systra made two variations to the preliminary design, regarding Urago Mella neighbourhood and next to the courthouse (Comune di Brescia, 2023). On 27 February 2023, the Municipal Council appointed Brescia Mobilità as the body responsible for implementing the project and awarding contracts for the construction of the tramway (Municipal council resolution 9/2023). On 8 August 2023, the verification process of non-subject to environmental impact assessment was successfully completed (Regione Lombardia, n.d.b). On 24 August 2023, the Municipality has started the Services Conference process, which concluded on 24 October 2023 with positive outcome (Municipal Notice Board Protocol 267524/2023; Municipal Notice Board Protocol 312029/2023).

In parallel with such technical-administrative steps, the municipality updated the PGT, closing the circle of urban and transport planning integration which began with the launch of the SUMP and PGT procedures in 2013. Indeed, with the fourth PGT variant adopted on 23 January 2023 (Municipal council resolution 5/2023), the tram project has been incorporated into the urban planning instrument (Comune di Brescia, 2024). The approval of the definitive project is expected in the first half of 2024 while the entry into operation of the Pendolina-Fiera T2 line is expected in 2030 (Fatolahzadeh, 2024).

## 4. The T2 tram: assessment of the route with a GIS-based approach

### 4.1 Method and materials

As mentioned in section 1, the location of stops is critical in the design of a new public transport line and, as the case of the Brescia metro (see section 2.2) shows, it is one of the issues where urban and transport planning can work together most effectively. GIS software can be used to determine how the public transport line relates to typical aspects of urban planning - such as housing density and land use - in order to understand the level of integration between urban and transport planning. This can be done by examining the population and urban destinations served by the existing metro and the future T2 tram line.

The evaluation was conducted on the existing metro line and the future T2 tramway line. Firstly, the needed georeferenced data (shapefile format) were downloaded: land use, transit line and its stop, census sections. Census sections are from the 2011 census, the most recent available, and were downloaded from the ISTAT website together with the corresponding csv files (from the 2021 census) with the residents' data (ISTAT, n.d.). Land use data and the metro line were downloaded from the geoportal of the Lombardy region. Land uses are from the "plan forecast" (*previsioni di piano*) dataset, which contain the *Ambiti\_tessuto\_urbano\_consolidato.shp* file. This file contains the field *DCOD\_DEST1* that classifies urbanised blocks by land use. The metro line is from the "mobility infrastructure" (*Infrastrutture della mobilità*) dataset, which contain the *Rete\_Metropolitana.shp* and *Stazioni\_Metropolitana.shp* file, respectively referred to the line and stop of the metros in the Lombardy region (Regione Lombardia, n.d.a)

The shape file of the future tram route was instead created from scratch, based on the definitive project general report available in the Municipality of Brescia's website. Secondly, the area of influence of the stops was determined. It was chosen to consider buffers of 800 metre for the metro and 600 for the tramway. The latter area, halfway between the catching area of a bus (400 metres) and a metro (800 metres) was chosen considering the performance expected from the tramway, halfway between those of the metro and a bus (section 3.3). Those values (400 metres for bus stops' buffers and 800 metres for metro stations' buffers) are commonly used in the public transport sector to identify the area from which the majority of transport users will access the system by walk (El-Geneidy et al., 2014). In addition, those catching areas are supported by a vast literature that sees this value as suitable for the context (a medium-sized European city) and the transport systems considered (i.e. in Moyano et al., 2023; O'sullivan & Morrall, 1996; Sarket et al.,

2020). Once the necessary data was important on GIS software, the influence area of the stops was obtained (with buffer geoprocessing tool) according to the criteria mentioned above (800 metres for the metro, 600 metres for the tram). The areas of influence were then summed up (with the dissolve geoprocessing tool) to obtain a single geometry, constituting the area of influence of the public transport line considered. The ISTAT census sections were merged with the corresponding csv files, in order to obtain geo-referenced population data.

## 4.2 Results

By intersecting the influence area of the tramway with the population data it appears that the tramway has the capacity to serve 80,350 people (equivalent to 41% of the population of Brescia). When the buffer is intersected with land use data, it becomes clear that the most served land destinations are residential (36.58%), particularly in the northern part of the line. Commercial (5.46%) and industrial (7.34%) uses are concentrated in the southern section (Fig.9). Public services occupy only 19.68% of the catchment area, with the Exhibition Centre being the only major urban attractor (see Fig.3, section 2.2). Applying the same procedure to the metro route, with an 800m buffer, the population served is 103,563, representing 52% of the municipality's total population. In terms of land use, in addition to the residential function (30.96%, lower than the T2 line), commercial functions and public services (23.89%, higher than the T2 line) are served, including several urban polarities (Fig.10). In order to improve the test, it could be assumed that the T2 line will be upgraded to the same rank as the metro line, effectively replacing the tram line with a second metro line. This would essentially mean that a second metro line would replace the tram line. Applying an 800-metre buffer around T2 stops would do this, indicating that the population served (93,290) would be comparable to that of the current metro. However, with the exception of the Exhibition Centre, major urban polarities would still remain unmet (Fig.11). The proposed method has some merits and some limitations. The first limits is that it consider buffers rather than isochrones. The latter tool is characterized by greater refinement (Rossetti et al., 2020) and can consider the accessibility of different means of transport (Tira et al., 2016). Thus, an improvement of the proposed method could take into account the calculation of isochrones. Secondly, it does not take into account all the data used in the transport sector (such as origin-destination matrices and benefit-cost ratios). However, since the T2 line has previously been examined from a transportation perspective using Brescia Mobilità's model, it is helpful to retrospectively examine how the tram project fits into the urban setting.

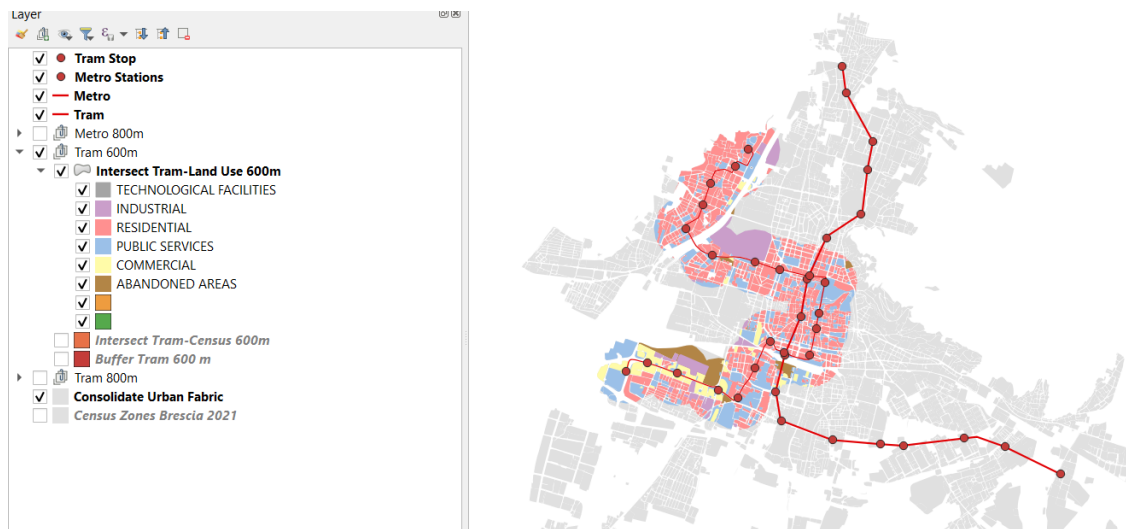


Fig.9 T2 Tram line 600 m catching area intersected with land uses

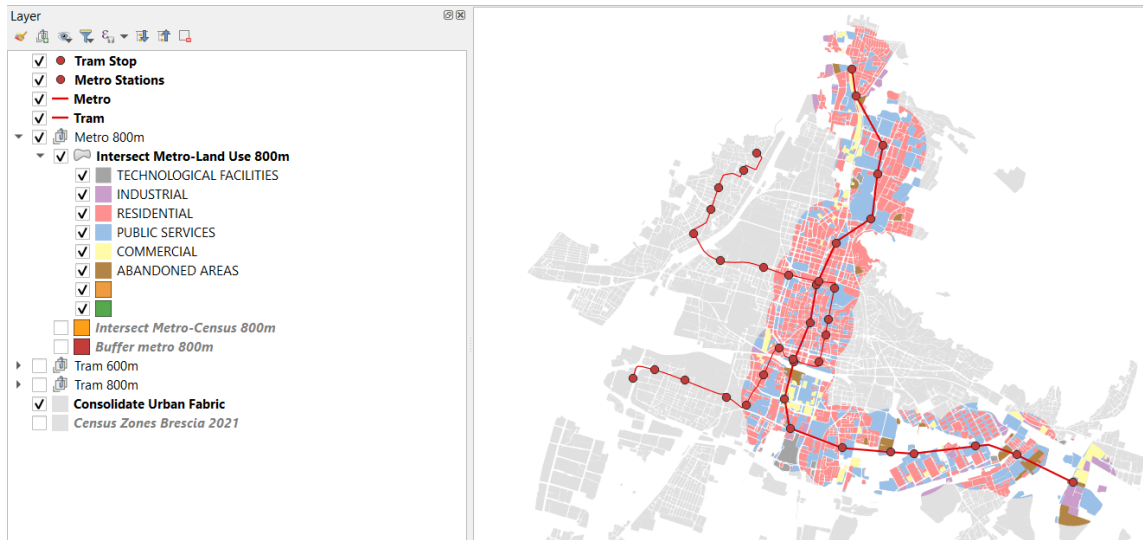


Fig.10 Metro line 800 m catching area intersected with land uses

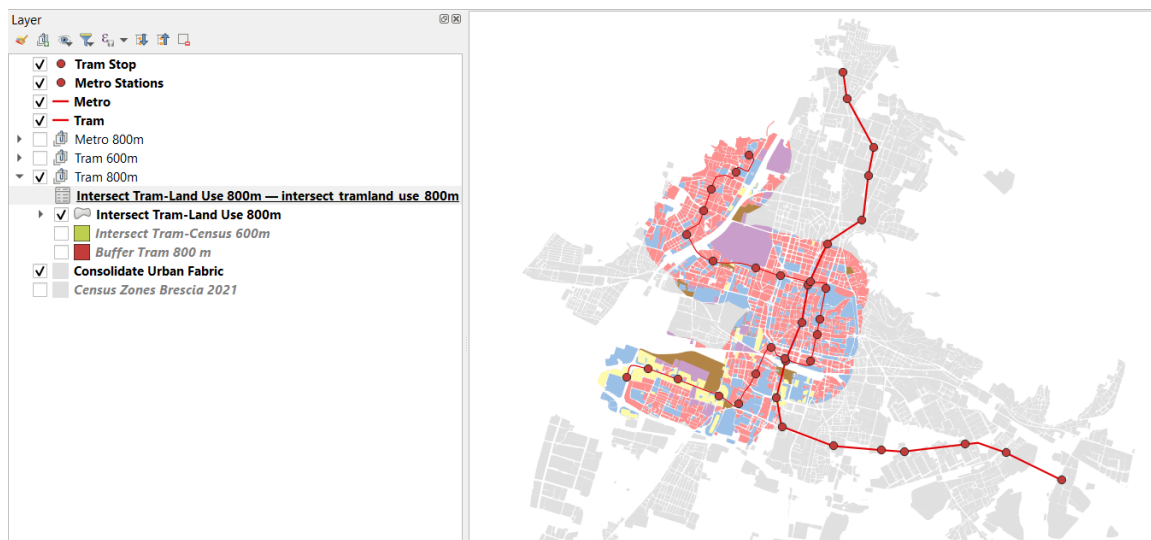


Fig.11 T2 line 800 m catching area intersected with land uses

	Line length	Population served	Pop./km	Residential	Commercial	Industrial	Public Services	Dismissed Areas	Other
Metro	13.7 km	103,563	7,559.34	30.96 %	3.35 %	2.63 %	23.89 %	3.42 %	35.75 %
T2 as tram	11.3 km	80,350	7,110.62	36.58 %	5.46 %	7.34 %	19.68 %	4.65 %	26.33 %
T2 as metro	11.3 km	93,290	8,255.00	33.58 %	4.74 %	7.38 %	19.13 %	4.65 %	30.52 %

Tab.1 Inhabitants and land uses intercepted by respective buffers

## 5. Final considerations: Brescia as a laboratory of integration between urban and transport planning

While in the three cases studies exposed in section 2 it is recognizable a particular attention to mobility issues, it is not clear an exemplified strategy. The idea of the metro, despite its innovativeness, was born from the desire to serve a specific city district, and only later was it included within a broader strategy to reduce the use of private cars. Furthermore, it was the urban development of the decades between 1950s

and 1970s that determined its path and not vice versa. Sanpolino was not conceived from the beginning as a TOD and it is not the consequence of an intended synergy between housing and transport policies, but it is the result of a punctual union between two previously separate projects. The LAM project brought some beneficial results in terms of public space and an increase in public transport passengers but remained largely incomplete. However, this attention to the topic of mobility has outlined, project after project, a vision of a city with fewer cars, with a continuous refinement of the integration between transport and urban planning, eventually emerged in the T2 line. The tram project is indeed included in a broad strategy to improve the quality of life in the city, consistently with objective 11 of the 2030 agenda for sustainable development. A strategy expressed in the municipality's general planning tool, the PGT, and in-depth in its technical details in a sectoral tool such as the SUMP. A project that is still pending approval, and that is likely to undergo further adjustments before final approval.

From the assessment in section 4 it emerges that the two mass public transport lines in Brescia have different roles: the metro connects major urban polarities each other (as mentioned in section 2.2), whereas the tramway connects large residential areas to the city centre and the nearest metro stations. Thus, the T2 line is at a lower hierarchical level than the metro line, which justifies the use of a less performing system. The city of Brescia is developing a hierarchically complex transport system consisting of bus, tram and metro, that in Italy, only four other much larger cities - namely Rome, Milan, Turin, Naples - can boast (Spinosa, 2019).

However, despite its lower hierarchical level, the T2 that has great potential not only for the redevelopment of public spaces, but also for the regeneration of abandoned areas. In fact, the T2 catchment area involves a fair number of abandoned areas (4.65% of the total), which will increase their recovery opportunities, consistently with the aims of the PGT. These areas are located mainly along Orzinuovi Street, a road axis in the south-western periphery of the city which the PGT identifies as a "complex urban fabric" to be "subjected to functional and structural redevelopment". The tram will therefore increase the possibilities of implementing the PGT in this area. Furthermore, the T2 line is characterized by a particular coverage of industrial areas (7.34% of the buffer) which are almost completely uncovered by the metro. This coverage not only allows to better serve large traffic attractors, but also provides a better recovery opportunity in the event of decommissioning of these production plants. Possible future recovery projects for these areas will not be able to avoid considering the presence of an important infrastructure such as the tram, opening the future to new opportunities for integration between urban design and transport planning in the city of Brescia.

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## Image Sources

Fig.1: Elaborations by the authors from a brochure issued by ASM, now Brescia Trasporti

Fig.2: Retrieved from: <https://www.professionearchitetto.it/mostre/notizie/2645/Italo-Rota-Linee-ad-Alta-Mobilita>. (Accessed on 24-10-2023)

Fig.3: Elaborations by the authors

Fig.4: Elaborations by the authors

Fig.5: Comune di Brescia, (2016). Piano di Governo del Territorio, Documento di Piano, V-DP02 Carta delle strategie. Retrieved from: <https://www.comune.brescia.it/aree-tematiche/urbanistica/piano-di-governo-del-territorio/documento-di-piano-pgt-2016> (Accessed 11-3-2023)

Fig.6: Elaborations by the authors from Comune di Brescia, (2018). Piano Urbano della Mobilità Sostenibile - Allegato L: Scenari di piano. Retrieved from: [https://www.comune.brescia.it/sites/default/files/imported/servizi/mobilitaetraffico/sett\\_mob/docPianificazione/pums/Documents/AllegatoL\\_Scenari%20di%20piano%20e%20schede%20di%20progetto.pdf](https://www.comune.brescia.it/sites/default/files/imported/servizi/mobilitaetraffico/sett_mob/docPianificazione/pums/Documents/AllegatoL_Scenari%20di%20piano%20e%20schede%20di%20progetto.pdf) (Accessed on 3-11-2023)

Fig.7: Elaborations by the authors from Robecchi (2009) and Secchi & Veigano (1998)

Fig.8: Elaborations by the authors

Fig.9: Elaborations by the authors in GIS environment

Fig.10: Elaborations by the authors in GIS environment

Fig.11: Elaborations by the authors in GIS environment

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