Policy Study

Options for Railway Infrastructure Development in Tbilisi

Comparative Analysis of the Alternatives

This document was prepared by PMC Research Center in cooperation with "Urban Lab" under the *Public Policy Discourse and Dialogue Platform* project

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I convey my gratitude to all of the respondents, as well as everyone else who assisted in the carrying out of this study. Above all, I thank Irakli Labadze, whose consultations and recommendations aided me throughout the working process. I would also like to thank Lana Grdzelishvili for her help with structuring and editing.

The target audience of this document includes representatives from Tbilisi City Hall, Georgian Railway, the Government of Georgia, railway-related organizations, as well as various specialists working in the fields of transport, ecology and urbanism.

The paper was prepared in cooperation with "Urban Lab".

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Executive Summary

Tbilisi has been one of the key junctions within the national and regional junctions. Railway lines leading to Azerbaijan, Armenia, Georgia's Black Sea ports, and soon a major international line leading to Europe via Turkey, all converge in Tbilisi.

Didube and Nadzaladevi districts are the areas of the city most covered by railway infrastructure, where a large-scale logistics junction has been operating for several decades. Parts of these districts could now be considered as part of the city center, and the profile of this former industrial zone has changed significantly since the railway infrastructure was first built. The city's population has also increased significantly and, in some areas, residential properties are located very close to the railway tracks. This presents a variety of urban, environmental and safety-related challenges, which prompts the need to assess various alternatives for the development of railway infrastructure in Tbilisi in the future.

This study compares the following four alternatives: keeping the status quo (Option 1); the 2009 Tbilisi Railway Bypass Project (Option 2); a city tunnel from Navtlughi district to Didube district (Option 3); and retaining the city's main railway line and central station, but relocating all other railway infrastructure from the Didube-Nadzaladevi districts to the city's peripheral districts (Option 4).

A comparative analysis of the four alternatives will employ a multidimensional approach based on urban, safety-related, environmental and economic indicators. The urban dimension refers to the potentially freed-up land and the possibilities for its reuse, while the safety dimension refers to the conducting of a risk assessment with regard to the potential impact on the population in the event of a rail accident or spillage/release of products. The environmental dimension refers to the conducting of an environmental impact assessment for noise, vibration levels, as well as possible spillage/release of products, and the economic dimension entails a comparison of railway operation costs, capacity, impact on passenger transfer and on railway-dependent enterprises, as well as implementation costs for each of the proposed alternatives.

This study does not aim to present a final verdict regarding the proposed models of railway infrastructure development in Tbilisi, which are examined herein. The purpose of the conclusions and recommendations presented is rather to stimulate a wider discussion on the subject among wider society, public sector representatives, stakeholders and specialists.

According to this study, the option of keeping the current railway infrastructure as it is in Tbilisi scored the lowest for effective usage of urban areas, impact upon population near the railway in the event of an accident, and ecological contamination of the city center. Therefore, the need for change is clear.

The railway bypass (Option 2) scores higher than the status quo in terms of urban dimension, impact upon population near the railway in the event of an accident, and ecological contamination of the city center. However, this alternative carries the risk of contaminating Tbilisi Sea in the event of an accident and long-term damaging effects on railway operating costs and capacity. This option would also bring accessibility problems for some of the city's districts and for railway-related enterprises. Taking these obstacles into account, neither keeping the status quo nor reviving the railway bypass are recommended as optimal options for Tbilisi's railway infrastructure development.

Among the discussed alternatives, the city tunnel (Option 3) scored the highest in terms of urban, safety, and environmental dimensions. Should this option be implemented, the main railway line between Navtlughi and Didube would be moved below ground through a tunnel, thereby freeing up around 70 ha of land by relocating railway infrastructure to Avchala and Africa districts. This alternative would reduce the negative environmental impact upon settlements near the railway in the event of an accident.

The city tunnel alternative also has its flaws though such as higher railway operation costs compared to the status quo, very uneven access to the main passenger station from some of the city's districts, loss of access to the railway for some railway-related enterprises, and high construction costs. However, on balance, this is the best of the four alternatives.

The second best alternative, after the city tunnel, would be the partial relocation of the railway from Didube and Nadzaladevi districts. For this alternative, the environmental impact would be reduced with less noise and vibration near settlements, there would be equal access to the main passenger station from the city's various districts, and depots and freight stations would be relocated to Avchala and Africa districts. This alternative would be an improvement upon the status quo with regard to urban, safety, and environmental dimensions and is better than the city tunnel alternative in the economic dimension as it would incur lower operational costs, improve the accessibility of various districts to the central station, decrease the negative impact on railway-related enterprises and would entail lower construction costs overall.

Although the partial relocation of the railway (Option 4) recorded a similar score compared to the railway bypass (Option 2), the former represents a more favorable option with regards to all of the economic and safety parameters discussed in this study.

Finally, in terms of urban, safety, and environmental dimensions, the city tunnel alternative represents the best option for Tbilisi.

Introduction

Ever since Georgia started operating a railway, Tbilisi has been one of the key junctions within the national and regional junctions. Railway lines leading to Azerbaijan, Armenia and Georgia's Black Sea ports converge in Tbilisi. Soon these will be joined by a major international line leading to Europe via Turkey, while the railway in Tbilisi also forms part of the east-west transport corridor known as the Silk Road.

However, a number of challenges exist related to the railway infrastructure in Tbilisi and there has been much discussion regarding the best way forward in this regard. This study aims to examine several possible alternatives for railway infrastructure development in the city and presents a comparative analysis taking into careful consideration the urban, safety, environmental, and economic dimensions.

The main recommendations arising from this study are to alter the existing railway setup in Tbilisi, to move the depots and the freight station to the outlying districts of Avchala and Africa, to hand the freed-up space over to the city, and to retain the central (double-track) railway line while undertaking noise insulation and safety measures (or move the central line through a tunnel from Navtlughi to Didube).

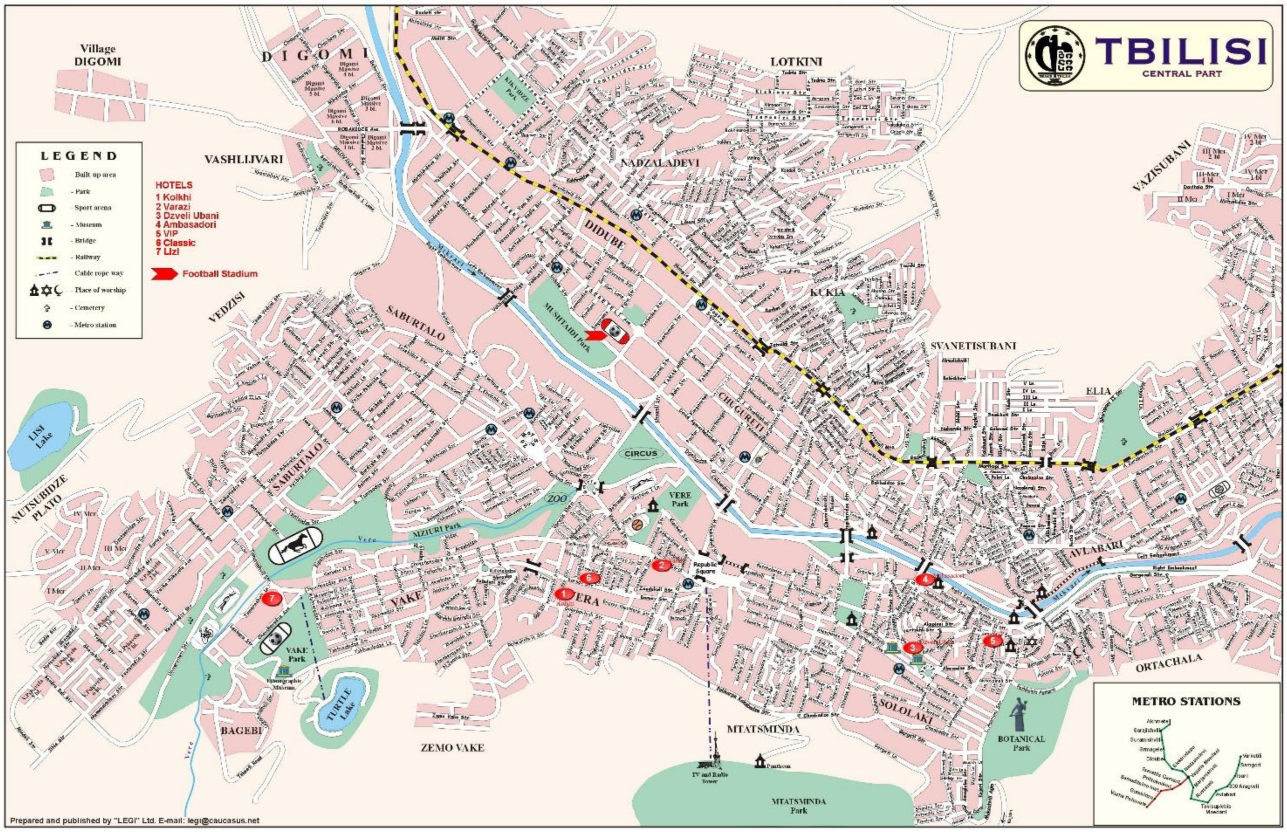
This study does not aim to present an objective and comprehensive verdict regarding the proposed models of railway infrastructure development in Tbilisi which are examined herein. The goal of the conclusions and recommendations presented is rather to stimulate a wider discussion on the subject among the wider society, public sector representatives, stakeholders and specialists.

Part One of the document provides an overview of the existing situation and the problems regarding the railway infrastructure in Tbilisi. Part Two describe the methodology of the research. Part Three examines four alternative courses of action. Part Four will provide comparative analysis of the alternatives based on various criteria. The final part, Part Five, contains a summary, as well as recommendations.

Problem Description

Georgian Railway transports 2.7 million passengers[1] and 10.7 million tons of freight[2] annually (2017). The largest parts of both groups are served by Tbilisi, where railway line covers 28 km of track. Several passenger and freight stations are located within the city limits, together with other necessary infrastructure. Dozens of organizations use the city's railway sidings, containers and oil terminals.

Map 1. Tbilisi Section of Georgian Railway. Source: maps.gol.ge



Didube district is the largest area covered by railway, where a large-scale logistics junction has been developed over several decades. Parts of this territory now form a part of the city center, and the profile of this former industrial zone has changed. The city's population has increased and, in some areas, residential accommodations are now located very close to the railway tracks. This presents a variety of urban, environmental and safety-related challenges.

An increase in the city's size, population, traffic flows and land prices has prompted some suggestions that land currently occupied by railway could be put to more beneficial use for the city's residents.

[1] Georgian Railway, 2018a.

[2] Georgian Railway, 2018b.

According to some experts, in addition to these areas being used ineffectively, Tbilisi's railway tracks and infrastructure present several other problems for the city.

The main problems linked to the existing railway infrastructure within the limits of Tbilisi Municipality can be sub-divided into the following main groups: 1) urban; 2) safety-related; 3) environmental; and 4) economic.

Urban problems arise from the city being divided in two and the unavailability of land that would be valuable for the city's development. Some experts are also of the opinion that the current railway infrastructure creates an artificial barrier for transport links between the districts situated on either side of it.

Safety-related problems largely relate to explosive materials being transported close to the city's residential areas. The majority of rail freight passing through Tbilisi contains oil products, and this passes very near residential areas.

The main sources of environmental pollution from the railway include gases formed from oil vapour during the transportation of oil products, the spillage of lubricants and fuel into the soil at the depots and stations, as well as exhaust fumes produced by diesel locomotives. Noise pollution is also a source of significant discomfort for those residing in the close vicinity of the railway, particularly in Didube and Nadzaladevi districts. Furthermore, there is the risk of accidents which may lead to fuel or other chemicals polluting the soil and groundwater, as well as various toxic elements and gases being released into the air. The extent and speed at which they may spread would depend on the specific meteorological circumstances at the time of the accident and during the clean-up period.

Economic problems are brought about by the ineffective use of valuable land in the city center. The market value of the land in question is high due to its central location, while only a fraction of this land is being effectively used for railway purposes. Indeed, the railway station located near the boundary between Didube and Nadzaladevi districts, covering an area of 30 ha[3], is only being used for parking decommissioned units.

[3] Based on map measurements.

Methodology of Research

This study will compare the following four scenarios: keeping the status quo (Option 1); the 2009 Tbilisi Railway Bypass Project (Option 2); a city tunnel (Option 3); and retaining the city's main railway line and central station, while relocating all other railway infrastructure from the Didube-Nadzaladevi area to the city's peripheral districts (Option 4).

When selecting the railway infrastructure development alternatives for examination, various factors and parameters have been taken into consideration. Option 1 represents the status quo and is therefore regarded as the most simple option, against which the other three alternatives (and their various parameters) will be compared. Option 2 constitutes a partially implemented but currently mothballed railway bypass project. It is the only alternative, aside from Option 1, for which the exact technical and economic parameters are known. Option 3 (tunnel) was chosen because the step of moving specific sections of railway underground for the purpose of freeing up space has been used successfully in numerous cities such as Vienna[4], Leipzig[5], New York[6], Washington[7], and Beijing[8]. Option 4 comprises a combination of individual components taken from the other alternatives. This study will not discuss the alternatives examined during the planning of the 2009 Tbilisi Railway Bypass Project, since a comparative analysis of these options has already been presented in the Environmental and Social Impact Assessment (ESIA) of said project.

The comparative analysis of the four alternatives will employ a multidimensional approach based on urban, safety-related, environmental and economic indicators. In this paper, the urban dimension refers to the potentially freed-up land and the possibilities for its reuse such as by setting up new traffic corridors. The safety dimension refers to the conducting of a risk assessment on the impact on the population in the event of a rail accident or spillage/release of products. The environmental dimension refers to the conducting of an environmental impact assessment for noise, vibration levels, as well as possible spillage/release of products. The economic dimension involves comparing railway operation costs, capacity, impact on passenger transfer and on railway-dependent enterprises, as well as implementation costs for each of the proposed alternatives.

We will be using a ranking system based on points on an ordinary scale to evaluate each of the alternatives. Each alternative will be marked on a scale from 1 point to 4 points, whereby 1 represents the best option, while 4 represents the worst. Should more than one alternative have the same or

[4] OBB, 2009.
[5] Preißinger, K. W., 2009.
[6] Schafer, M; Solomon, B., 2009.
[7] The Virginia Avenue Tunnel.
[8] Beijing Underground Cross City Railway.

similar parameters, then they will be awarded the same number of points. The ranking process will be based on quantitative data wherever such data is available. In cases where quantitative data is unavailable, subjective assessment will be used. Even though the parameters have varying contents, are made up of varying numbers of sub-components, and are measured on different scales, the points will not be weighted due to the lack of an objective weighting system. The final assessment will be based on the total number of points scored, with the option with the lowest number of points being selected as the best option.

The limitations of the research include a lack of detailed technical and economic parameters and exact construction cost data for Options 3 and 4. Technical feasibility assessment and budget estimates for these alternatives would only be possible after detailed planning has taken place. Due to the lack of exact parameters (routes and other technical and economic indicators), we will use examples of similar projects in other countries to deliver an approximate assessment of how these options would work out in Tbilisi, or indicate the expected changes compared to Options 1 and 2. In addition, the project and its costs will be significantly affected by local geological, geographical, hydrological, infrastructural and other factors. Therefore, only an approximate evaluation of the project parameters is possible. Meanwhile, we have been unable to obtain information from Georgian Railway regarding several technical and economic parameters of Options 1 and 2. Therefore, we used qualitative evaluation instead of quantitative variables when comparing the alternatives.

The assessment is also limited due to its subjectivity and the awarding of unweighted points on the same scale to varying factors. In spite of these limitations, this system of assessment was the most suitable option given the lack of more objective tools with which to identify and select the best alternative. Furthermore, with regards to individual parameters for which we lack sufficient data to include them in the evaluation process, we will indicate (where appropriate) their value and the need for them to be taken into account in any future discussions. In light of the aforementioned limitations, the primary aim of this study is to stimulate discussion, rather than to deliver a definitive verdict on the issue.

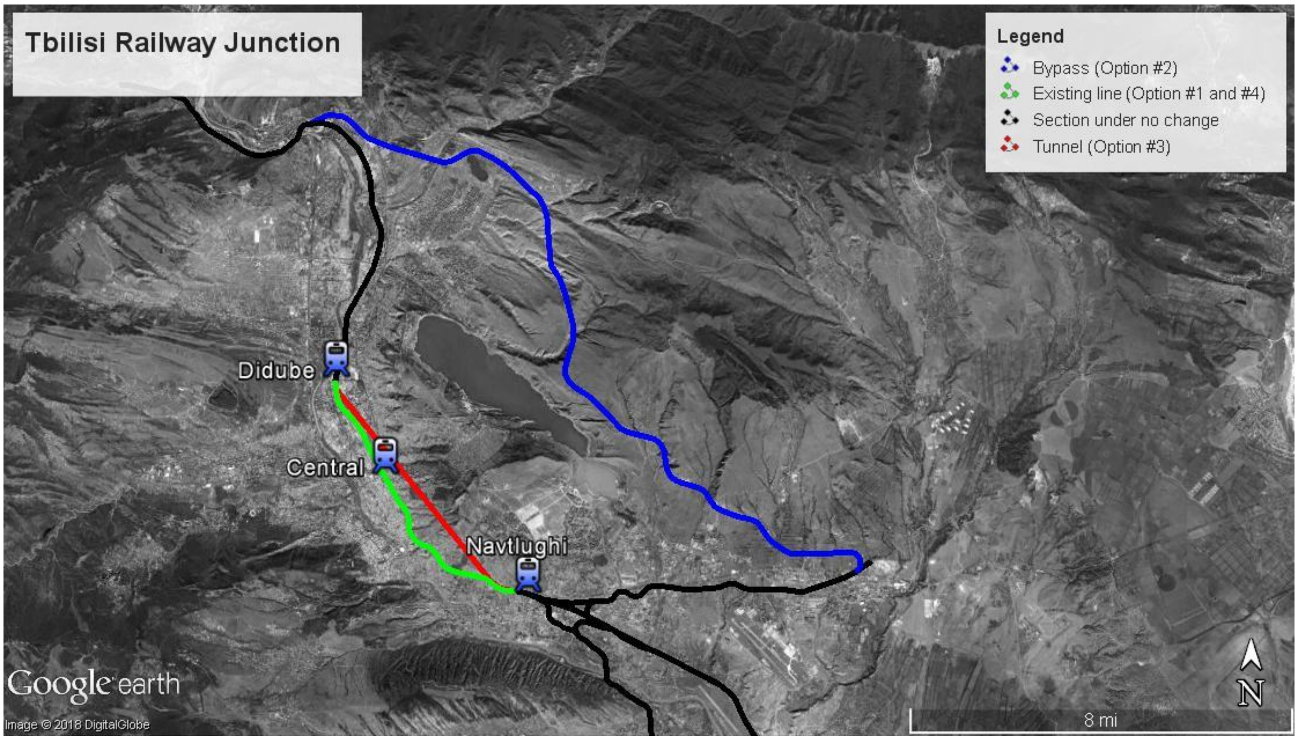
The sources used for this study include analysis of secondary materials (articles, reports and consultation documents), map analyses and measurements taken from satellite photos, as well as semi-structured, in-depth interviews with relevant specialists.

It is international practice for railway-related cost estimates to be given in Swiss Francs. However, for the purposes of comparison and understanding, we will be using US Dollars instead. Price conversions will be conducted using the average official exchange rates for the dates on which the cost estimates were produced.

Description of the Alternatives

In this chapter, we describe the following four options (alternatives): the status quo; the railway bypass; the tunnel; and the partial relocation of the railway. In addition, the affected routes, infrastructure and key technical indicators will also be presented.

Map 2. Tbilisi Railway Junction. Satellite Photo: Google Maps

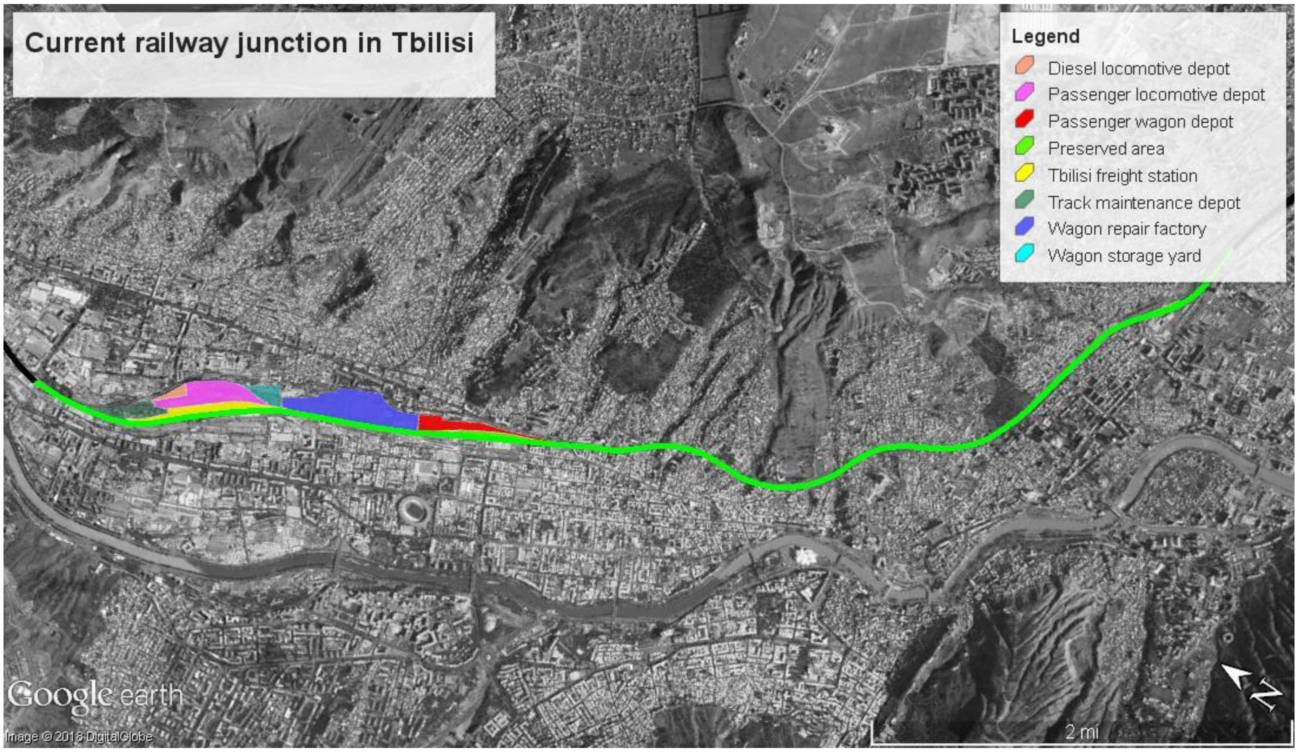


Option 1: Status Quo

This option involves retaining the status quo. At present, the railway in Tbilisi stretches from Zahesi (Upper Avchala HES) on the left bank of the Mtkvari River to the city's Africa district. From Tbilisi, the railway lines split into the following four main directions: towards the Black Sea; towards Georgia's eastern region of Kakheti; towards Azerbaijan; and towards Armenia. The latter three lines depart from Tbilisi-Sakvandzo station ('Junction station') in the Navtlughi district in eastern Tbilisi. The Armenia line is due to be extended towards Turkey in the near future (see Appendix 1 for details).

The Tbilisi railway junction includes 11 stations (see Appendix 2) accommodating a mixture of freight and passenger transport, railway infrastructure maintenance works and its safe operation.

Map 3. Central Part of the Tbilisi Railway Junction. Satellite Photo: Google Maps



Option 2: Railway Bypass

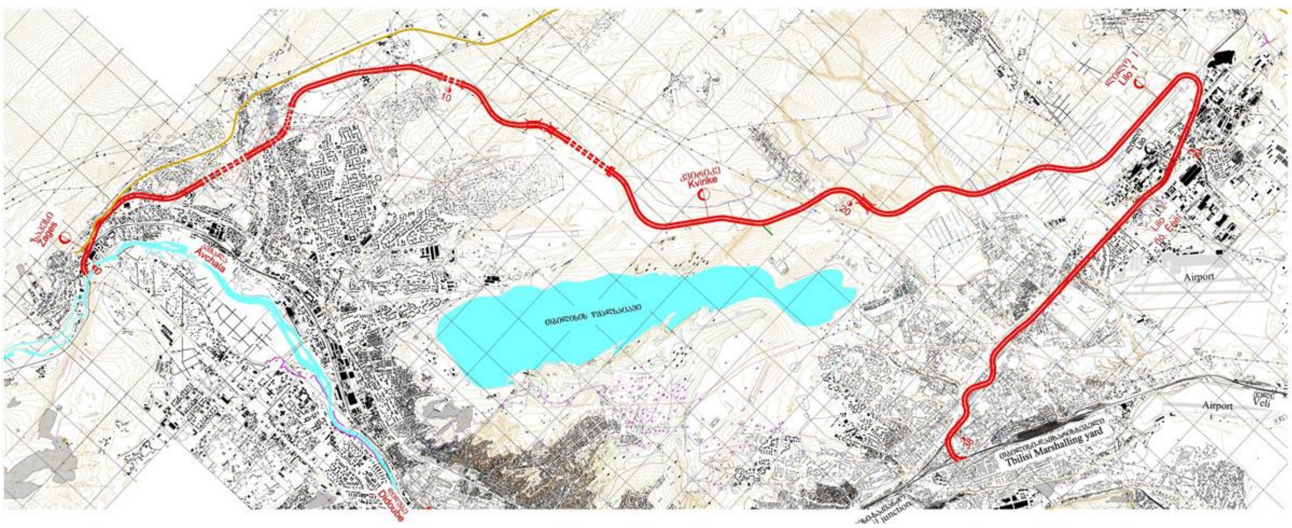
In order to address the environmental, urban and safety-related problems associated with the railway in Tbilisi, the Tbilisi Railway Bypass Project was launched in 2009 with its implementation starting in 2011. The project envisaged dismantling 10km of railway track and other infrastructure (stations, depots, sidings, etc.) in the city center and moving them north of Tbilisi Sea. Freight transportation was to be moved from the marshalling yard in Africa district to a 27km section north of Tbilisi Sea, joining up with the western line at Zahesi. Tbilisi Central station was to be closed as part of the project with the Didube and Navtlughi stations to be renovated instead, serving passengers travelling east and west.

If implemented successfully, the project would have freed up 73 ha of space for urban development[9]. This space was then to be used for the building of residential and commercial properties, as well as a major road. The project was being carried out by China Rail 23rd Bureau Group and JSC Khidmsheni[10]. Its initial cost was CHF 303 million (USD 283 million as per the 1 January 2009 exchange rate), later rising to USD 350 million.

[9] Georgian Railway, 2009b.
[10] Transparency International, 2016.

The project was to be completed by the summer of 2013. However, construction of the railway bypass was brought to a halt in 2012, by which point construction works amounting to approximately USD 213 million (60% of the total project) had already been carried out[11]. The cost of completing this project has been estimated at USD 137 million[12]. Unfavorable technical and economic indicators have been cited as the reasons for the project being stopped. More specifically, a study conducted by a consulting firm showed that the bypass, had it been implemented fully, would have increased the operational costs on the Tbilisi railway section by 57%, while also reducing the daily freight capacity on the same section by 25%[13].

Map 4. Tbilisi Railway Bypass Route. Source: railway.ge



Option 3: Tunnel

The option of building a tunnel was considered at an early planning stage of the 2009 Tbilisi Railway Bypass Project, but was ruled out due to safety concerns[14].

As the railway bypass project focused on freeing up land between Navtlughi and Didube from railway infrastructure, we will also consider placing the tunnel in this section. Should this option be implemented, the main railway line between Navtlughi and Didube would be moved below ground through a tunnel, thereby freeing up land by removing railway infrastructure. Satvirto station ('Freight station') and the container terminal would either be removed, or relocated to the city's Africa district, while the passenger and diesel locomotive and wagon depots would be moved to Avchala district.

[11] Georgian Railway, 2013.
[12] Ibid.
[13] MC Mobility Consultants, 2013.
[14] Georgian Railway, 2009b.

Implementing this option would entail the closure of Central station, and in Navtlughi station serving passenger trains. In total, more than 70 ha of land would be freed up in the districts of Didube, Nadzaladevi, Chughureti and Isani.

At this stage, it is not possible to provide exact parameters for the tunnel. However, we believe that, at the shortest, the tunnel would be approximately 9.5km long.

Option 4: Partial Relocation of the Railway

Option 4 represents a compromise between Options 1 and 2. Like Option 1, it involves retaining the city's double-track electrified main line and Central station. But it also entails the land between Navtlughi and Didube stations being cleared of railway infrastructure (similar to Option 2). All stations other than Central station, depots, sidings, freight terminals and other railway-related facilities would be partly closed and partly relocated to the city's peripheral areas. Unlike Option 2, the city's main line would be retained, and the railway bypass route would not come into effect. The length and the radius of the main line would remain the same as in Option 1. Consequently, operational costs and capacity would also remain unchanged.

The freight station would be relocated to the Africa district, east of the marshalling yard. The container terminal, as well as the locomotive and wagon depots, would also be relocated. In total, more than 60 ha of land would be freed up.

Option 4 would involve noise insulation and safety measures being implemented across the full length of the main railway line in Tbilisi. Jointless tracks (CWR)[15] would be installed within the city limits, and noise insulation screens would be installed close to residential areas.

[15] Jointless (continuously welded) tracks reduce noise and vibration of a moving train.

Analysis of the Alternatives

In this chapter, we will compare the four alternatives described above from urban, safety-related, environmental and economic perspectives. Existing relocation projects involve the dismantling of railway infrastructure between Navtlughi and Didube. Therefore, we will also be focusing on this section, except when the proposed changes affect a more extensive section. Whenever accurate quantitative data is unavailable, we will state whether the specific figure is likely to increase or decrease in relation to other options. Each option (alternative) will be assessed on a scale of 1 to 4 points, whereby 1 represents the best option, while 4 represents the worst.

Urban Dimension

The focus of the urban dimension is to compare the amount of space that would be freed up by each alternative option for residential, recreational and commercial use, as well as for transport corridors (major roads or light rail), by removing railway infrastructure.

In the case of **Option 1,** no additional space would be freed up. Therefore, it would be impossible to carry out any new infrastructural or recreational projects on the land in question. This option is the least attractive with regards to urban development. Moreover, it restricts the possibilities of establishing new transport facilities in the city.

In the case of **Option 2,** approximately 73 ha would be freed up[16]. This land could then be used for residential, commercial and recreational purposes[17]. In accordance with the Tbilisi General Land Use Plan, part of the available land could be used to establish a transport corridor – specifically, a major road and light rail transit (LRT) line serving the Gardabani-Rustavi-Tbilisi-Mtskheta route[18]. Together with Option 3, this alternative frees up the most land. However, in contrast to Option 3, it occupies an area north of Tbilisi Sea, which could potentially be used for recreational purposes. With regards to freeing up space and creating opportunities to establish transport corridors, this is the second most favorable alternative.

In the case of **Option 3,** around 73 ha would also be freed up, akin to Option 2. The cleared space could be used for residential, commercial and recreational purposes. This alternative also offers the possibility of establishing a transport corridor. In contrast to Option 2, it does not occupy any additional land north of Tbilisi Sea. With regards to freeing up space and creating opportunities to establish transport corridors, this is the most favorable alternative.

[16] Georgian Railway, 2009b.
[17] Georgian Railway, 2009a.
[18] City Institute Georgia, 2017.

In the case of **Option 4,** approximately 60 ha of land would be freed up[19], which is less than in the cases of Options 2 and 3, as Central station and the main line would be retained. In this case, the possibilities in terms of using the vacated space to establish a transport corridor would be limited. According to Options 2 and 3, such a corridor would mainly be established in place of the main railway line, yet Option 4 would not entail the removal of the main line. However, Option 4 does allow for the possibility of establishing a transport corridor in a different way. This would involve reviving and implementing a 1980s project which was halted, whereby the Kakheti Highway (George W Bush Avenue) would be linked to Tsotne Dadiani Avenue through an overpass above the main railway line.

Unfinished overpass above the railway line in Svanetis Ubani. Photo: Roman Khatoev, 2013

Completing the overpass would potentially allow for the establishment of transverse transport corridors and connecting them to the new longitudinal overpass, which would not be possible if Option 1 was chosen. However, building links of this kind would be more costly than Options 2 and 3, since two-level crossings would have to be constructed on the main railway line. Therefore, with regards to freeing up space and establishing transport corridors, Option 4 is better than Option 1, but it is more

[19] Based on map measurements.

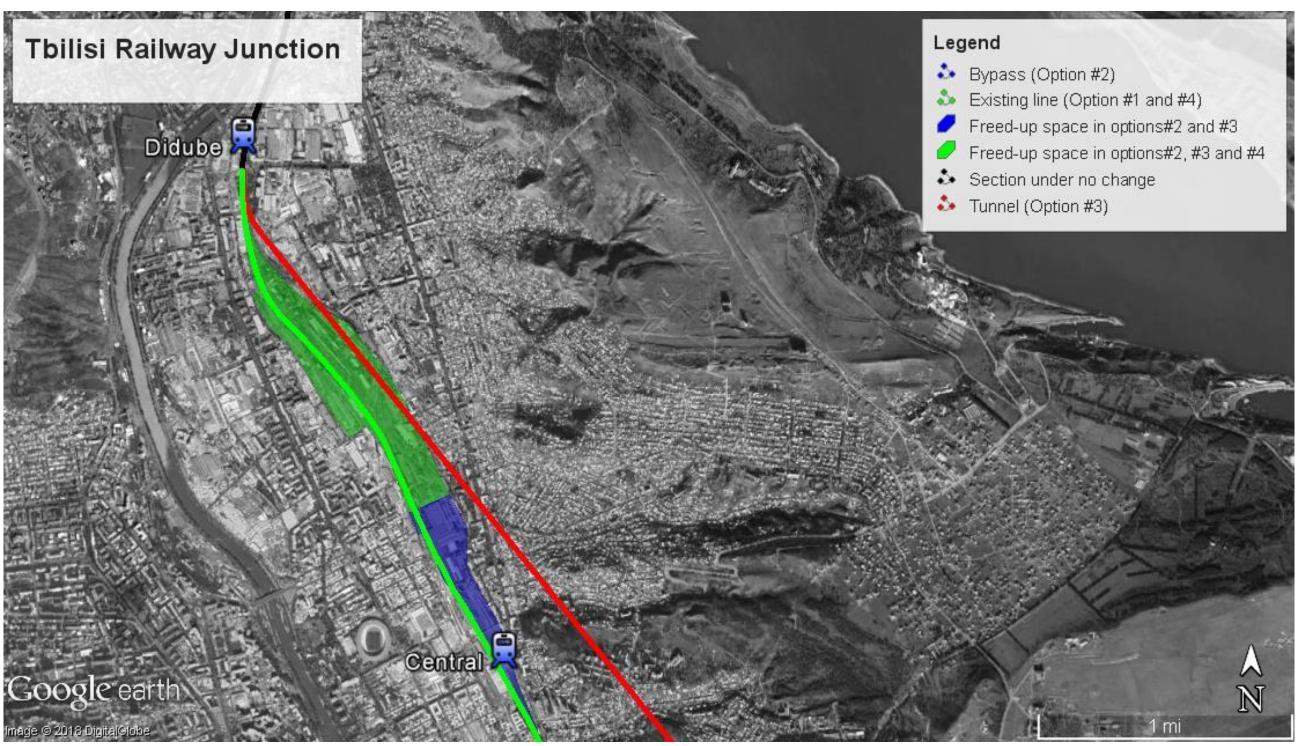
expensive than Options 2 and 3. Even in the cases of Options 2 and 3, a two-level crossing would have to be constructed in the Didube-Nadzaladevi area in order to cross the open metro line.

Summary: Options 2 and 3 would free up the most space (more than 70 ha). Option 4 would free up approximately 60 ha, while Option 1 would not free up any space. In the cases of Options 2, 3 and 4, land would be occupied in the Avchala and Africa districts in return for freeing up space in the city center (Didube and Nadzaladevi), while Option 2 would also involve occupying currently uninhabited land between Zahesi and Lilo, north of Tbilisi Sea. The latter three options would all have a more significant infrastructural impact while also freeing up valuable land.

In contrast to Option 1, not only do Options 2, 3 and 4 entail making valuable land available by clearing railway infrastructure to make way for residential, commercial and recreational concerns, but they would also potentially enable the establishment of transverse and longitudinal transport corridors to connect currently divided parts of the city. Establishing such links would be more expensive in the case of Option 4, compared to Options 2 and 3.

Urban Dimension	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Rank	**4**	**2**	**1**	**3**

Map 5. Areas Affected by the Four Offered Alternatives. Satellite Photo: Google Maps



Safety Dimension

Most railway freight in the Tbilisi area comprises oil products, which pass in the immediate vicinity of the Metromsheni, Elia and Svaneti districts. In these locations, the railway passes through a pit, thereby somewhat mitigating the risk of harm to the population in the event of an accident. In other sections, however (e.g. in Isani district), the railway runs over embankments, which would potentially endanger the local population in the event of an accident. The distances between the railway and the residential districts range between a few meters and several tens of meters. A total of 95 accidents of varying severity took place on Georgian railways between 2003 and 2009[20].

Statistics show that the main causes of railway accidents and fires include technically out-of-date rolling stock, poor condition of railway track, freight being packaged with low-quality fireproof materials and the violation of regulations regarding transportation of dangerous goods. Railway accidents may result in derailment and could lead to fuel tanks exploding. Based on the EISA of the Tbilisi Railway Bypass Project, the critically dangerous area in the event of an explosion (with the possibility of heavy damage and lethal consequences) is located within a 0-300/400m radius of the source of the explosion, while the area within a 400-700m radius would likely be subject to relatively light damage.

In the case of **Option 1,** the railway would continue to pass by residential areas at a closer proximity than is allowed by safety norms. This is the least safe of all of the alternatives.

In the case of **Option 2,** some sections of the railway would pass residential areas at a closer proximity than is allowed by safety norms. However, since these sections would mainly be used for passenger transport, this option is relatively safe. Meanwhile, this option does not remove the possibility of accidents on the section north of Tbilisi Sea where it would be possible for oil products to seep into the Tbilisi Water Reservoir, which forms part of the city's water supply[21]. Although this option is safer than Option 1, the scale of possible damage to Tbilisi Sea from fuel contamination in the event of an accident[22] leads us to believe that this is the third safest of the alternatives.

In the case of **Option 3,** some dangers would be posed by an accident taking place inside the tunnel. According to the EISA of the Tbilisi Railway Bypass Project, tunnel-related risks in the event of an accident include a large-scale environmental disaster and the high possibility of large-scale pollution of groundwater and soil[23]. Furthermore, due to the difficulty of dealing with the consequences of an

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[20] Georgian Railway, 2009.
[21] GWP website.
[22] Green Alternative, 2014.
[23] Georgian Railway, 2009.

accident inside the tunnel, this could completely paralyse the Georgian railway junction for several days or possibly even weeks.

Nevertheless, tunnels are widely used in rail junctions across the world, and there are safety systems (e.g. fire detectors, automatic fire extinguishers, emergency exits, etc.), which could mitigate some of the possible consequences of an accident[24]. Therefore, we consider this to be the safest option, since the direct impact on the population would be less than for the other options.

In the case of **Option 4,** the situation is similar to Option 1, with the difference being that clearing the Didube area of railway infrastructure would increase the distance between residential areas and the railway, thereby increasing the level of safety. It would also be possible to mitigate the impact of a possible accident upon the population by erecting protective barriers. In light of the possible scale of a possible accident, we consider this to be the second safest of the alternatives.

Summary: The advantage that Option 2 has over the other alternatives is that the distance between the railway and residential areas would be greater. At the same time, Option 2 carries the potential danger of Tbilisi Sea being polluted by chemicals or oil products in the event of an accident. Tbilisi Sea supplies drinking water to part of the city's population, therefore we assess this risk as critical. The other options do not bear the same risk. In the case of Option 3, an accident could damage the settlements located above the tunnel, and it was precisely for this reason that the tunnel option was ruled out in 2009. Further safety challenges would be presented by the difficulty of cleaning and clearing up the aftermath of an accident inside the tunnel, leading to the potential paralysis of a section of the country's railway junction for a period of days or weeks. At the same time, Option 3 does not carry the risk of explosion and/or release of toxic chemicals into the air in the direct vicinity of residential areas as a result of an accident, a risk that is present in Options 1 and 4. Therefore, Option 3 looks to be the optimal choice in terms of safety. For Option 4, the risk is mitigated by downsizing the railway infrastructure and constructing protective barriers in Didube-Nadzaladevi district.

Safety Dimension	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Rank	**4**	**3**	**1**	**2**

[24] Interview with the City Institute representative.

Environmental Dimension

Railway-related environmental risks include ground pollution from fuel and lubricants, noise pollution, vapour generated by oil products, as well as exhaust fumes produced by diesel locomotives. We will not be discussing the risks of pollution for Tbilisi Sea here, as this has already been discussed within the safety dimension section.

Option 1 would continue to involve an area of more than 70 ha being polluted by stations and depots, as well as by spilled fuels and lubricants. The areas most affected by pollution from rolling stock include the marshalling yard in the Africa district, the junction station in Navtlughi, Central station, as well as the freight stations located between the districts of Nadzaladevi and Didube. Based on measurements taken 10 years ago, the level of noise in the vicinity of Central station exceeds permissible norms by 2-4 times both during the day and at night[25]. This is the worst of the available options.

In the case of **Option 2,** the situation in terms of environmental pollution (ground pollution, noise, smell, etc.) would not change in the areas around the marshalling yards and junction stations. However, railway-related pollution would cease in the areas around Central station and the freight station. At the same time, new sources of pollution would emerge around the railway bypass line north of Tbilisi Sea, as well as around the new stations of Kvirike and Lilo-2. Due to the distance from this line and the stations to residential areas, the direct impact of pollution upon the population would be less severe than in the case of Option 1. Noise levels would decrease across Tbilisi as a whole but would increase in the districts of Gldanula and Lilo, which would be located near the bypass line. Furthermore, new sources of pollution and noise would emerge in the districts of Avchala and Africa as a result of the relocation of the depots and freight terminals. Since these districts are relatively sparsely populated, the pollution would affect fewer people than in the case of Option 1. If the railway was to be replaced by a major road, then the level of noise near the districts that are currently located along the railway route is likely to actually increase, rather than be reduced.

Option 3 presents a more encouraging outlook regarding environmental pollution than all of the other alternatives. Like Option 2, there would be almost no environmental or noise pollution in the section between Didube and Navtlughi. Moreover, there would be no additional sources of pollution north of Tbilisi Sea, as would also be the case with Option 2. However, new sources of pollution would emerge in the districts of Avchala and Africa. Furthermore, Option 3 would carry the additional risk of pollution in the form of noise and dust generated during the construction of the tunnel. This would be a

[25] Georgian Railway, 2009a.

temporary source of pollution that would cease once the tunnel became operational. If a major road was to be built, then the level of noise near the settlements that are currently located along the railway route is likely to actually increase, rather than be reduced.

In the case of **Option 4,** the current level of environmental pollution would remain in the Central station area. Compared to Option 1, the level of pollution would be significantly reduced in the districts of Nadzaladevi and Didube by the removal of the Freight station. Only the double-track main line would remain in the latter's place. As with Options 2 and 3, new sources of environmental pollution would emerge around the new rail depot in Avchala, as well as in the Africa district and the Veli station area, to where the infrastructure from the current marshalling yard and freight stations would be partially relocated. Option 4 would entail utilizing noise insulation screens and jointless tracks to reduce noise and vibration levels in the vicinity of residential areas. If a major road is to be built, then the level of noise near settlements is likely to increase, rather than be reduced. From an environmental point of view, we consider this option to be the third best among the alternatives.

Summary: Regarding negative effects on the environment, as well as noise and vibration levels, Options 2 and 3 offer the most encouraging figures, as freight transport would be almost completely removed from the city limits in both cases. Passenger transfer would also cease in the city center. Furthermore, while Option 2 would establish new potential sources of environmental pollution (Gldanula and Lilo), this would not be the case with Option 3. If, upon the implementation of Options 2, 3 or 4, the railway line is replaced by a major road, then the noise levels for nearby settlements would not be reduced and could actually increase.

Environmental Dimension	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Rank	**4**	**2**	**1**	**3**

Economic Dimension

The economic dimension will examine the operational costs, capacity, impact on passenger transfer and on railway-related enterprises, as well as the expected implementation costs for each of the alternatives.

Operational Costs

The railway's operational costs include: the costs of maintenance and repair works on bridges, tunnels and other buildings, stations, rail track, contact network, as well as regular maintenance and repair of signals, communications and other systems; the costs of servicing the locomotive and wagon fleet; electricity and fuel costs; staff salaries; and other costs of operating the railway. The magnitude of the operational costs depends on numerous factors, including the length and gradient of the railway, the number of buildings attached to it, as well as the impact of external factors upon railway infrastructure.

The MC Mobility report describes the operational costs and capacity figures for the railway bypass (Option 2 in this document) and for keeping the status quo (Option 1). We will use the data from this report to compare Options 1 and 2. We will discuss Option 3 without any specific numbers, since no such final project has been submitted and its exact parameters are unknown. We will use data from Option 1 in order to examine Option 4, since the main railway line's length, gradient, radiuses and other technical parameters would be the same.

Option 1: For the 11-year reporting period required by the Austrian consulting firm MC Mobility in its study of the technical and economic parameters of the railway bypass, the total operational costs amounted to USD 126 million[26].

Option 2: The operational costs for the Tbilisi section of railway amounted to USD 198 million for the 11-year reporting period, which is 57% higher than for Option 1[27]. The increase in costs is mainly due to the higher electricity costs as a result of the higher gradient, the increased wear and tear of the rolling stock, and the regular servicing costs of the railway line.

Option 3: In this case, the operational costs are not publicly known at this stage. However, the 2009 EISA, which examined the viability of the tunnel option, stated that this would be the shortest of all proposed bypass alternatives, and would therefore reduce the costs of transporting goods[28]. In comparison with the status quo, we can presume that the costs of servicing the infrastructure would increase due to the additional costs of servicing the tunnel (protection from groundwater, ventilation, lighting, repairs, etc.). We are currently unable to specify the costs of servicing the tunnel, but we can use the data from the MC Mobility report as a guide. On average, the servicing of all existing tunnels on the bypass route (total length: 4.037 km) costs USD 253 000 annually, which should mean that the cost of servicing 1km of tunnel would amount to approximately USD 63 000 per year. The estimated length of the tunnel in Option 3 is approximately 9km (the shortest distance from Navtlughi to Didube). Therefore, an annual cost of approximately USD 550 000 (9 x 63 000) for servicing the tunnel is added to the amount in Option 1, which is still less than in the case of Option 2.

[26] MC Mobility Consultants, 2013.
[27] Ibid.
[28] Georgian Railway, 2009.

Option 4: The operational costs would be similar to Option 1, since the railway line's technical and economic parameters would be unchanged. In Option 4, the length of the railway section under review (marshalling yard to Zahesi) is 24km (compared to Option 2, which is 40km). The technical figures are no worse than in the case of Option 1. Therefore, the capacity and operational costs of the transfer of goods would remain unchanged.

Summary: The operational costs would be similar for Options 1 and 4. The tunnel's servicing costs are likely to increase the overall operational costs for Option 3, yet we believe that this increase will be lower than in the case of Option 2, where the higher gradient and length of track, as well as the maintenance costs of the many structures situated along the route, constitute a significant cost increase.

Capacity

The capacity of a railway section is calculated as the maximum number of trains that can technically pass through the given section within a certain period of time. The capacity depends on the technical parameters of the section, specifically its length, gradient, radiuses, speed limit and the shortest safe interval between trains. Apart from a track's capacity, which refers to the number of trains it serves, its freight capacity (the maximum weight of freight transported in a 24-hour interval) is also of importance. Currently, 20 freight trains are pass through Tbilisi in an east-west direction in a 24-hour interval, and the same number pass in the west-east direction. The market demand for railway service in Georgia is substantially below the Tbilisi section's capacity for all four alternatives examined in this study. As a result of the opening of the deep-water port at Kulevi, and the subsequent increase in container transport from China and Central Asia to Europe through the South Caucasus transport corridor, demand for rail transportation may increase, and with it so too would the importance of freight capacity.

In the case of **Option 1,** the maximum capacity of the Tbilisi section is 217 trains per day (100 trains in the east-west direction, and 117 trains in the west-east direction)[29]. The freight trains passing through Tbilisi in the east-west direction mainly contain oil products being transported from Azerbaijan to the Black Sea, while the trains going in the opposite direction are mainly empty units having been unloaded at the ports. Therefore, the maximum capacity figures are mainly determined by the

[29] MC Mobility Consultants, 2013.

maximum capacity of the rolling stock moving in the east-west direction. The average weight of a train is 1800 tons, which would allow 66 million tons to be transported annually in the case of Option 1[30].

In the case of **Option 2,** the higher gradient reduces the train's average speed and weight limit, thereby reducing its capacity. In this case, the maximum capacity would be 163 trains per day (78 trains in the east-west direction, and 85 trains in the west-east direction), allowing 51 million tons to be transported annually in the east-west direction[31].

In the case of **Option 3,** the maximum capacity is currently unknown. Based on the EISA, the length of the tunnel would be approximately 9.5km, which is 0.5km shorter than the route in Options 1 and 4. The gradient, which is one of the factors determining capacity, is unknown. Due to the shorter distance, we can presume that the capacity for Option 3 would be higher than for Option 2, and would not differ significantly from Options 1 and 4.

In the case of **Option 4,** since the length, gradient and route of the railway line do not change from the status quo, we can state that the capacity for Option 4, as for Option 1, would be 66 million tons per year in the east-west direction.

Summary: The weight limit for each train would be the same in each of the four alternatives, but the capacity would vary. The capacity of Options 1 and 4 is higher than Option 2. In the case of Option 3, the precise figure is not known at present, but we can presume that it exceeds the capacity of Option 2, since the tunnel reduces the distance and does not significantly differ from Options 1 and 4. In the event of a future increase in freight turnover (as a result of the opening of the deep-water port at Kulevi, and the subsequent increase in container transport from China and Central Asia to Europe through the South Caucasus transport corridor), Options 1 and 4 would be better equipped than Option 2 to service the freight. Capacity figures for Option 3 are unknown, but we can presume that the tunnel would run along the shortest possible distance between Didube and Navtlughi, and that the total length would be less than Options 1 and 4. Conditionally, we award Option 3 the same number of points as Options 1 and 4. However, this is only until more precise capacity figures are made available for Option 3.

[30] MC Mobility Consultants, 2013.
[31] Ibid.

Impact on Passenger Transfer

Currently, 34 local and two international services run through the Tbilisi section per day[32]. Here, the impact on passenger transfer for each alternative is determined by the extent to which access to train stations would be affected.

In the case of **Option 1,** Central station is fairly easily accessible from across the city with 27 bus and 10 minibus routes passing the station. The metro (subway) is more evenly accessible for the population residing at both ends of the city than the Didube and Navtlughi railway stations, thereby replacing these stations to a certain extent. As public transport in Tbilisi improves, passenger flow at railway stations is likely to increase.

In the case of **Option 2,** instead of one central station, there would be two dead-end railway stations in Didube and Navtlughi, which would be less accessible for the city's population compared to having a single central station[33].

In the case of **Option 3**, there is likely to be only one station in Navtlughi, since the tunnel portal and ramp would decrease the space requirements for a station in Didube.

In the case of **Option 4,** the impact on passenger transfer would be no different from Option 1.

Summary: In Options 1 and 4, Central station would remain in place, while in the case of Option 2 it would be closed, with passengers instead using two central stations: Navtlughi for eastbound services; and Didube for westbound services. As is currently the case for Central station, these two stations would also be accessible by metro. However, while Central station is currently located at approximately midway between the eastern and western ends of the city, Navtlughi and Didube stations would be less accessible for many residents of Tbilisi. Therefore, this option is less attractive in terms of passenger transfer. Moreover, the seasonal Armenia-Tbilisi-Batumi service would have to travel a greater distance than it would in Options 1 and 4. Internal transfers would also be more convenient with one central station as opposed to two. Option 3 is similar to Options 1 and 4 in terms of having one central station, however this would likely be in Navtlughi rather than Didube or at the current Central station. In Option 3, passenger stations would be more difficult to access for the public than in Option 2 (which foresees two stations), as well as Options 1 and 4.

[32] Georgian Railway website.
[33] Green Alternative, 2010.

Impact on Railway-Related Enterprises

There are 64 single-ended (dead-end) sidings in Tbilisi, of which 55 are privately owned, while 9 are owned by Georgian Railway[34]. Organizations and companies operating the privately owned single-ended sidings rely on receiving freight directly. Therefore, in the event of the railway being moved, they would have to either relocate to the area next to the new railway, or change the nature of their operations. Some companies deciding to relocate would perhaps be able to obtain additional income from selling their land.

Large enterprises that benefit from the railway include the Wagon Repair Company ('Vagonshemketebeli'), Temka and Tbilisi Metro (Tbilisi Transport Company). The first two cannot operate without the railway. As for Tbilisi Metro, its connection with the railway is important in terms of receiving and distributing passengers and industrial trains. Of particular significance is the Metro wagon repair factory (owned by, and situated on the territory of, the Metro) and its connection to the railway, through which it can receive wagons from the Baku and Yerevan subway systems.

Option 1 would have no impact upon associated enterprises.

In the case of **Option 2,** the Wagon Repair Company would lose its connection to the railway line, which would probably lead to the closure of this enterprise. The Metro requires a connecting track to the railway in order to receive new wagons and to send wagons/industrial units for repair. The railway can also be used by the Metro to transport large and heavy equipment such as tunnel ventilators to its industrial depot, from where these are transported to tunnels by special industrial rolling stock. The Tbilisi Metro also has its own wagon repair factory, which takes orders from the Yerevan and Baku subway systems for the repair and modernization of their subway wagons[35]. This income stream would be lost in the event of a railway closure. There exists the possibility of establishing a connecting track to the railway at Didube station, but this would be far more complicated than Option 1.

In the case of **Option 3,** the Wagon Repair Company would lose its connection to the railway line, which would probably lead to the closure of this enterprise. Moreover, the Metro would also lose its connection to the railway and, unlike in Option 2, it would not be possible to create a connecting track at Didube station. It would therefore become necessary to connect the Gldani depot to the railway line at Avchala, which would require the purchase of privately owned land.

In the case of **Option 4,** in spite of retaining the main rail line, the system of single-ended sidings would be eliminated, and the Wagon Repair Company would lose its connection to the railway. However, a

[34] Georgian Railway, 2009c.

[35] Electric Rolling Stock Repair Plant.

connection could be established from the main line to the Metro and the Wagon Repair Company through rail tracks that are 'sunk' in asphalt (similar to tram lines). These tracks would be constructed along the roads on the cleared land, leading to both the Metro depot and the Wagon Repair Company's headquarters.

Summary: The connection to Temka would not be affected by any of the alternatives. The most favorable alternative for railway-related enterprises would be Option 1, through which none of the enterprises would lose their connection to the railway. With regards to the Metro, Option 2 offers a relatively cheap alternative to retain its connection, although that may be accompanied by certain operational difficulties. The Wagon Repair Company would lose its connection to the railway in Options 2 and 3. In the case of Option 3, the Metro would also lose its connection to the railway, and would require a new connecting line to be constructed from Avchala station for which private land would need to be bought. Option 4 would technically retain the possibility of setting up a new connecting track to the Metro depot and the Wagon Repair Company's headquarters.

Construction Costs

Construction costs include the costs of dismantling/relocating railway facilities, as well as the actual costs of constructing.

In the case of **Option 1,** there would be no construction costs.

In the case of **Option 2,** it was estimated (in an interview with a City Institute Georgia representative) that the construction works would cost approximately USD 170-210 million. Aside from completing the actual building works, this option would also require that Mtskheta station be modernised for the manoeuvring operations of auxiliary locomotives, and this would bring additional costs that have not yet been calculated.

In the case of **Option 3,** the construction costs are currently not known. According to the MC Mobility report, construction works on the tunnel would cost USD 13 421 per linear meter. Based on the estimated length of the tunnel (9.5 km), the costs would then amount to approximately USD 130 million.

In the case of **Option 4,** construction costs would be lower than for Options 2 and 3. Relocating depots and freight terminals would incur the same costs for Options 2, 3 and 4, while dismantling the existing railway facilities would be included in the construction costs. Since this would also be the case for the existing bypass model, this option would not be more costly than Options 2 and 3 in this regard.

Construction costs for this alternative would only include the dismantling and relocation of the existing infrastructure to Avchala, as well as the relocation of the freight station to the area between Veli and the marshalling yard.

Summary: Option 2 would be the most expensive, while Option 1 would require no expense.

Economic Dimension	**Option 1**	**Option 2**	**Option 3**	**Option 4**
Operational Costs	1	3	2	1
Capacity	1	2	1	1
Impact on Passenger Transfer	1	2	3	1
Impact on Railway-Related Enterprises	1	3	4	2
Construction Costs	1	4	3	2
Average	**1**	**2.8**	**2.6**	**1.4**

Conclusions

In the final part, we summarize and compare the positive and negative aspects of each alternative. We also add up the assessment scores for each of the alternatives based on the criteria discussed above (impact on urban development, safety, environment, operational costs, capacity, impact on passenger transfer, impact on railway-related enterprises and construction costs). Finally, we present our recommendations.

Comparison of the Advantages and Shortcomings of the Alternatives

Option	Advantages	Shortcomings
1	• Maintaining logistical connections for companies using the railway. • Railway operating costs maintained at current level. • Railway capacity maintained at current level. • Equal access to main passenger station from the city's various districts. • No construction costs.	• Stunts the city's urban development. • Danger of oil product explosion and/or release of chemical products into the air in direct vicinity of residential areas in the event of an accident. • Environmental impact on settlements near the railway.
2	• Freeing up land with significant potential for the city's development. • Improved safety along the railway track adjacent to the city's current main railway line. • Less negative environmental impact on settlements near the railway.	• Noise from major road which may be built in the area made vacant by cleared railway. • Possible pollution of Tbilisi Sea from spilled oil products or chemicals in the event of an accident. • Higher railway operating costs compared to Option 1. • Reduced railway capacity compared to Option 1. • Uneven access to the main passenger stations from some of the city's districts. • Some railway-related enterprises

		would lose access to railway; probable closure of the Wagon Repair Company; poorer connections to the Metro. • Highest construction costs of all of the alternatives.
3	• Freeing up land with significant potential for the city's development. • Improved safety along the rail line adjacent to the city's current main railway line. • Reduced negative environmental impact on settlements near the railway. • Railway capacity likely to decrease insignificantly compared to Option 1, in contrast to Option 2.	• Noise from major road which may be built in the area vacated by cleared railway. • Likelihood of damage to residential buildings situated above the tunnel in the event of an accident. • Likely paralysis of the Georgian Railway's east-west corridor for several days or weeks in the event of an accident. • Higher railway operation costs compared to Option 1. • Very uneven access to the main passenger station from some of the city's districts. • Some railway-related enterprises would lose access to the railway; probable closure of the Wagon Repair Company; necessity to build a connecting line to the Metro which would entail buying privately owned land. • Second highest construction costs after Option 2.
	• More space freed up compared to Option 1. • Reduced environmental impact, with less noise and vibration near	• Less space freed up (including for the purpose of constructing a longitudinal transport corridor) compared to Options 2 and 3.

4	settlements compared to Option 1. • Railway operating costs maintained at current level. • Railway capacity maintained at current level. • Equal access to the main passenger station from the city's various districts. • Better possibilities for maintaining connection between railway-related enterprises and the railway compared to Options 2 and 3. • Low construction costs compared to Options 2 and 3.	• Danger of oil product explosion and/or release of chemical products into the air in direct vicinity of residential districts in the event of an accident (The impact of this shortcoming could be reduced by building protective embankments). • More difficulties maintaining connections between railway-related enterprises and the railway compared to Option 1. • High construction costs compared to Option 1.

Overall Assessment of the Alternatives

In the table below, we award points to each of the given alternatives based on urban, safety, environmental and economic criteria, whereby a score of 1 represents the best option, and 4 represents the worst. It is possible for two or more options to be awarded the same number of points. For the economic dimension, the points are calculated as an average of its sub-components (see the 'Economic Dimension' chapter above). An overall assessment of the alternatives is reached by adding up the points from each of the criteria.

Option

	#1 Status Quo	**#2 Bypass**	**#3 Tunnel**	**#4 Partial Relocation**
Urban Dimension	4	2	1	3
Safety	4	3	1	2
Environment	4	2	1	3
Economic Dimension	1	2.8	2.6	1.4
Total	**13**	**9.8**	**5.6**	**9.4**

According to the above table, Option 3 is the best alternative, followed by Option 4 and Option 2. Option 1 has the fewest advantages. The given system of assessment is orientational, subjective and unweighted. Therefore, our assessment is subjective and aims to stimulate discussion. Stakeholders could utilize an alternative method of assessing the examined alternatives, including attaching weights to the urban, safety, environmental, and economic parameters.

Recommendations

Taking the constraints of this study into account, our recommendations are as follows:

1) Option 1 (the status quo) cannot satisfy the city's current needs from urban, safety and environmental perspectives, and change is required.
2) Of all the alternatives examined within this study, Options 3 (tunnel) and 4 (retaining the main line in the city and relocating the remaining infrastructure) appear most attractive.

   Option 3 would involve:

   - Constructing a railway tunnel from Navtlughi to Didube and using it for both passenger and freight transport.
   - Closing the Central station to passengers.
   - Constructing railway stations in Navtlughi and (possibly) Didube.
   - Establishing a railway connection at the Gldani Metro depot or at Didube station.

   Option 4 would involve:

   - Retaining a double-track railway line from Navtlughti to Didube and using it for both passenger and freight transport.
   - Retaining the Central station and only using it for passenger transfer.
   - Conducting noise insulation measures and placing protective barriers along the main railway line within the Tbilisi Municipality limits.
   - Retaining railway connections to the Wagon Repair Company and the Nadzaladevi Metro depot.

   Options 3 and 4 would involve:

   - Moving the Nadzaladevi Metro depot to the second block while dismantling the first block and handing the freed-up space over to the city.
   - Moving the industrial Metro depot to the Gldani depot area and handing the freed-up space over to the city.

- Moving the railway depots between Navtlughi and Didube to a specially designated area in Avchala.
- Moving the freight station to the Africa district, in the area between the Veli and marshalling yards.
- Handing the freed-up land over to the city, to be used for residential, commercial and/or recreational purposes.
- Developing linear transport communications on the freed-up land.

3) On the one hand, combining Options 3 and 4 would significantly mitigate the negative characteristics of the status quo (Option 1), such as obstruction to urban development, as well as safety and environmental problems. Meanwhile, these options (especially Option 4) would not impact negatively upon capacity, operational costs, and the railway's income in general, as would be the case with Option 2. These options (3 and 4) would not be burdened by new safety challenges such as the pollution of Tbilisi Sea from oil and chemical products spillages. Furthermore, of all the available alternatives, Option 4 would have the least negative impact on large railway-related enterprises, such as the Wagon Repair Company and the Metro. In terms of passenger transfer, this option offers similar or better possibilities compared to the other alternatives. This option is also considerably better in terms of construction costs compared Options 2 and 3. Although Option 4 had a similar point score compared to Option 2, the former represents a more favorable option with regards to all of the economic and safety parameters discussed in this study. Considering the significance of the safety factor for the population, we deem Option 4 to be more acceptable, and recommend a more detailed examination of this alternative together with Option 3. In light of the constraints of this study and the lack of data, it will be necessary to conduct a deeper analysis of Options 3 and 4, based on quantitative data.

Addendum

Appendix 1: Route-Marking of the Main Lines on the Tbilisi Railway Junction

The single-track electrified line to Kakheti passes a station located in Navtlughi. From the Junction station, it runs east (parallel to the Kakheti Highway), passing the Africa district and the airport from the north before crossing the Lilo district, crossing the Kakheti Highway via a bridge, passing Tsinubani village from the southeast, and moving outside the Tbilisi Municipality limits after crossing the Lochini Ravine. A branch line parts from the main line near the airport district, leading towards the passenger station at the airport.

The double-track electric line to Azerbaijan leads from the junction station eastwards towards the Samgori district (parallel to Cairo Street), then onwards to the marshalling yard, passing the Africa district to the south, Veli station, and ultimately the Azerbaijani border via Rustavi and Gardabani.

The single-track electric line to Armenia parts from the main line at the junction station from the south, passing the industrial zone, Moscow Avenue and the ZMK district in the south, crossing the Mtkvari River and leaving the Tbilisi Municipality limits by Ponichala, ultimately leading to Sadakhlo on the Armenian border via Marneuli. This line will also serve the Marabda-Kartsakhi service to Turkey when it becomes operational.

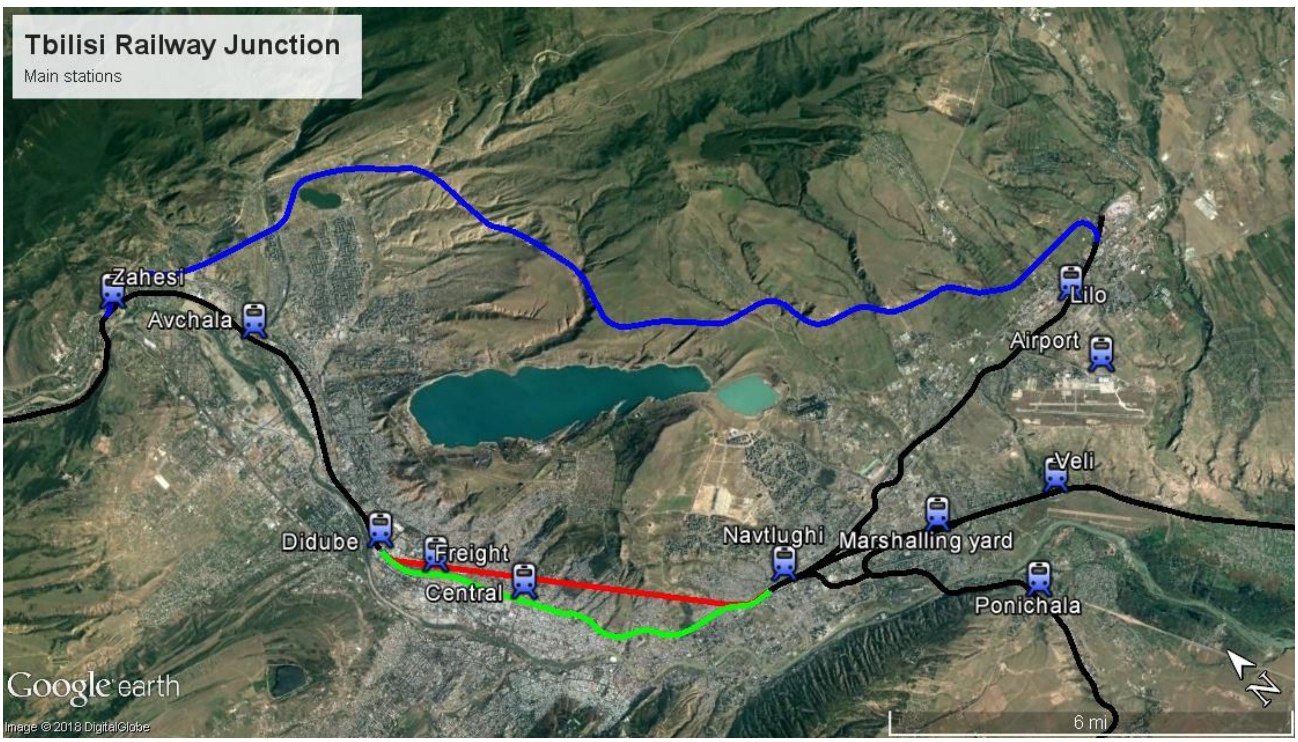
From the junction station, the double-track electric line travels westwards on an artificial embankment parallel to the Kakheti Highway, passing the Isani district from the north (partly on an embankment south of the Petre-Pavle cemetery, and partly in a pit). It then passes between Elia and Avlabari, then onwards to the Arsenal district between Svanetis Ubani and Chughureti, crossing a bridge at Sabcho Square and connecting to Central station. The length of this section is 5.5km.

From Central station to the freight station, the railway passes through Nadzaladevi district south of the Wagon Repair Company, joining with several sidings at the freight station (including passenger, diesel locomotive, wagon depot, rolling stock repair depot, container terminal, the Metro's logistical and electric rolling stock depot, as well as two siding systems towards Didube and Kirov factory). The stage from the freight station to Didube station crosses the bridge on Tsotne Dadiani Avenue. This is connected to the firefighting/recovery train depot.

From Didube station, the main line passes through commercial and industrial zones in the Didube district (parallel to the Metro line), then along the left embankment, passing the commercial area on the embankment, an elevated area with a settlement at the top, then between Peikrebi Street and the locomotive factory area, crossing Sheshelidze Street via a bridge, passing the Koniaki district (the industrial zone from one side and the residential zone from the other) to Avchala station, where it connects to several sidings towards various enterprises, the most important of these being JSC Elmavalmshenebeli (locomotive factory).

From Avchala station, the main line leads to Zahesi via Avchala district. It is also joined by sidings with connections to various enterprises. After Zahesi station, the railway crosses the Mtkvari River and leaves the Tbilisi Municipality limits.

Appendix 2: Stations on the Tbilisi Railway Junction



Veli station – Class III intermediate station, serving suburban trains and fulfilling a transit function for freight trains and international passenger services.

Tbilisi-Makhariskhebeli (marshalling yard) station – Class I sorting station, where local and transit goods are sorted. It plays a key role in freight transport within the Tbilisi Junction area. The station houses a locomotive depot, a wagon service point, and a passenger wagon fleet.

Lilo station (Kakheti branch) – serves freight transfer and rail tracks to industrial facilities.

Airport station – passenger station serving the international airport and nearby district.

Ponichala station – serves suburban trains and fulfills a transit function for freight trains and international passenger services.

Tbilisi-Sakvandzo/Navtlughi station ('Junction station') – Class I freight station serving local and transit freight. The station is connected to sidings leading to industrial facilities.

Tbilisi Passenger station (Central station) – Class II passenger station, and the main passenger station of the Tbilisi transport junction, serving local, suburban and international trains.

Tbilisi-Satvirto station ('Freight station') - Class I freight station housing a wagon depot, a locomotive depot, a diesel locomotive manoeuvring depot, a firefighting/recovery train, as well as an autonomous refrigerator wagon fleet. The station is connected to freight yards and a container terminal.

Didube station – passenger transit station serving local and suburban trains.

Avchala station – serving passenger trains (suburban and local) and fulfilling a transit role for freight trains.

Zahesi station – intermediate transit station serving passenger and freight trains.

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