THE CLUJ METRO PROJECT. ISSUES AND CHALLANGES

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ABSTRACT. The Cluj metro project. Issues and challenges. Recently, excavations had started in Cluj-Napoca for the building of Romania's second metro line after Buchrest, which is expected to resolve the problem of daily traffic and overwhelmed streets. However, the planning and the implementation of the project face issues and challanges regarding first of all environmental impacts, as the route crosses a protected arheological and cultural area, which is very densely populated and has busy traffic on one hand and instabil soil on the other hand. Thus, the project requires comprehensive feasibility studies, field studies (including preventive archaeological research) and technical expertise. In this paper, some of these issues will be discussed in detail.

Keywords: metro project, urban mobility, traffic, congestion, metropolitan area

1. Introduction

In Cluj-Napoca, the largest city of the North-West development region with about 300,000 inhabitans has started the building of the second metro line of Romania after Bucharest Metro. This would be a light metro system with a 21 km lenght and 19 stations with a transport a capacity of 15,200–21,600 passengers per hour per direction (according to Cluj-Napoca Local Council offical announcement). The metro line will link underground the commune of Floreşti with Cluj-Napoca giving solution first of all for the immense commuter traffic between the city and its close neighbour, the giant commune with its 50,000 inhabitants which commute daily into the city and back home.

The metro project resonates perfectly with the Integrated Urban Development Strategy of the Cluj Metropolitan Area (2021-2030): one of the five stategic objectives of this strategy is decongestion, respectively fluidisation of traffic in the municipality and its metropolitan area, beyond developing the metropolitan area of Cluj and making it more livable (Integrated Urban Development Strategy of the Cluj Metropolitan Area 2021-2030).

One of the main goals of the metro project is to improve the attractiveness of the metropolitan sustainable public transport system in order to quickly access socio-economic opportunities on the main axis, the east-west axis of the municipality. A further goal is to support economic growth aspirations and increasing employment by providing extended transportation capacity to serve the same zone of metropolitan area. Last but not least, a third aim is to reduce the

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environmental impacts of traffic activities (air pollution and noise) by creating a sustainable traffic axis that contributes to modal shift from personal car transport (Statement of the Cluj-Napoca City Hall).

Recent studies have found direct relations between air quality and mobility and transport issues (Boitor 2015), not only in the city itself, but also Floreşti, respectively at the North ring road between Floreşti and Cluj-Napoca (Nistor 2019). Studies revealed that the concentration of main pollutant emissions were higher in the working days of the week, while in weekend the concentration of air pollutants decreases, in accordance to the decreasing of the heavy traffic in the city (Ilarie 2011, p. 69). All of the studies urge improving air quality in order to achieve better living conditions, as well improving the overall quality of life addressing the issue of traffic generated noise pollution (Marusceac 2024), while improving public transport services appears as the main solution (Ilarie 2011, p. 70, Boitor 2015).

Optimization of mobility itself, beyond its economic and time-related impact, directly contributes to societal developments and enhances the quality of life. Urban mobility is directly linked to a settlement's vitality, serving as an economic catalyst, and affects the population accessibility to urban functions, thus congestion and traffic disparities lead to disparities in urban functions with persistent and long-term effects (Popa 2023, p. 23).

According to the project, the metro line will link up with the newly renovated rail network, which is expected to provide faster access to the city centre, airport and emergency hospital, as well as providing park-and-ride connections from the A3 Transylvania Highway.The idea of a metro line in Cluj-Napoca could be a justifiable one, as in Europe there are several examples of cities like Cluj-Napoca, or even smaller that have metro lines[2].

2. Literature review

Cities represent the human context in which opportunities are concentrated and where the mobility system has been strongly implemented. Hence, mobility becomes almost a synonym for the city itself (Kaufmann, 2011). Improving accessibility to places and services is an aspect of social equity (Mattioli and Colleoni, 2016). An effective and inclusive mobility system influences the degree of sustainability of cities from environmental, social and economic points of view. Goal 11 of the 2030 UN Agenda focuses on "Sustainable cities and communities". In this framework, sustainable mobility is

[2] Such towns are, for example Bilbao (355,000 inhabitants) or Catania (313,000 inhabitants), and the smaller Lille (233,000 inhabitants), Rennes (215,000 inhabitants), Brescia (196,000 inhabitants) and Lausanne (137,000 inhabitants).

achieved by providing a safe, affordable, accessible and sustainable transportation system for all citizens.[3]

Fixed-track transportation systems, especially underground rail networks, constitute a sustainable and cost-effective approach to addressing urban mobility demands. Experiences regarding underground transport systems even in smaller towns and cities appear in a considerable number of scientific articles. Uster and his colleagues present a record of the first five years of operation of the Lille Metro system in France, and also describe the development of the system, including a progressive addition of a second line, analysing data regarding operating statistics, namely number of passengers, number of emergency brakings, missed stations, operation incidents, operating parameters and on-time probability, concluding not only that the VAL system in Lille has fulfilled its requirements its first years of operation, but also proving the efficiency of the driverless automatic systems in general (Uster et al. 1990). Other papers address the effects of transportation infrastructure location on real estate prices and rents, such as Efthymiou and Antoniou (2015) in Thessaloniki, Greece, investigate the impact of a future metro line on the area metro line in construction, which is partly operational.

The effects of the metro on traffic and air pollution were measured in Bilbao (Ibarra-Berastegi et. al 2002). The authors concluded that the new metro achieved for two years a significant reduction in congestion levels and number of cars circulating inside Bilbao which meant reductions both in ozone and CO2, while public parking's by the metro stations of the surroundings of Bilbao contributed to reduce external traffic. Unfortunately, later congestion and circulating number of vehicles increased as well as CO2 and ozone levels (Ibarra-Berastegi et. al 2002). There are also numerous articles which focus on the infrastucture from a technical point of view, especially tunnels (Madinaveitia, 2004).

La Greca and Martinico (2018) focus on the integration between land use policies and transport planning within a sustainable urban mobility framework. Based on a case study of Catania, a medium sized metropolitan area in Southern Italy, the authors argue that in spite of the lack of integration between land use and transport planning, this example demonstrates that the construction of a new metro line has a substantial potential for revamping outdated planning practices, promoting a comprehensive approach towards a strategic planning of the metropolitan area. Similar to Cluj-Napoca, Catania faces challenges arising from inadequate urban planning and transport infrastructure, which leads to significant environmental problems, intensified by traffic congestion and heavy reliance on private vehicles for urban travel (La Greca and Martinico, 2018). Another paper

[3] Sustainable transport, sustainable development. Interagency report for second Global Sustainable Transport Conference. United Nations, 2021

evaluates urban rail effects in Catania using GIS. The authors argue that urban railways connect different areas by crossing them and trigger relationships between them, resulting in the emergence of new centralities, urban regeneration practices and sustainable and inclusive mobility behaviour. This also improves the organisation of urban spaces by a better allocation of the city facilities (Accordino et at. 2024). Other studies focus on intermodal practices, respectively on understanding the role and the integration of the metro in the wider public transport network. For example, Richer et al. (2019) analyse passenger behaviour, especially passenger travel patterns between the buses and the metro in Rennes using smart-card data, offering useful insights for transportation planning.

In an others study, Rosetti el al. (2015) evaluates accessibility changes following introduction of Brescia's light rail system. Similar studies examine how the Brescia metro fits into broader urban and transport planning frameworks, focusing among other issues, on the crucial role of public transportation stops, the interface between the user and the transport system, 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 (Fusi and Tiboni, 2024).

A considerable amount of papers address technological and construction-related issues, first of all tunnel excavation monitoring. Nahli et al. (2018), for example, use satellite data to detect small surface deformations caused by tunnel excavation for Line B of the Rennes metro, demonstrating that deformations are correlated in space and in time with the excavation works. Gaj and Badoux (2007) are researching the construction of the M2 metro in Lausanne, addressing challenges like the city's steep topography and dual tunnelling methods. With a population of about 250.000, Lausanne is a relatively small city for a fully automatic subway system, which is characterized by a difficult topography and a growing traffic problem. Engineers face difficult technical and logistical challenges as these tunnels are excavated at low depth in a dense urban environment.

Choosing the suitable excavation technics is not negligible, as the underground space – the so-called fourth dimension of a metropolis – not only facilitates transport, but also provides gas, water and other supplies. Underground space may also be utilised for living, working and recreational facilities and industrial storage. Using the wrong tunnelling methods can cause harm even on the surface.

3. Methodology

This article employs a multidisciplinary methodological approach that combines literature review, case study analysis, comparative analysis, and spatial examination. The case study of the Cluj metro line uses urban mobility research, feasibility studies, planning documents, and official development strategies

related to the Cluj metropolitan area. Furthermore, the paper compares the Cluj metro project with similar underground transportation systems in several European cities to evaluate sustainability, traffic decongestion, and urban development impacts. A comparison with other metro projects in similar-sized cities is made, incorporating findings regarding positive and negative effects of such metro lines on traffic, congestion, commuter patters, environmental aspect and real estate prices and rent. The research also applies geographical and spatial analysis to examine traffic flows, suburbanization, land use patterns, and geomorphological conditions. In addition, environmental and technical assessments are used to evaluate issues such as air pollution, soil instability, landslide susceptibility, and the protection of archaeological and built heritage.

2. Geographical aspects and spatial structure

Cluj-Napoca is in the basin of Someșul Mic river, surrounded by hills under 700 m in height, which form the southern side of the Someșan Plateau. To the south, the municipality is dominated by the hill of Feleac (759 m). To the west of the municipality is the Hoia Hill (507 m), which constitutes the watershed between Someșul Mic and Nadăș rivers. This geographical environment with its relatively low level of gradient lacking steep slopes had a crucial role on the development of the city, which spread first of all on the west-east direction, but also on the side on the terraces of the Someș, but penetrating all the valleys converging towards the central area (Archaeological studies, 2020). This development into a single-cored and radial-shaped form of the city (Boitor et al. 2013) resulted in a very densely populated area, while high hills the north and south concentrate much of the traffic into the east-west axis creating significant congestion on the principal roads.

A further issue is that socialist legacy which resulted in the artificially created and swollen residential neighbourhoods of Mănăștur, Gheorgheni and Mărăști. These neighbourhoods are located around the historical center and concentrate the majority of the population. Urban mobility researches found that Mărăști and Mănăștur districts, together with Zorilor district are residential neighborhoods characterized by high density and intense traffic, urbanized with developed road infrastructure that attracts intensive traffic, used for commuting as well (Popa 2023, p. 27). Inhabitants from these parts of the city commute daily in the city center, as the majority of public and private services – including public offices, renowned schools, leisure activities such as coffee shops and restaurants – are mostly located there. Workplaces are also concentrated in two major poles; one of them is exactly the city centre, while the other one is the Iulius Mall area. The geographical location of the workplaces results in a predominantly periphery-center type flow, thus, the arteries linking the main residential areas, the collective housing neighborhoods and the central area are congested at peak

hours. Some of the streets have their traffic capacity exceeded by 200%, according to the Territorial Planning Plan (PATJ) of Cluj.

The configuration of the relief favoured not only the development to the west, north and east of the city, but suburbanization as well, especially in the Florești, Baciu, Gilău and Apahida area, the localities with the strongest population growth and substantial load of real estate developments (Nagy et al. 2018). These localities have developed in a very fast pace, especially Florești which is among the top ranking rural localities regarding sustainable development (Benedek et al. 2021).

Suburbanization is one of the most challenging issue of current day Cluj-Nopoca. In addition to the 300,000 inhabitants of the city, about 110,000 inhabitants live in the area, respectively in the other 19 localities of the Cluj Metropolitan Area, according to the official data of the Cluj Metropolitan Area Inter-community Development Association. Moreover, the population growth in the surrounding localities is stronger than in the city itself. While the annual growth rate of population of Cluj-Napoca is around 0.3%, which resulted in a 3% increase in the number of resident in 2019 compared to 2008, the population growth rate in the areas nearby is approximately 4% per year, resulting in a 54.5% increase in the number of residents over the same period. The localities that concentrate the largest share of the population and have experienced the most significant growth between 2008 and 2019 are located in the first ring of settlements around Cluj-Napoca, benefiting from their proximity to the city. While Cluj-Napoca serves as the main attraction pole for the population, the localities within its functional area take on the residential function, driving a significant process of urban development, commuting, and interaction between the core and the periphery. This generates additional needs and challenges related to mobility to and from the workplace, accessibility to essential services, pollution, and traffic congestion, all of which impact the quality of life for the majority of residents in the Cluj Metropolitan Area. A part of these inhabitants commune also daily into the city center, especially from Florești, Baciu and Apahida, but on a smaller case also from Gheorgheni, Aiton and other communes. The commuting population is estimated around 47,000 individuals in the peri-urban areas of Cluj-Napoca (Popa 2023, p. 29).

The dormitory towns represent serious traffic problems which require a proper solution, as in the present the buses of the public transport system are blocked in the same traffic jams.[4] In addition, in localities such as Florești, Gilău and Apahida more and more logistic centers have appeared[5] in the recent years which resulted in visible commuter traffic not only from the metropolitan are to

[4] Controversially, sometimes the buses even worsen the traffic, because on single-lane roads are slowing down the cars.

[5] For example, Nervia Industrial Park in Apahida

the city, but also from the city in the direction of its metropolitan zone. Furthermore, public transport services cover a smaller area than the current boundary of the metropolitan zone. The reason for this limitation is the lower demand for transport as well as the difficulty of ensuring the necessary fleet for service expansion.

Commuter traffic is doubled with transit traffic in the direction of Oradea, respectively Turda and Târgu Mureș. Because of the absence of adequate bypasses, he congestion on the no. 1 motorway is a real problem. The Turda – Cluj-Napoca – Oradea segment was one of the most heavily overloaded roads in the region in 2017, carrying a large share of transit traffic and supporting commuter flows within functional urban areas (not only from Florești to Cluj-Napoca, but also from Turda to Cluj-Napoca and from Aleșd to Oradea). The overlap of long-distance traffic with medium and short-distance traffic is visible on the section between Turda and Cluj Napoca, where the current A3 highway only manages to take medium and long-distance flows from Târgu Mureș and Alba Iulia to Oradea and Zalău, with an average traffic of about 5,000 vehicles per day. Taking into account the layout of the A3 highway, for the links to the East and Northeast of Cluj-Napoca, the long and short distance traffic continues to very high values, more than 10,000 vehicles per day for the Cluj-Napoca – Turda sector and about 20,000 vehicles per day on the Cluj-Napoca – Dej segment. Recent studies have found that at the exit from Cluj-Napoca to Oradea, the two-laned road from Cluj-Napoca to Florești, respectively Oradea is one of the busiest in Romania, with about 75,000 vehicles passing through daily, causing massive congestion and frequent traffic jams, but it is also a hotspot for accidents (Approval Report for the Feasibility Study). The road traffic crashes vulnerability areas, or hotspots in an urban environment are characterized by high economic dynamics, intense spatial mobility and old road infrastructure. Studies revealed that hotspots are located in geographical areas with the highest values of traffic intensity: the inner city (which is the most dangerous zone) and the three main city entrances-exits, respectively in the West, North-West and East (Benedek 2016).

Thanks to the sourraunding mountains, the unburdening of the main axis is a difficult task, as the infrastucture system simply cannot face the demand. The sum of all these elements led to a saturation point in the road infrastucture, respectively in traffic which asks for a solution. The geographical features, together with the configuration of the population and its movement led to the idea of building a single lined metro on the east-west axis which would perfectly cover the demand (Archaeological studies, 2020).

3. Historical and archeological heritage

An inevitable issue is that the entire route of the proposed itinerary passes through areas protected from archaeological and historical point of view, as in the

roman and medieval period the city has been developed in the same geographically narrow space. The area has probably been inhabited since the Paleolithic, with clear evidence from the Neolithic. In the Dacian 'classical' period (1st century BC - 1st century AD), the settlement of Napuca developed, which was overlapped with the Roman Napoca after conquering Dacia. This early history of the city resulted in a very wast archeological heritage which later, in the following centuries was enlarged with a rich built historical heritage as well (Archaeological studies, 2020).

To protect these heritage, under the current legislation, in the case of permanent interventions, as in the case of subway stations inside medieval and Roman enclosures, it is necessary to carry out preventive archaeological research.

The most important law that shapes the legal framework is Act no. 422/2011 on the protection of historical monuments, republished with subsequent amendments. Other relevant acts are Act no. 50/1991 on authorization of the execution of constructions, republished with subsequent amendments, as well as Government Ordinance no. 43/2000 on protection of archaeological heritage and declaring certain archaeological sites as areas of national interest, approved with amendments by Act no. 378/2001, with subsequent amendments.

Infrastructural investments are a series of activities that modify irreversibly the natural conditions and features of areas, which in most cases contain anthropogenic traces of an archaeological nature. These traces are protected by both Romanian and European level from a legal point of view, thus must be mapped, researched and documented in such a way that these, when they are no longer found on the field, could be available for future generations to study. Because of the given complexity of the known archaeological situations in the aforementioned area, and because the possible route of the metro passes through extremely important areas in terms of archaeological and cultural built heritage (Archaeological studies, 2020) it is not excluded that the proiect will need to be modified.

The proposed route, as well as the stations are located in archaeological sites and built protected areas(Archaeological studies, 2020). The General Urban Plan of the Municipality of Cluj-Napoca delimits two areas of archaeological protection (archeological protectian areas) in the area of the metro line, as follows: 1. the area adjacent to the site and monument "Calvaria", respectively 2. the area which practically encompasses the historic center and the areas organically connected by it.[6] The General Urban Plan of Cluj Napoca Municipality delimits also a protected built-up area that encompasses the historical center (Roman and medieval remains), but also its surrounding area where there are historical monument buildings or buildings proposed to be

[6] For the exact topographic coordinates please the PUG Cluj

classified as historical monuments, and the proposed route of the metro line crosses in lenght this protection zone.

3.1 Archeological heritage

On the Florești section of the proposed route, near Vivo shopping center is located the archeological site of "Șapca verde" („Green cape"). In the forest of Făget the so called tumulus necropolis of Cluj Napoca is to be found. In the area of Calvaria there is an archeological protection zone which includes a medieval archeological site with a settlement and a necropolis, a Hallstattian dwelling on the Mănăştur, as well as the medieval fortress of Calvaria whose remais can be observed in Mănăştur, Calvaria Hill and in the neighboring areas. Approaching the city center, on Memorandumului Street there is a Roman archaeological site, namely a Roman tomb. In the city center there is a wide archeological ensemble, in fact the ancient city of Napoca, which extends from Muzeului Square (actually between the Mill Canal, Păcii Square, Victoriei Square and Muzeului Square) to Regele Ferdinand Street, the intersection of Cotită Street and Tipografiei Street (namely the Central shopping center), then to Eroilor Avenue, V. Deleu Street and General Traian Moşoiu Street. In this case, on the proposed location of the station, Roman sarcophagi have been discovered. In addition, a Neolithic settlement can be found in Victoriei Square and Ştefan cel Mare Square, in the southwest corner of the park, parallel to the building of the National Theater.

Not exactly on the route, but ralatively close is also a section of the Roman road, near the St. Joseph's Greco-catholic Cathedral, as well as a Roman necropolis near the Archeological Park on the Cipariu Square (Archaeological studies, 2020)[7].

3.2 Built heritage

The historical built heritage is similarly rich to the archeological one. The Roman Catholic Church in Florești (Avram Iancu Street no. 217) was built in the 14th-15th century. In Cluj-Napoca, along the Memorandumului Street several protected buildings are to be found, such as the Reduta-house, currently the building of the Ethnographic Museum (Memorandumului Street no. 21), built in the 17th-19th century; the Knoblauch – Nemes-house which hosts the Ioan Bob school, built in the 18th century (Memorandumului Street no. 22); respectively the Merza-house, built in 1740 (Memorandumului Street no. 23). On Avram Iancu Square (by its intersection with Dorobanţilor Sreet no. 1) is located the building of the Public Finance Administration, built in the 19th century, while on the Ştefan cel Mare Square no. 1 by its intersection with Dorobanţilor Street no. 24 are located the Tribunal and Court of Appeal which share the same building from 1902.

[7] The identification numbers are to be found in the Appendix.

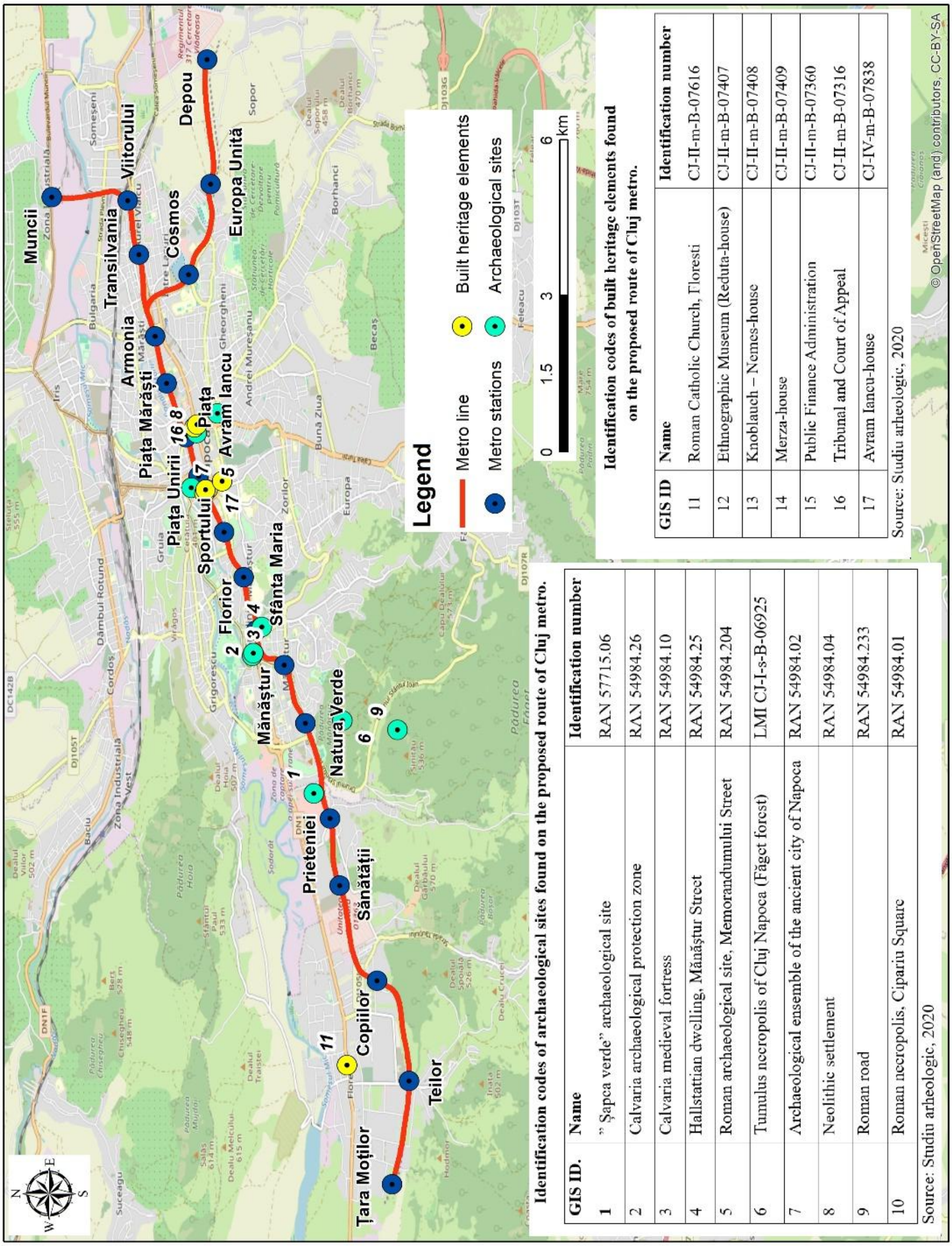
The house where Avram Iancu lived is an other piece of the built haritage of Cluj-Napoca from the 19th century; this is located on the road named after this personality (Avram Iancu Street no. 5).

Because of the numerous buildings with historical values (especially those located in the city centre), the excavations will be carried out by the modern technique of tunnel boring machine that, unlike the so-called „cut and cover" method (excavation followed by covering, which involves the total demolition of the surface constructions, used by the building of the Bucharest metro system in the 1970s) which teoretically will not affect the buildings above. According to the plans, in the city centre even the tunnels will overlap each other instead of being parallel in order to fit under the relatively narrow boulevard, without having inpact ont he historical buildings on the edges (Archaeological studies, 2020). As stated above, the central area is also problematical from an archaelogical point of view. Practically, in the last few years remains were found at every small-scale work that was carried out in the area.

Traffic congestion and the lack of parking spaces is just one of the problems of the city center. Among others, there is the degradation and pauperisation of the his centre's cultural landscape together degradation of heritage buildings with architectural value through inappropriate use or lack of capital, modernisation projects that do not respect the specificity of the place and the migration of luxury shops from the central area to peripheral malls (Marosi 2025, p. 121).

In the centre, even the sidewalks are crowded, making pedestrian traffic difficult, especially on Memorandumului Street where pedestrians have to struggle through the crowd of people waiting for the bus. This inconveniences negatively affect any activity and function in this area. The central area enconpasses several functions, from recreational (being dominant first in Ștefan cel Mare Square, secondly in Avram Iancu Square and Museum Square, next in Mihai Viteazul Square, in Union Square, and lastly in Lucian Blaga Square) through cultural (especially in Lucian Blaga Square, followed by Union Square, Ștefan cel Mare Square, Museum Square, Avram Iancu Square and Mihai Viteazul Square) to commercial function (more relevant for Mihai Viteazul Square, followed by Union Square, and Museum Square). In addition, civic function (highly prevalent in case of Union Square), religious function (Avram Iancu Square), symbolic function (Mihai Viteazul Square), the aesthetic function (Avram Iancu Square), historic function (Museum Square) and the transit function (Lucian Blaga Square) are also present (Marosi 2025, p. 133).

The metro line, together with the establishment of a pedestrian areas and walking zones could solve the problem of both transport and pedestrian congestion, as well as the parking issues, and can contribute to a better perception of the city center and improve the quality of time spent there by the citizens.



Identification codes of archaeological sites found on the proposed route of Cluj metro.

GIS ID.	Name	Identification number
1	"Şapca verde" archaeological site	RAN 57715.06
2	Calvaria archaeological protection zone	RAN 54984.26
3	Calvaria medieval fortress	RAN 54984.10
4	Hallstattian dwelling, Mănăştur Street	RAN 54984.25
5	Roman archaeological site, Memorandumului Street	RAN 54984.204
6	Tumulus necropolis of Cluj Napoca (Făget forest)	LMI CJ-I-s-B-06925
7	Archaeological ensemble of the ancient city of Napoca	RAN 54984.02
8	Neolithic settlement	RAN 54984.04
9	Roman road	RAN 54984.233
10	Roman necropolis, Cipariu Square	RAN 54984.01

Source: Studiu arheologic, 2020

Identification codes of built heritage elements found on the proposed route of Cluj metro.

GIS ID	Name	Identification number
11	Roman Catholic Church, Floresti	CJ-II-m-B-07616
12	Ethnographic Museum (Reduta-house)	CJ-II-m-B-07407
13	Knoblauch – Nemes-house	CJ-II-m-B-07408
14	Merza-house	CJ-II-m-B-07409
15	Public Finance Administration	CJ-II-m-B-07360
16	Tribunal and Court of Appeal	CJ-II-m-B-07316
17	Avram Iancu-house	CJ-IV-m-B-07838

Source: Studiu arheologic, 2020

Fig. 1. Proposed route of the Cluj Metro and its potential impact on archaeological sites and built heritage elements (source: Cluj-Napoca Local Council)

4. Technical challenges and soil caractheristics

In the city center area narrow streets, as well as the presence of archaeological and built heritage make almost impossible the ground-level works. But underground construction has also its challanges due to soil caractheristics.

Different types of natural risks local floods, large-size landslides, extended rainfalls and erosion due to over moistened soil cover are frequent in Cluj-Napoca and several surrounding rural localities (Surdeanu et al. 2006, p. 24). Geomorphic processes are among the factors restricting development, affecting built-up areas, transport infrastructure, and economic activities. In Cluj county, geomorphic processes consist mainly of active landslides that directly impact the accessibility of communities and their degree of safety, and of soil erosion which severely affects the output of land used for agriculture (Moldovan et al. 2024). One of the most common causes of landslides is erosion at the base of the slope, which can be caused by excavations for the construction of buildings or to access infrastructure (Moldovan 2004).

According to the North-West Region Development Plan, in 2017, an area of 95,500 ha was affected by landslides in the region; in Cluj county, the total area affected by natural processes in 2018 was 47,508 ha, which represents 50% of the entire region. Cluj County faces problems related to landslides and that updated studies are needed in the context of high urbanization rates, to avoid authorizing construction in areas susceptible to landslides (Moldovan et al. 2024). In Cluj-Napoca both types of landslide, primary and reactivated are encountered. The analysis of the landslide spatial distribution at the level of administrative units highlighted the existence of large areas affected by stabilized landslides with a certain potential for reactivation (Bilasco et al. 2011).

Through its diverse morphologic features, its specific land use and human activities, the entire Someş Plateau constitutes an area that favors the occurrence of landslides. The high and extreme susceptibility classes are well represented, among others, in the Cluj and Dej Hills regional unit. The changes in the slope morphometric elements and partially the land use changes are mainly determined by the presence of some mass movement processes (landslides, falling and rolling processes etc.), as they induce to their manifestation areas a certain degree of exposure. The increasing human pressure contributes to the above mentioned phenomena, with significant impact on residential areas, communication infrastructure and agricultural land use (Bilasco et al. 2011).

Landslides and other mass moving processes are related to the presence of salt and gypsum in the sedimentary basins, while some groups of clays have increased susceptibility to mass moving processes through the geochemical transfer, a fact proved also by the frequency of processes in such areas. Some clay minerals have a different behaviour depending on various climatic conditions. Therefore, during the long periods of drought, they present deep cracks, while in

the presence of water they get inflated and increase their volume considerably (reaching 150%). This upright game ends, in built-up areas, in fissures of the buildings (oblique cracks) that can lead even to their destruction. This phenomenon is also possible in the pile of rocks nearby, in such a manner that, through a slow circulation of the water from rainfalls, those critical cases that lead to the release of the mass movement process can be realized (Surdeanu et al. 2006, p. 24).

Identifying, monitoring and management of the areas affected by landslides represents a very important stage in context of territorial planning. Ensure the management of sensitive areas by means of preventive and risk remediation measures as well as the implementation of a special regime of construction in sensitive areas by temporary or permanent interdictions (Dolean 2017, p. 38). Even more so, Cluj-Napoca has a landscape with ecological equilibrium severely affected, while the landscape of Floresti is at the limit of the ecological equilibrium (Surdeanu et al. 2006, p. 27).

5. Urban transport and main urban routes

The route of the metro line can be devided in three main sections. The Western section follows the route of Șesul de Sus Street – Teilor Street – Liziera pădurii (between Eroilor Street and Subcetate Street) – Abatorului Street – Cazarmă Florești – future Regional Emergency Hospital – Răzoare Street with the following stations: 1. Țara Moților (Teilor), 2. Teilor (Eroilor), 3. Copiilor (Subcetate), 4. Sănătății (Spitalul de Urgență), 5. Prieteniei (Răzoare).

The center section would be located along Sfântul Ioan Road – Primăverii Sreet– Mănăștur Road – Moților Road – Memorandumului Sreet – Unirii Square – 21 Decembrie 1989 Boulevard – Avram Iancu Square – 21 Decembrie 1989 Boulevard – Mărăști Square with the following stations: 6. Natura Verde (Bucium), 7. Mănăștur (Izlazului), 8. Sfânta Maria (Câmpului), 9. Florilor (Cluj-Arena), 10. Sportului (Mihai Eminescu), 11. Piața Unirii, 12. Piața Avram Iancu, 13. Armonia (Petofi Sandor), and 14. Piața Mărăști.

The Eastern section has two branches, Muncii and Sopor. Muncii branch consists of Mărăști Square – Aurel Vlaicu – IRA – Beiușului Street – Muncii Boulevard with stations 15. Transilvania (Siretului), 16. Viitorului (IRA) and 17. Muncii. The Sopor branch goes along Mărăști Square – Teodor Mihali Street – Alexandru Vaida Voevod Street – Sopor, with stations 18. Cosmos (Alexandru Vaida Voevod), 19. Europa Unită (Becaș), respectively Sopor Depot.

Excavation works started from Sopor, as the first phase of the project – the depot and 9 metro stations – is due for completion in August 2026[8]. The Sopor area was an easy start from environmental point of view: there is wasteland and space to start the constuction, hence works cause less inconvenience. In contrast,

[8] The project is partly funded by the PNRR.

organizing construction works in Floresti, respectively the city center area will be a difficult and problematic task. The implementation of the project, with its estimated time span of about 10 years, even if it is divided in smaller phases, is not possible without closing routes and redirecting traffic in an already extremely crowded city center where traffic jams are an everyday problem. Withdrawal from the traffic one of the main routes, the Memorandumului and Motilor streets for years seems inpossible, as the amount of cars simply could not be devied through other routes. Parking would be another issue to solve, as well as the protection, or even relocation of the utilities.

A solution would be using a transfer type bus transport service, but with a frequency of even 2-3 minutes in the rush hours, which could fluidize also the pedestrian traffic. Currenty, the city center is extremely crowded even from a pedestrian point of view, especially in the proximity of the Memorandumului bus station, where pedestians have to cross those waiting for buses.

Reorganisation of the surface public transport network will be definitely unevitable not only in the implementation phase of the project, but also in order to integrate the new metro line in the transport system of the city. The metro stops are relatively densely distributed, close to each other, and this will have a direct and significant impact on the surface network.

6. Final remarks

The city has limited capacity to accommodate a strong surface rail (high-speed) line, as the road capacity offered is simply needed. In the case of Cluj-Napoca, the problem is that the city is wedged between major mountain ranges, making the replacement of main roads at all levels very difficult. Hence, an underground model could be an adequate solution, but it must be projected carefully. An inadequately prepared project leads not only to higher costs, but also to a prolonged implementation which couses inconveniences lasting for a longer period of time. The metro is also much more environmental friendly, in comparison with buses and cars, and can improve the overall life quality of the residents of Cluj-Napoca, but also of the neighbouring settlements.

From an urban mobility perspective, the city of Cluj-Napoca and its metropolitan area need an integrated planning strategy. The metro line will not solve the traffic problem of the whole metropolitan zone, probably not even the problem of Floresti, as crosses only the southern part of it. The transport system of Floresti needs to be projected so that its inhabitanst could reach easily the metro line.

The section within Cluj-Napoca follows the main traffic directions, connects two main residential areas, Mănăștur and Mărăști with each other and with the city center, and reaches the northern industrial district as well. But it needs to be integrated in a broader transport system. Currently, does not connect either the train station or the airport, and there istn't real possibilty for regional

bus or rail connections at neither endpoints, altough the National Territorial Planning Plan[9], the Territorial Planning Plan of Cluj[10], the General Urban Plan of the City of Cluj-Napoca, as well as the General Urban Plans of the Communes in the Cluj Metropolitan Area[11] refer to several development projects. Developments that can be integrated into other existing fixed-track systems, which are already part of the network, not only have a significantly higher overall value and potential, but they are also much cheaper due to the shared use, as in many cases the existing infrastructure is utilized, and the additional elements – such as depots – are not required separately.

As the metro line will pass through protected areas, adapting the stations to the character and architectural elements of the zone would be desirable. A late archaeological research could lead to a prolonged and more expensive implementation, or even to a need to change the original plan in terms of route.

The planned transport capacity – 15-20 thousand passengers per hour and 90-second intervals – is a huge one. The real need may be not achieve this number. A considerable part of the inhabitants is simply not located in the metro's catchment area. Moreover, such a development should not be planned specifically to replace surface transportation. It must be operated in cooperation with other transportation means in orther to maximize the capacity and value of the whole network[12].

The diversity of transportation is a strength of any urban settlement. Costs are an other risk of the project. On one hand, financing from the recovery fund was cut, on the other, compared to the scale of the city, the works involve such high costs that other transportation development projects could be delayed or cancelled for years. This would be a serious problem, as the metro can't solve all the traffic issues of the city.

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[9] Planul de Amenajare a Teritoriului Național (PATN) includes, among others the railway line Halmeu – Satu Mare – Oradea – Poieni – Cluj-Napoca – Apahida – Coșlariu, modernization works at Cluj-Napoca Airport, and odernization works at the Cluj-Napoca East combined transport terminal.

[10] Among other major projects with an impact on the Cluj Metropolitan Area, the Planului de Amenajare a Teritoriului (PATJ) Cluj includes the construction of the metropolitan beltway in the southern area of the city, which will facilitate traffic both within the city and from the communes of Căpușu, Gilău, Florești, Baciu, Cluj-Napoca, and Apahida.

[11] The proposed projects in the General Urban Plan (PUG) of Cluj-Napoca are those aimed at expanding the infrastructure towards the suburban/metropolitan area, thus completing the transportation system and aiming to streamline traffic: express Road Florești Bypass, intermodal hubs and regional urban train stations in Apahida, Sînnicoară, Airport, IRA, Clujana, Central Station, Tetarom, Baciu, as well as extension of the tram line in the commune of Florești.

[12] Feld 2024

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