ESTIMATION OF THE EXISTING AND POTENTIAL TRANSPORTATION DEMAND FOR A TRIESTE - RIJEKA TRAIN PASSENGER SERVICE

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ESTIMATION OF THE EXISTING AND POTENTIAL TRANSPORTATION DEMAND FOR A TRIESTE - RIJEKA TRAIN PASSENGER SERVICE

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Study developed in the framework of the Regional Law 18/2011 – DGR592/2022 – Operational Plan of Central European Initiative - Friuli Venezia Giulia Region 2022/2023 - Specialist technical assistance service aimed at carrying out a research aimed at estimating the potential demand for long-distance transport the Trieste Central - Divača - Rijeka line to evaluate the possible planning of a direct passenger rail link.

The authors wish to thanks for their cooperation in the investigations carried out for this report:

- Central Directorate for Infrastructure and Territory of the Friuli-Venezia Giulia Region
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- Regional and Local Public Transport Service of the FVG region
- Slovenske Železnice
- Trenitalia

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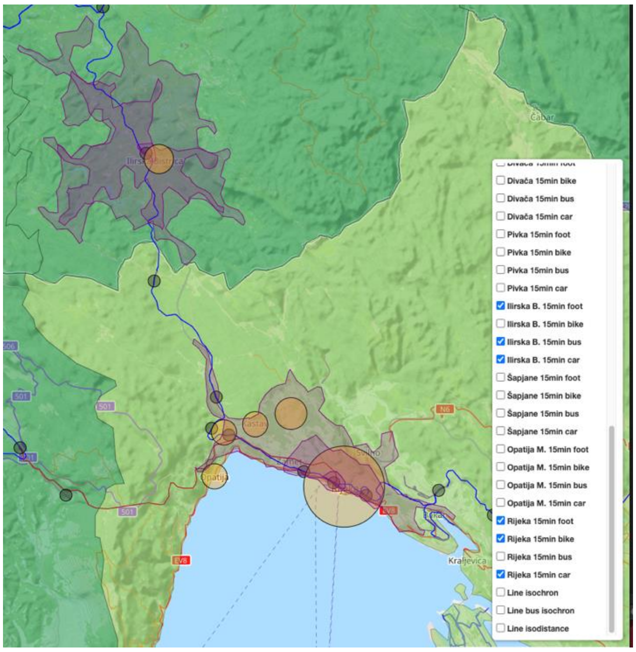
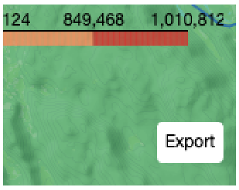
Website for consulting the georeferenced information used in the report.

The report utilizes information obtained from open-source web-GIS platforms, which are listed at the end of this report. These data were processed appropriately to generate the report's findings. To facilitate easy access and independent examination of the main georeferenced parameters essential for interpreting the study, an interactive web page has been developed. The web page can be accessed at:
http://virgo.unive.it/pesenti/TS_RJ/IT_SI_HR_index.html
Please note that this web page is hosted on a server belonging to Ca' Foscari University, is not indexed, and is not publicly accessible. Therefore, it is crucial to handle this information strictly confidentially.

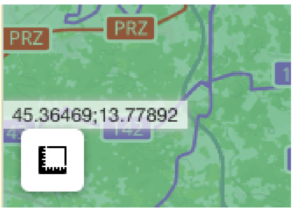
Please note that the above web page is best navigated using a PC, as it is not optimized for mobile phone use.
You can explore the page by zooming in or out of the displayed area using the browser and computer operating system commands.



The menu on the right side of the page allows you to select different types of background cartography and provides options to highlight or hide various information layers such as isochrones, cities, stations, railway infrastructure, and more.



At the top right corner, you will find an "export" button that enables you to export data in JSON format.



The geographical coordinates of the location indicated by the cursor on the map can be read at the bottom left. Just below the coordinates, there is a button that allows you to measure distances on the map.
On the left side of the map, you will find a list of links to data and information sources, as well as the open-source webGIS platforms that were utilized.
By clicking on different points of the map, such as areas, cities, and stations, a pop-up window will appear, providing georeferenced information specific to that selected point. The information displayed corresponds to the options chosen in the menu on the right.

Executive summary

Quantifying a demand forecast for a rail link between Trieste and Rijeka presents a complex challenge due to various factors:

- Lack of historical data to be used in statistical models and of disaggregated socio-economic and demographic data to be used in econometric models.
- Fragmentation of estimates, forecasts, and surveys from previous studies of intermediate sections, which do not allow a clear assessment of the potential use of the whole rail link.

To overcome these limitations, an additive and linear estimation approach was employed. It extrapolates the forecasts formulated for 2030 (where available) to 2024 and similarly extrapolates earlier data using the growth rates of the most recent years available. Gravity estimates based on resident population, incident population, and different distance weights were applied where transit data or forecasts were available.

Multiple scenarios were considered, resulting in an annual demand range for the Trieste-Rijeka railway service, spanning from 7,300 passengers in the most pessimistic hypothesis to 66,650 passengers in the best-case scenario. However, both extremes are highly unlikely, and the most probable range falls between 28,400 and 36,000 passengers per year.

Based on current tariffs and the most likely forecasts, the service would generate an initial annual turnover ranging from 386,000 to 489,000 euros. Due to the inelasticity of demand, even a significant change in tariffs would lead to a decrease in revenue, as the expected increase in demand would not be proportionate to the reduction in fares. Literature suggests that intervening to reduce travel times is more effective than adjusting fares, as indicated by the respective elasticity values.

Consequently, during the initial phase of launching the service, which is crucial for building awareness and familiarity with the new travel option, it is unlikely that the service will be able to break even at market prices. Previous studies support the notion that demand potential is high when connectivity with the Istrian network is improved.

Additionally, demand can significantly increase through "soft" interventions, including enhancing last mile connectivity with local points of interest and establishing consistent communication channels to improve access to travel information, which is currently poorly coordinated and inconsistent.

List of Abbreviations

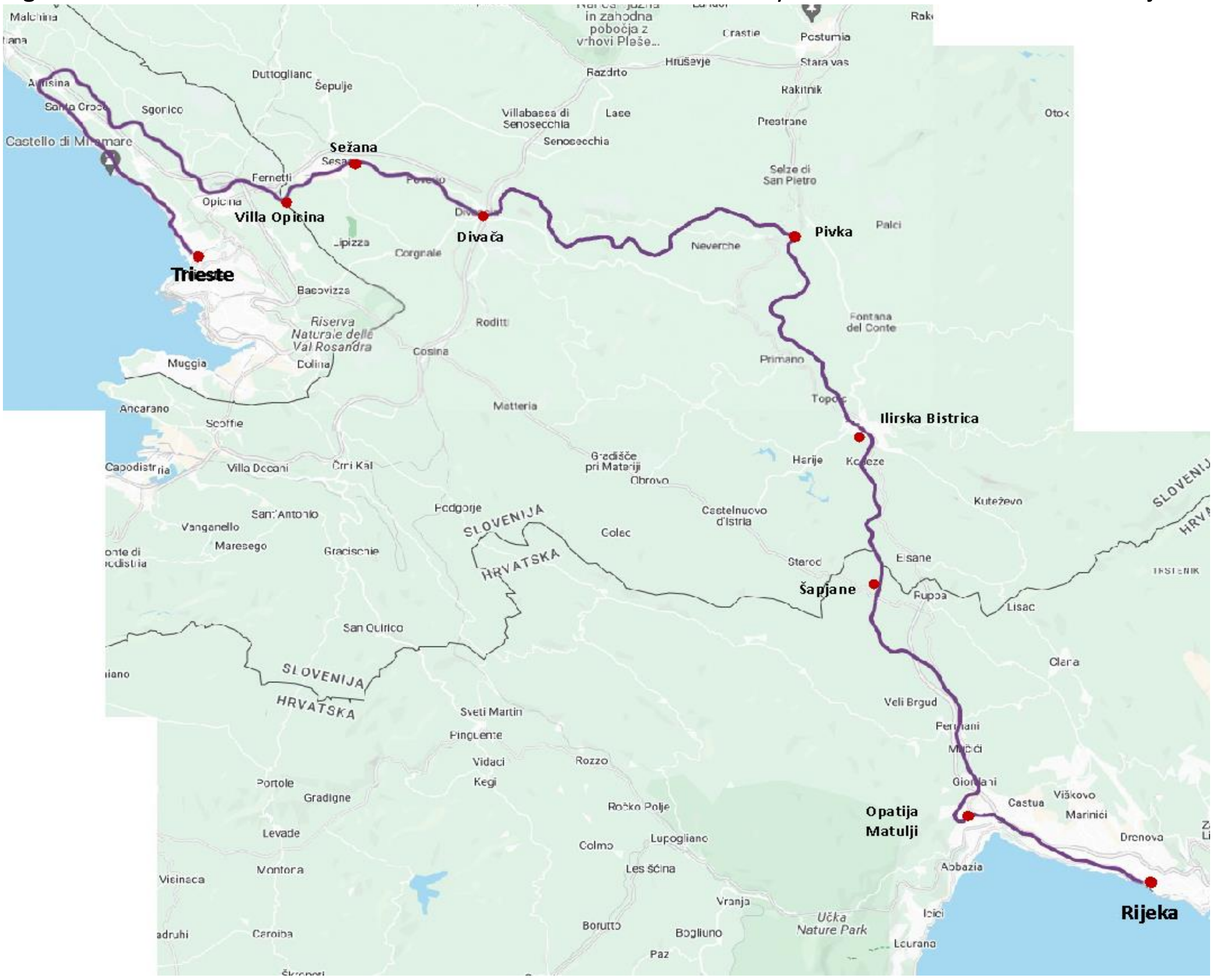
DŽS - Državni Zavod za Statistiku (Croatian National Statistical Office)
ECBM – European Cross Border Mechanisms
ETCS: European Train Control System
ERTMS - European Rail Traffic Management System
FVG – Friuli Venezia Giulia
GHSL - Global Human Settlement Layer
GSM-R: Global System for Mobile communications for Railways
HŽPP - HŽ Putnicki Prijevoz (Railways Croatian)
OBB - Österreichische Bundesbahnen (Railways Austrians)
PGC - Primorje -Gorski Kotar
SWOT – Strengths , Weaknesses, Opportunities & Threats
Yes - Slovenske Železnice (Slovenian Railways)
TEN-T - Trans-European Transport Network
TI – Trenitalia
LPT – Local Public Transport

1. Introduction

1.1. Objectives and structure of the study

The aim of this study is to estimate the potential demand for a new cross- border railway service between Trieste Centrale and Rijeka. The route of the new railway service considered for the purposes of this study is depicted in figure 1.1.

Figure 1.1: route and main intermediate stations of the new railway service between Trieste and Rijeka.



As will be explained in chapter 4, it has not been possible to estimate the demand using traditional models (statistical analyzes based on historical series, econometric analyzes based on correlations with socio-economic and demographic data), for a series of specific reasons within the context at hand. These reasons include:

a) there are no previous historical series on which to rely in order to use forecasting statistical models,

b) catching areas are mostly restricted to local areas of limited size for which sufficiently disaggregated socio-economic data are not available to enable the adoption of econometric models.

The impossibility of using statistical and econometric models has also been recognized in other previous works [1], including one (Amanović & Kralj 2016) which had the same objective as this study and which we will discuss later in this chapter.

[1] In particular: European Commission, Directorate-General for Regional and Urban Policy, Roux, L., Wolff, D., Nolte, J.et al., *Comprehensive analysis of the existing cross-border rail transport connections and missing links on the internal EU borders – Final report* , Publications Office, 2018, **https://data.europa.eu/doi/10.2776/69337** ;

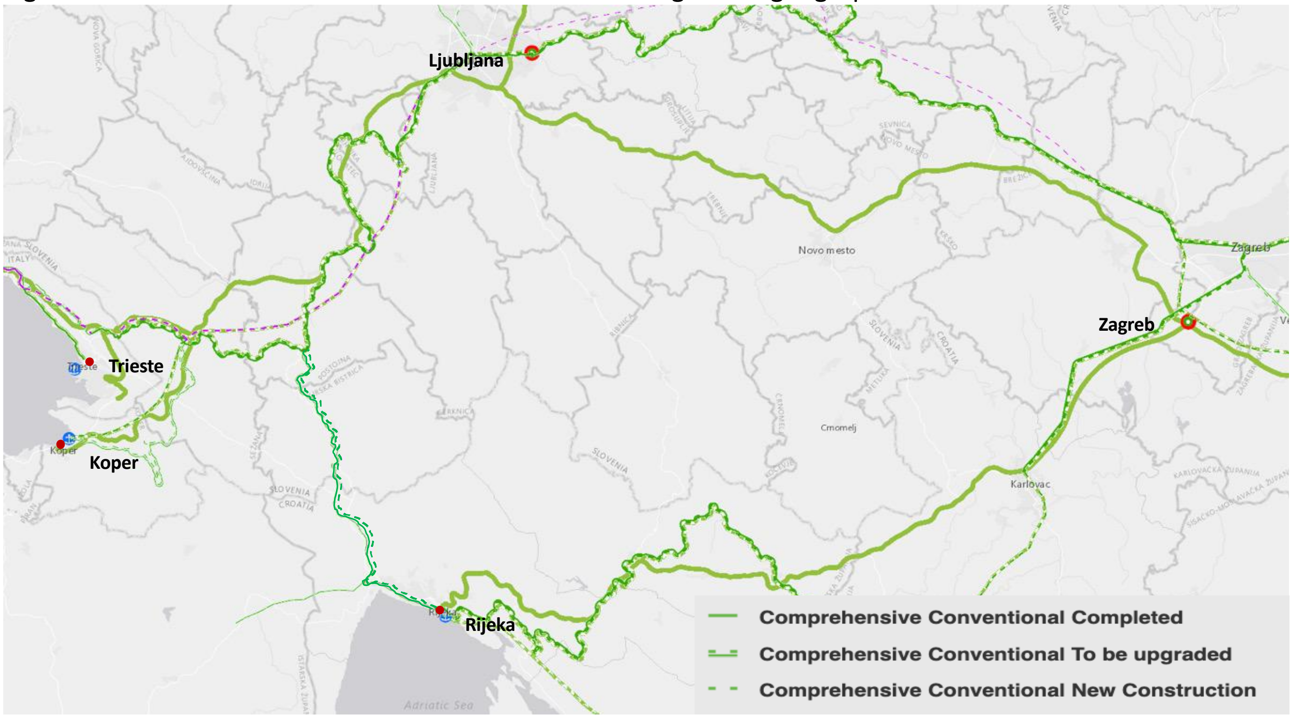
As will be explained in detail in chapter 4, an ad hoc (linear additive) model was therefore opted for which would allow the inclusion of data and estimates relating to partial sections as well as estimates based on the analysis carried out through questionnaires on a sample targeted on the resident or accident on the catching area of the rail link under study. The opportunity to make use of data collected on the traffic between the intermediate stops of the route, which are currently already the subject of regional services, has led to such a methodological choice.
There is also a further "critical" factor for the evolution of travel demand, namely the recent evolution of the economic and political context, which saw Croatia enter the Schengen area and the euro area at the beginning of 2023. A fact of this magnitude marks a discontinuity with the past that can nullify the interpretative potential of autoregressive models (even if it were possible to apply them), and above all determines a condition in which the rate of development of travel demand is determined by the supply of services. Basically, the general framework of reference is characterized by conditions for which travel demand is predominantly a variable dependent on the supply of services, thus reversing the traditional relationship of the "predict & provide" type, *for which services* are planned downstream (rather than upstream) of the need to respond to an expected growth in demand. In this case, political and economic integration is taking place and the demand for mobility between countries is bound to grow. In the absence of alternative means, it is destined to spill over entirely or almost entirely onto the road and into private cars, with all the consequences of the case.
The new railway service is part of a panorama of growing socio-economic integration of the Trieste – Ljubljana – Zagreb – Rijeka quadrilateral. These 4 cities, like Venice, are all located on the "Mediterranean" core network TEN-T corridor under construction (EU Regulation No 1315/2013, 2021/1153, under revision). In particular, European planning, up to this point, designates the rail link that goes from Aurisina to Divača as a "core-network" , and the link between Rijeka and Pivka as a "comprehensive network" (figure. 1.2). In this contexts, the Croatian railway's development plan includes the implementation of ERTMS (European Rail Traffic Management System) and of the double track on the Rijeka - Jurdani - Divača section, whereas the Divača - Trieste section is part of the reconstruction and modernization plans under the Mediterranean Corridor Investment Programme[2]. This information is supported by various official documents, from the Croatian and Slovenian governments as well as the European Union and is corroborated by previous studies conducted within the relevant area. The following paragraph will provide a concise overview of the most significant of these studies.

1.2 Preliminary Analysis of Existing Studies on Cross-Border Transport Demand in the Reference Area

This section collects the main findings from analyzing various types of sources that have addressed the topic of the railway connection between Trieste and Rijeka. Only documents capable of providing significant contributions were selected for this review. These documents are included in their original form as "attachments to the report," along with others that were used in the drafting of other chapters. It should be noted that documents in Croatian and Slovenian were consulted using automated translators, verifying possible interpretation errors by utilizing multiple translators and comparing the results.

[2]In this regard, however, it should be noted that the "V work plan of the European coordinator" of the Mediterranean corridor notes a delay in the procedures of the high-speed line between Ljubljana, Divača and the Italian border.

Figure 1.2: section of the TEN-T "Mediterranean" relating to the geographical area of reference.



Source: https://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/map/maps.html

At least three types of documents and studies can be distinguished that have addressed the railway connection between Trieste and Rijeka in various ways:

1. Programming and planning documents: These include regulations and decisions from the European Commission - DG Mobility and Transport, as well as territorial planning documents and transportation plans from Slovenia and Croatia.
2. Articles and studies conducted by research institutes, universities, centers, etc.: These are mainly documents that do not have a policy purpose but discuss the topic (or related topics) that help build the analytical framework for this study.
3. Studies conducted within European territorial cooperation programs: These are predominantly studies that have examined, among other things, the opportunities related to intermodal land passenger transport between Italy and Croatia, and Italy and Slovenia, with the aim of determining medium- and long-term policies.

The complete list of previous studies used, in various capacities and ways, for this report is provided at the end of this report in the "Bibliography of Sources Used and Cited in the Text" section. Below are the summarized key findings that emerged from the analysis of these documents.

1.2.1 Summary of Documents Addressing the Relevance of the Trieste-Rijeka Railway Route and Infrastructure Development Plans or Programs, Including New Routes

In analyzing the previous studies related to the connection between Trieste and Rijeka, reference was made to the entire current connection area, which passes through Ilirska Bistrica - Pivka, as well as the Istrian area, where a hypothetical future infrastructure is planned to connect the current line to Istrian locations.

In general, planning documents and studies of various kinds all assign national and international significance to the Trieste-Rijeka-Koper-Trieste railway connection, without specifically mentioning passenger traffic. Instead, they frame the connection within the context of European infrastructure integration.

To our knowledge, the earliest evidence of the importance assigned to the railway connection between Trieste and Rijeka dates back to at least 1959, in a map that depicts not only a "standard gauge" railway connection between the two cities (with the Pivka-Trieste section "adapted for direct international traffic"). Additionally, this map also includes a "under construction" section between Rijeka and Lupoglav (Figure 1.3), which, however, was never realized.

Figure 1.3.: Map from 1959 indicating "under construction" a link between Rijeka and Lupoglav .

Source: “Traffic strategies and traffic development studies” (Prometne strategije i studije prometnog razvitka PGZ) presentation by prof. Lyudevit Krpan , Rijeka, October 2019). Map provided by HŽ Infrastruktura doo . https://www.hgk.hr/documents/03krpanprometne-strategije-u-pgz-20195d9dbeb2708ab.pdf

Several documents, including Croatian territorial planning documents, outline plans and perspectives for enhancing the infrastructure connecting Trieste and Rijeka. These plans include the development of a "variant" (new route) via Lupoglav, which would involve constructing a tunnel through Učka, approximately 12 km long. This tunnel would significantly shorten the connection between Rijeka and Trieste, as well as the connection with Istria (Table 1.1).

Table 1.1.: Railway distances from Rijeka to Pula, Raša and Trieste current and of the planned variant via Lupoglav (Učka tunnel)

	Current Distance	Distance via variant
Rijeka - Trieste	124	84
Rijeka - Pula	200	95
Rijeka - Rasha	179	68

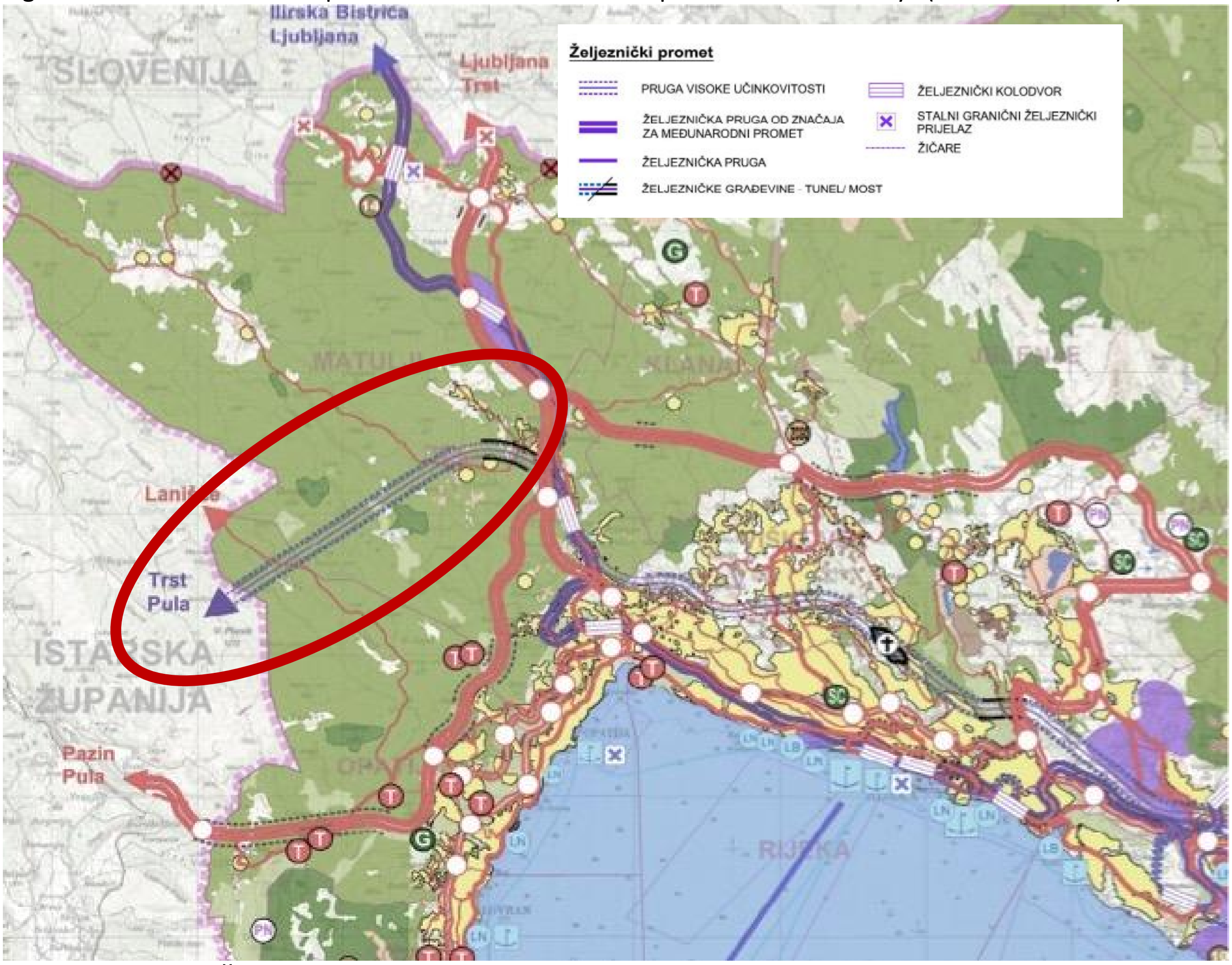
Source: Vilke , S., Šantić , L., & Glad, M. (2011). Redefining of the Rijeka railway junction. *Promet-Traffic&Transportation* , *23* (6), 443-451.

The railway connection known as the "variant" via Lupoglav, if actually realized, would be a key element. Documents discussing this variant indicate that it would reduce the distance by one-third and provide significantly higher speed and interoperability compared to the existing line. The fact that the variant is planned is unquestionable as it periodically reappears in documents such as the "Spatial Plan of Primorje-Gorski Kotar County (PGC)”. [3] Specifically, in the implementing provisions of the PGC County Spatial Plan

[3]https://zavod.pgz.hr/docs/zzpuHR/docsplanovizupanija/913/pp-pgz.pdf

dated September 13, 2013, Chapter 160 mentions the "implementation of a high-efficiency railway line Trieste/Capodistria – Lupoglav – Rijeka – Josipdol (Karlovac) – Zagreb/Spalato – Dubrovnik, Trieste – Koper – Lupoglav – Rijeka," along with the doubling of the line between Rijeka and Šapjane. The same phrase is also repeated verbatim in the more recent "modifications to the County PG Spatial Plan" in June 2022[4] and the proposed modifications in December 2022[5]. Figure 1.4 displays an excerpt from the map attached to the spatial plan, where the left side indicates the route direction for Trieste-Pula towards Lupoglav.

Figure 1.4: extract of the map attached to the "Territorial plan of the PG County" (December 2022)



Source: III. ID PPPGŽ-PP- Korištenje i namjena povrshina.pdfu
https://zavod.pgz.hr/pdf/ID_PPPGZ_PP_Koristenje_namjena-povrsina.pdf

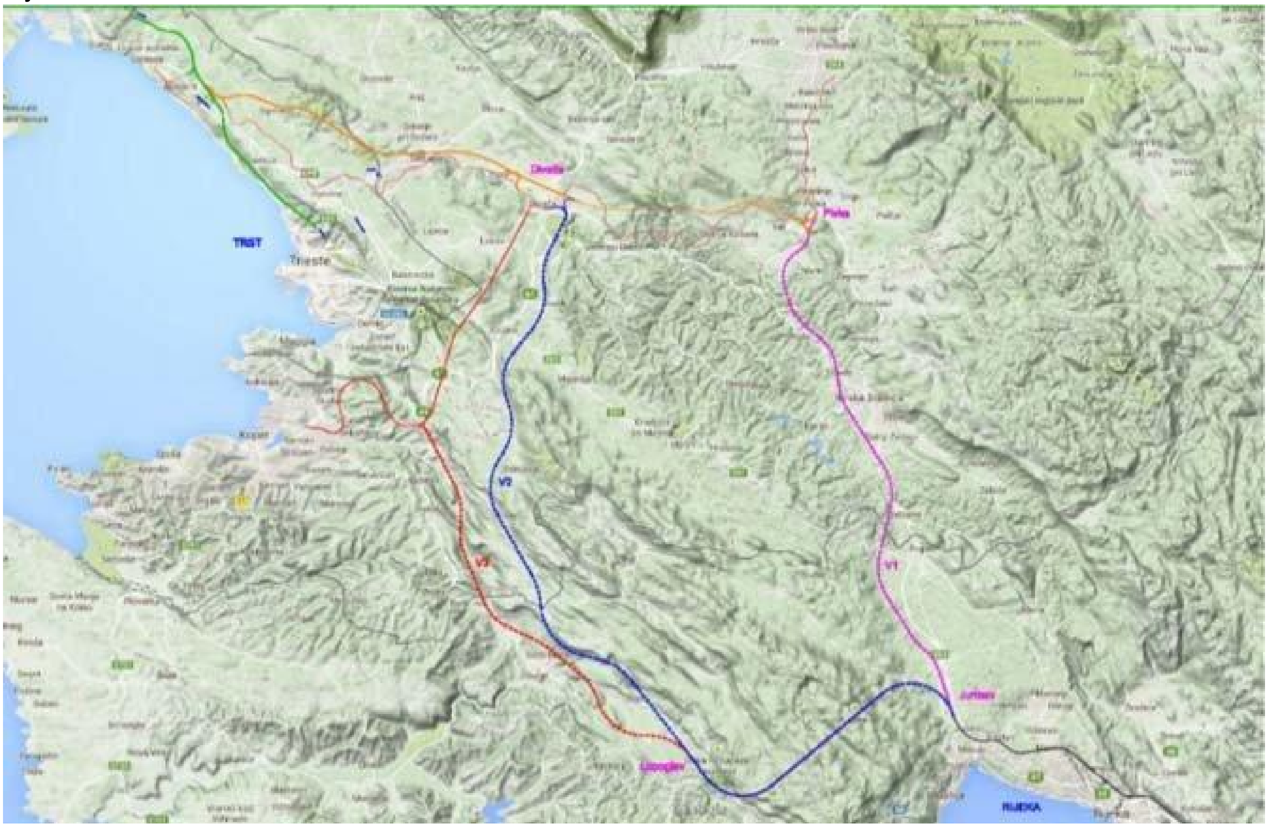
We are aware of a study published by the IGH Institute in Zagreb in 2014, which is referenced in numerous documents[6] and focuses on the possibility of connecting the Northern Adriatic port system with a high-efficiency railway. Unfortunately, we have been unable to obtain the original study, but the sources citing it provide, among other things, a map showing alternative routes connecting Trieste and Rijeka, as depicted in Figure 1.5.

[4] https://zavod.pgz.hr/docs/zzpuHR/docsplanovizupanija/1511/ppz-pgz-ii-id.pdf

[5] https://zavod.pgz.hr/planovi_i_izvjesca/prostorni_plan_pgz

[6] Studija okvirnih mogućnosti povezivanja sustava sjevernojadranskih luka željezničkom prugom visoke učinkovitosti, Institut IGH Zagreb 2014.

Figure 1.5: map of alternative routes ("variants") of the railway connection between Trieste, Koper and Rijeka.



Source: Vilke , S., Brčić , D., & Kos, S. (2017). Northern and Southern European traffic flow land segment analysis as part of the redirection justification. *TransNav , the International Journal on Marine Navigation and Safety of Sea Transportation* , *11* (4), 673-679.

In the document "Transport Development Strategy of the Republic of Slovenia (Strategija razvoja prometa v Republiki Sloveniji do leta 2030[7])," only enhancement projects for the Koper-Divača and Sežana-Divača-Ljubljana routes are mentioned. Therefore, any potential new connection between Rijeka and Lupoglav, located further south in the direction of Trieste, would still need to link up with the Divača line. However, it has not been possible to determine whether an actual project has been developed for this connection. In a 2021 interview, the president of HŽ, Ivan Kršić, stated that it is a "long-term project for which profitability needs to be demonstrated and adequate funding sources need to be secured (...) technical documentation needs to be prepared, and the necessary consents and permits obtained[8]." This suggests that while the project is included in strategic planning, preliminary feasibility analyses have not yet been conducted.
The Lupoglav route would radically change the perspective of the connection between Trieste and Rijeka for at least two reasons: a) the railway route would be one-third shorter than the current one and built to modern quality standards, and b) it would create a direct connection to the Istrian Peninsula, opening up tourism opportunities that currently rely solely on road connections. Currently, Lupoglav is connected to

[7]https://www.gov.si/assets/ministrstva/MzI/Dokumenti/Strategija-razvoja-prometa-v-Republiki-Sloveniji-do-leta-2030.pdf

[8]https://www.glasistre.hr/istra/ivan-krsic-do-2030-u-zeljeznicku-infrastrukturu-u-hrvatskoj-ulozit-cemo-54-milijarde-eura-te-obnoviti-i-modernizirati-780-kilometara-pruga-760736

Rijeka by HŽPP buses (a direct journey of approximately 40 minutes). It is also connected to Pula by railway, with five daily trains (four by HŽPP, one by SZ), taking between 1h27 and 1h48. In the past, Lupoglav was also connected to Raša via an infrastructure that still exists but is currently not in use. Furthermore, the line to Pula used to branch off at Kanfanar with a direct railway route to Rovinj, which no longer exists as the tracks have been removed and the path converted into a cycling and pedestrian route.
The majority of documents mentioning these variants emphasize the need/opportunity to: a) connect to European networks and b) exploit logistical integration opportunities of the Upper Adriatic ports (including Koper). For example, the document "Transport Development Strategy of the Republic of Croatia (2017-2030)[9]" highlights how the ports of Rijeka, Koper, Trieste, and Venice are part of the North Adriatic Port Association and that due to their location, these ports provide the most cost-effective shipping route from the Far East to Europe via the Suez Canal, with a distance of approximately 2,000 nautical miles less than other Northern European ports.
While the relevance of the connection between ports seems indisputable in terms of benefits for freight traffic, very few previous studies have focused on estimating the potential passenger traffic. Among these studies, only one, which we will discuss in the next paragraph (Amanović & Kralj 2016)[10], attempted to forecast the demand for the entire examined route.

1.2.2 Summary of the results of previous studies which carried out passenger demand forecasts on the Trieste – Rijeka route and/or on intermediate or connected sections

Passenger Traffic Forecast for the Optimization of the Trieste-Rijeka Railway Route
Amanović & Kralj (2016) conducted a study specifically focused on the optimization of the railway line between Trieste and Rijeka. The study analyzed existing projects and plans at the European level, concluding that the infrastructure optimization of the Trieste-Rijeka route is economically and environmentally justified for both freight transportation and shifting passengers from cars to trains. This study, in addition to providing a rough forecast, serves as a reference point for some of the methodological issues addressed in our work.
In summary, according to Amanović & Kralj: "The prospective volume of transportation on the Rijeka-Trieste railway cannot be objectively predicted using statistical methods based on past data (p. 21). It is also argued that the potential demand will depend on the overall development landscape of infrastructure, as well as a range of factors, including the size and development of the gravitational area, competitiveness of the transport system, and the degree of railway integration into the global transportation system. Essentially, this study, with which we fully agree, states that the potential demand for passenger transportation between Trieste and Rijeka is a function primarily of the railway transport supply, rather than a variable derived from existing factors (socio-demographic, economic, territorial, etc.). From this perspective, through a scenario analysis that integrates the Croatian railways (including those in Istria) into the European network and optimizes the connection infrastructure between Trieste and Rijeka, this study suggests a potential annual demand of 660,000 passengers by 2030 on the Trieste-Rijeka-Zagreb railway route (Table 1.2).
However, these data show some inconsistencies. Firstly, the total of the daily and annual forecasts does not correspond (for 2016 and 2050, they are parameterized at 200 days/year, while for 2030, it is 50 days/year. We believe this to be a typographical error). For our specific interest (the highlighted row in yellow in Table 1.2), the total daily passengers on the line from Trieste to Zagreb would be 6,300 passengers per day.

[9] https://mmpi.gov.hr/UserDocsImages/dokumenti/INFRASTRUKTURA/Infrastruktura%2010_19/Transport%20Development%20Strategy%20of%20the%20Republic%20of%20Croatia%202017-2030%2029-10_19.pdf
[10] Amanović, S., & Kralj, S. (2016). Optimizacija Željezničkog Povezivanja Rijeke I Trsta. *Željeznice 21*, *15*(2), 7-15.

Table 1.2.: Forecast of passenger transport volume

	Number of trains per day		
	2016	2030	2050
Trieste - (Rijeka) – Zagreb	4	16	24
Total connections including other internationals	4	18	28
Potential forecast passengers / day	**1400**	**6300**	**9800**
Trieste – Pula	0	2	4
Pula - Rijeka – Zagreb	0	6	8
Potential forecast passengers / day	0	2100	2800
Rijeka – Pula	0	14	22
Potential forecast passengers / day	0	4900	7700
Total estimated daily passengers for the connections considered	1400	13300	20300
Total estimated annual passengers for the connections considered	280,000	660,000	4,060,000

Source: Amanović , S., & Kralj , S. (2016). Optimization Željeznickog Povezivanya Rijeke I Trsta . *Željeznice 21* , *15* (2), 7-15. The table appears on p. 12 of the publication

By adopting a non-weighted[11] "gravitational"[12] allocation criterion, based solely on the population of the main centers and disregarding intermediate destinations for simplicity, the three destinations would account for the following passenger flows as origin/destination (Table 1.3).

Table 1.3.: breakdown of the travel demand forecast for 2030 by Amanović & Kralj (2016) by destination (our elaboration)

Destination	Population	Population share	Passenger fee
Stadt Zagreb	767.131	71.12%	4,480
Rijeka	107,338	9.95%	627
Trieste	204.234	18.93%	1.193
Total	1,078,703	100.00%	6,300

In essence, according to the study in question, the potential demand for railway passengers between Trieste and Rijeka in 2030 amounts to 1,820 daily passengers. Using the "200-day" criterion that the study employs to calculate daily traffic from the annual value, there would be a total of 364,000 railway passengers per year between Trieste and Rijeka.

According to the authors of the report, this forecast should be considered within the framework of a project that includes: a) the completion of the Mediterranean TEN-T corridor in the Croatian area, b) the connection of Istrian railways with the rest of the Croatian railway system (referring to the variants mentioned at the beginning of this chapter), c) the creation of connections between the northern Adriatic ports with the Danube and the Black Sea.

It should be noted that this study is from 2016 and, in outlining the aforementioned framework, it assumes the completion of several projects whose completion times have been prolonged. In fact, regarding this

[11]Since the estimates relate to the entire route, it makes no sense to weight the populations with a coefficient expressing the distance since each station is both origin and destination. In this regard, see annex 1 for further explanations.

[12]Gravity *models* are a family of models that estimate the flows (of various types) between two regions follow a behavior similar to that of gravitational attraction, where this is replaced by variables expressing the relevance that certain parameters have in determining the investigated phenomenon (Anderson, JE (2011). The gravity model. *Annu. Rev. Econ.* , *3* (1), 133-160.). For example, in transport it is assumed that flows are directly proportional to population, GDP, etc. and inversely proportional to the distance, where the latter can be measured in various ways. In our case, we assume that given the estimated flow, it is divided according to the resident or incident population. See also annex 1 of this chapter for a description and application of this criterion.

matter, the "Fifth Work Plan of the European Coordinator" for the Mediterranean corridor[13] notes that the development of the high-speed line between Ljubljana, Divača, and the Italian border is behind schedule. Specifically, the Slovenian railway development plan for 2030[14] mentions the route but does not include the tendering of infrastructure works. In the study we are describing, this interconnection is assumed to be completed. Therefore, on one hand, it can be considered that the proposed estimate for 2030 is actually optimistic or, at least, not cautious. On the other hand, it is noteworthy that for Rijeka station, the predicted figure from this study (627 daily passengers) is very similar to the upper limit (605 daily passengers) estimated from a study by HŽ Infrastruktura and the IGH Institute, which we will discuss in the next section.

Forecast of travel demand on the Slovenian railway routes of the Trieste-Rijeka route

The document "Transport Development Strategy of the Republic of Slovenia Until 2030"[15], also referenced in the Croatian document "Construction of the Second Track, Reconstruction and Modernization of the Skrljevo-Rijeka-Jurdani Railway route - Feasibility Study and Cost-Benefit Analysis (CBA)," [16] contains a table that shows the potential volume of passenger and freight traffic on certain railway routes in Slovenia in 2009 and a forecast for 2030. This table is presented here only for the part related to passengers and for the routes relevant to the Trieste-Rijeka route (Table 1.4).

Table 1.4: volume and potential forecast of passenger traffic on some Slovenian lines

Railway route	Traffic 2009	Forecast to 2030	% change
Divača - Sežana	229,813	359,890	56.6%
Divacha - Koper	261,511	692,770	164.9%
Divača - Pivka	388.185	1,991,440	413.0%
Pivka - Lulliana	973,000	3,009,060	209.3%
Border with Croatia - Ilirska Bistrica – Pivka	53,798	76,852	42.9%
Sežana – border with Italy	229,813	359,890	56.6%

Source: Republic Of Slovenia Ministry Of Infrastructure, Transport Development Strategy of the Republic of Slovenia Until 2030. https://www.gov.si/assets/ministrstva/MzI/Dokumenti/Transport-Development-Strategy-of-the-Republic-of-Slovenia-Until-2030.pdf

However, the data presented in this document should be approached with caution for several reasons. Firstly, it refers to a forecast for 2030 based on a study from 2011, which is a significant time gap that could only consider the macroeconomic landscape and the development strategies of trans-European networks at that time. Secondly, there is ambiguity regarding the table since it is mentioned in the text as "transport potential," but the table is titled "no. of passengers per year on individual railway routes in the Republic of Slovenia in 2009 and 2030," implying that it represents an actual passenger traffic forecast. Lastly, the document does not specify whether the passenger figures per section include route overlaps. However, considering that: a) the reported numbers are from 2009, b) the figure for Divača – Sežana is identical to Divača – Sežana – Border with Italy, we interpret the data as excluding overlaps. Our interpretation of this data is thus depicted in Figure 1.6, which we will use for estimating the overall potential demand model.

It should be noted that the 2030 forecast for the Divača - Pivka route depends on the assumption that the Divača - Pula line is open and operational, although it is currently served by buses. In the past, there was a "seaside service" from Ljubljana to Pula, and that forecast is based on a projection of passengers who

[13]Fifth Work Plan of the European Coordinator – September 2022, https://transport.ec.europa.eu/system/files/2022-10/5th_workplan_med.pdf.

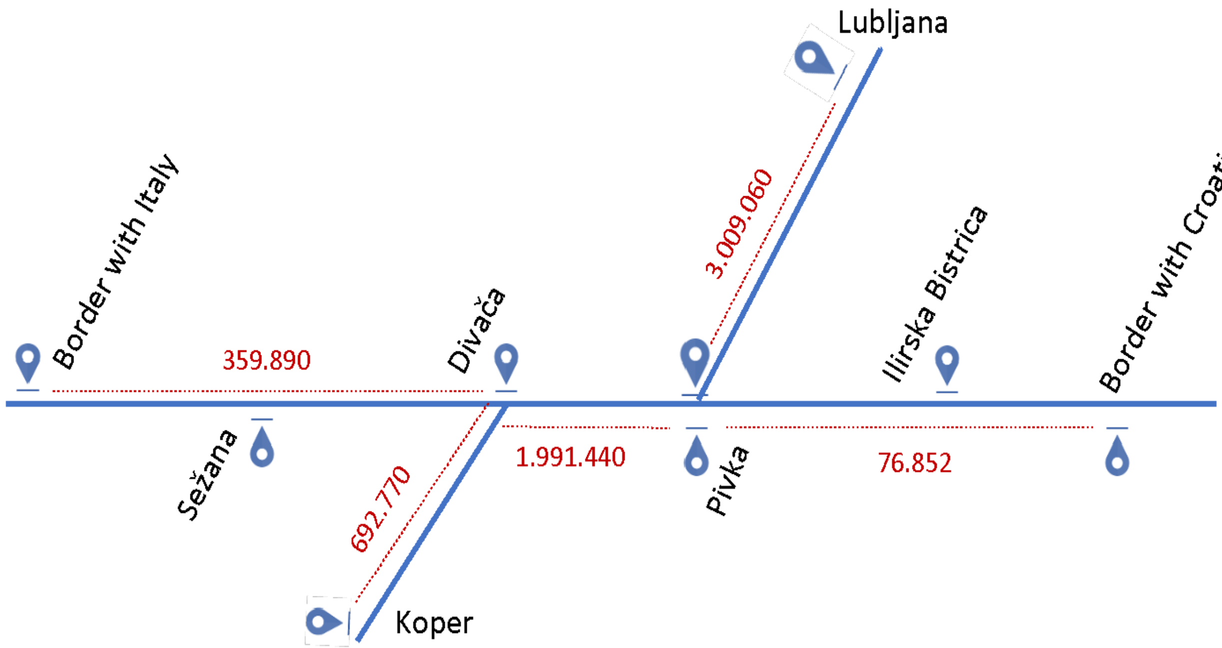
[14]https://www.gov.si/assets/ministrstva/MzI/Dokumenti/Strategija-razvoja-prometa-v-Republiki-Sloveniji-do-leta-2030.pdf.

[15]https://www.gov.si/assets/ministrstva/MzI/Dokumenti/Transport-Development-Strategy-of-the-Republic-of-Slovenia-Until-2030.pdf

[16]Izgradnja drugog kolosijeka, obnova i modernizacija pruzne dionice Skrljevo-Rijeka-Jurdani. Studija izvodljivosti i analiza troskova i koristi (CBA) projecta, HŽ Infrastruktura, IGH Zagreb (available in attachments to the report)

gravitated towards the Istrian line and could use it with its electrification and doubling. Therefore, we include that forecast for reference, but we will not use it in our analysis.

Figure 1.6: graphical representation of passenger traffic forecasts for 2030 on some sections of interest of the Slovenian railways.



Source: Republic Of Slovenia Ministry Of Infrastructure, Transport Development Strategy of the Republic of Slovenia Until 2030. https://www.gov.si/assets/ministrstva/MzI/Dokumenti/Transport-Development-Strategy-of-the-Republic-of-Slovenia-Until-2030.pdf

Travel demand in the metropolitan area of Rijeka

HŽ Infrastruktura and Istituto IGH[17] have provided a forecast of the passenger traffic trend on the Škrljevo railway route (about 9 km south of Rijeka) - Rijeka - Opatija/ Matulji - Jurdani , which we report in table 1.5..

Table 1.5. Forecast of transport demand on the route Škrljevo - Rijeka - Opatija/ Matulji - Jurdani (thousands of passengers per year)

Number of passengers	**2020**	**2024 - 2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Long distance	651	997	1.208	1,451	1,597	1,737	1,858
Regional	370	953	1.142	1,256	1.404	1.503	1,524
Urban and suburban		11,500	12.070	12,800	13,400	13,750	14,000
Index 2020 = 100							
(2024/25 for urban traffic)	**2020**	**2024 - 2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Long distance	100	153	186	223	245	267	285
Regional	100	258	309	339	379	406	412
Urban and suburban		100	105	111	117	120	122

Source: Project izgradnje drugog kolosijeka , obnove i modernizacije pruzhne dionics Škrljevo – Rijeka – Jurdani (Šapjane), Hž Infrastruktura , Institut Igh , Granova , public presentation, Rijeka 23 January 2020. https://www.hzinfra.hr/wp-content/uploads/2020/01/2020.01.23-Prezentacija-RI-23.01.20.-V2 -final.pdf.

[17] Projekt izgradnje drugog kolosijeka, obnove i modernizacije pružne dionice Škrljevo – Rijeka – Jurdani (Šapjane), Hž Infrastruktura, Institut Igh, Granova, public presentation, Rijeka 23 January 2020. https://www.hzinfra.hr/wp-content/uploads/2020/01/2020.01.23-Prezentacija-RI-23.01.20.-V2-final.pdf.

According to this forecast, compared to 2020, there will be an 86% increase in long-distance passengers by 2030 (total annual 1,208,000 compared to 651,000 in 2020), a more than three-fold increase in regional passengers (1,142,000 compared to 370,000 in 2020), while urban and suburban traffic would remain substantially at the levels projected for 2024/25, slightly over 12 million passengers (Table 1.5). The forecast is deemed "realistic" by the authors. Looking at the projected urban and suburban traffic for 2024-25, the approximately 12 million annual passengers correspond to an average movement of around 16,500 commuters per day in both directions, a figure that appears compatible with the overall population residing in the area served by the considered route (approximately 130,000 people).
It is reasonable to assume that a significant portion of urban and suburban travel would be directed towards public services, while for regional and long-distance passengers, it is likely that the proportion of those using automobiles will increase. However, the estimated increase for these two types of demand between 2020 and 2030 remains significant, namely an 86% increase for long-distance passengers and over 300% increase for regional traffic (Table 1.5). These increases should be interpreted in light of the strengthening of the Rijeka - Karlovac - Zagreb line.
Based on these data, it is possible to estimate the demand for local transportation on individual routes, assuming two hypotheses: a) Travelers are distributed among origins and destinations based on a "gravitational" criterion, meaning according to the population density incident and residing within a reference radius from the railway stations (i.e., more densely populated centers are the origin and destination for a larger proportion of travelers). b) The modal split of travel reflects that observed by Eurostat for the country.
With these assumptions and a procedure for estimating the incident population density in various destinations, we have estimated the average daily demand for railway travel in the urban and suburban area of Rijeka (Table 1.6). The data is presented as a range because the incident population and resident population differ for smaller localities, as the former parameter also considers population density associated with work activities, commercial activities, etc. According to the cited study, these values are expected to grow, especially for long-distance travel (forecasted +86% in 2030 compared to 2020) and regional travel (+205% in 2030 compared to 2020, Table 1.6). The details of the methodology used for this estimation are described in Annex 1 of this report.

Table 1.6: Estimate of the average daily number of rail passengers in transit for stations in the urban and suburban area of Rijeka on the Rijeka - Šapjane section (forecast 2024-2025)

Railway route	Daily passenger forecast
Rijeka - Opatjia / Matulji	650 - 660
Rijeka - Sapjane	7 - 79

Source: elaboration of data from Projekt izgradnje drugog kolosijeka , obnove i modernizacije pruzhne dionics Škrljevo – Rijeka – Jurdani (Šapjane), Hž Infrastruktura , Institut Igh , Granova , public presentation, Rijeka 23 January 2020. https://www.hzinfra.hr/wp-content/uploads/2020/01/2020.01.23-Prezentacija-RI-23.01.20.-V2 -final.pdf

1.2.3 Summary of the results of previous surveys on cross- border travelers between Italy, Croatia and Slovenia

A series of informative sources are represented by projects developed within territorial cohesion programs, particularly bilateral transport projects between Italy and Croatia, and Italy and Slovenia. Although most of these projects focus on maritime transport, some of the completed or ongoing projects have also addressed land passenger transport and hinterland interconnectivity. Among these, the following are noteworthy:

- ICARUS: Intermodal Connections in the Adriatic-Ionian Region to Upgrowth Seamless solutions for passengers (2019-2022)
- MIMOSA: Maritime and multimodal sustainable passenger transport solutions and services (2019-2023)
- SUSPORT: Sustainable Ports (2020-2023)

- CROSSMOBY: Mobility planning and sustainable cross-border passenger transport services, promoting intermodality (The project involved, among other things, the reactivation of a direct railway service between Trieste and Ljubljana, sharing the Trieste-Pivka section with the Trieste-Rijeka route.)
- ADRIPASS: Integrating multimodal connections in the Adriatic-Ionian region PLUS

These projects have produced numerous analyses directly or indirectly related to the objective of our study. In most cases, the analyses are conducted at the national, regional, or county level and are not directly applicable to estimating travel demand between Trieste and Rijeka. Therefore, we will only mention those that we consider useful for our estimations.

Analysis of potential demand between Rijeka and Šapjane and survey on travel frequency to Italy

Within the MIMOSA project, an in-depth study[18] was conducted, including a survey of passenger movement on cross-border trains between Rijeka and Šapjane. The results of the survey, repeated in 2022, are presented in Table 1.7. It should be noted that the numbers in Table 1.7 do not include passengers on the six daily local trains in each direction between Rijeka and Opatija-Matulji, which terminate their route at Permani (before Šapjane). If, as reasonable, the growth observed between 2020 and 2022 in July and October is due to the pandemic's easing, it is reasonable to assume that the 2022 data aligns with "normal" conditions and may even increase in 2023 following Croatia's entry into the Schengen Area and the Eurozone.

Table 1.7: Passengers recorded on cross- border trains on the Rijeka – Šapjane section (2020)

	Feb-20	**Jul-20**	**Oct-20**
Average daily	66	114	25
Monthly	1,878	3,526	776
Annual estimate	22,536	42,312	9,312
Average		24,720	

	Feb-22	**Jul-22**	**Oct-22**
Average daily	35	414	119
Monthly	971	6.404	3,679
Annual estimate	11,652	76,848	44.148
Average		44.216	

Source: for 2022: HŽPP; for 2020: HŽPP MIMOSA Project, D.4.1.3. Analysis on market potential research – with railway through Istria: route Rijeka- Šapjane .

The study carried out by HŽPP for the MIMOSA project also included a survey related to the travel demand. Table 1.8 presents some relevant data from the survey, carried out in 2021 on a sample of 246 travelers interviewed on Istrian trains and in the stations of Pula and Rijeka.

Table 1.8: some main results of the survey carried out for the MIMOSA project on a sample of 246 travelers

They travel to Italy	No	58%	
	Yes	42%	= 100%
	Weekly	1.3%	3%
	Monthly	31.5%	75%
	Annually	39.5%	94%
	Train users	5.0%	12%

Source: HŽPP - MIMOSA Project, D.4.1.3. Analysis on market potential research – with railway through Istria: route Rijeka- Šapjane .

[18]MIMOSA Project, D.4.1.3. Analysis on market potential research – with railway through Istria: route Rijeka-Šapjane.

According to these interviews, 42% of these travel to Italy, and of these almost all (39.5%) declare an annual frequency, 31.5 a monthly frequency and 1.3% a weekly frequency. By applying these percentages (with all the necessary precautions) to the average number of cross-border travelers recorded by HŽPP on the Rijeka – Šapjane route , we should conclude that more than 18,500 travelers traveled by rail between Rijeka and Italy in 2022.

Arrivals of Croatians in the metropolitan area of Trieste

Also, within the MIMOSA project, the Friuli-Venezia Giulia Region (project partner) conducted an analysis of cross-border movements based on mobile phone data[19]. According to this analysis, in 2022, the municipality of Trieste received 522,000 Croatian visitors, of which 122,000 were "one-time visitors." The study does not specify how many of these visits were made in a single day, which would have allowed for a more precise estimation of the number of visitors from the Rijeka area. However, an estimate can still be made based on the assumptions of the gravitational distribution criterion, which means that Croatian trips to Trieste are distributed proportionally based on the distance from the origin and the population of the region/city of origin of the trip. By adopting these assumptions, it is cautiously estimated that out of the 522,000 annual trips made to the municipality of Trieste from Croatia in 2022, those from the urban area of Rijeka range from approximately 68,000 to 175,000 (between 185 and 345 per day). Including Opatija in the estimate raises the daily average to a range of 202 to 479 visitors[20]. These data are consistent with a survey conducted specifically for this study on bus travelers, which we will discuss more extensively towards the end of this chapter. It is specified that this estimate takes into account the fact that a large part of Istria and the urban and peri-urban area of Rijeka can be reached within 1 hour and 15-30 minutes by car, beyond which the frequency of day trips decreases rapidly[21] (for details on the methodology used, see Annex 2 of this chapter). It is also worth noting that the same study identified approximately 2,243,000 visitors from Slovenia in 2022. Using the same criterion, we estimated that between 43,000 and 96,000 annual passengers (averaging between 120 and 260 per day) could transit from Slovenian intermediate stations. Annex 2 provides detailed information in this regard as well.

Cross-border tourism between Italy and Croatia

As part of the MIMOSA project, the authors have carried out various analyzes on the volumes of cross- border travelers between Italy and Croatia, as well as an analysis on the evolutionary scenarios up to 2030[22] (table 1.9). The first thing we notice is that the growth of movements from Croatia to Italy is visibly higher than that in the opposite direction [23].

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[19]MIMOSA Project, Annex to Deliverable D.3.1.1. Cross-border movements analysis based on mobile phones.

[20]It is worth remembering that unlike the passenger survey, in this case each visitor corresponds to two steps (there and back)

[21] Ahmed, A., & Stopher, P. (2014). Seventy minutes plus or minus 10—a review of travel time budget studies. *Transport Reviews* , *34* (5), 607-625.

van Exel, NJA, & Rietveld, P. (2010). Perceptions of public transport travel time and their effect on choice-sets among car drivers. *Journal of Transport and Land Use* , *2* (3/4), 75-86.

Zhu, W., Fan, WL, Wahaballa, AM, & Wei, J. (2020). Calibrating travel time thresholds with cluster analysis and AFC data for passenger reasonable route generation on an urban rail transit network. *Transportation* , *47* , 3069-3090.

[22]MIMOSA project - D.3.1.4. - Development Scenarios

[23]This is due to the fact that two types of models were used (one auto-regressive, therefore based on historical series of previous years, the other econometric, therefore based on correlations with socio-economic and demographic factors) and two factors: a) the flow trend prior to 2019, used for the estimate which adopted an autoregressive method, b) the population trend, and income.

Table 1.9: Forecast of the number of travelers between Italy and Croatia

Travelers	Year	Italian travellers Low estimate	Italian travellers High estimate	Croatian travellers Low estimate	Croatian travellers High estimate	Total Low estimate	Total High estimate
"tourists" (with overnight stay)	2019	1,175,069		294,825		1,469,894	
	2030	1,160,000	1,365,000	430,000	542,000	1,590,000	1,907,000
"hikers" (in the day)	2019	2,750,482	3,300,579	450,986	676,479	3,201,468	3,977,058
	2030	2,715,210	3,834,064	657,760	1,243,625	3,372,970	5,077,689
	2019/30	-1%	16%	46%	84%	6%	28%

Source: MIMOSA Project - D.3.1.4. - Development Scenarios

Unfortunately, an estimate of how many of these travelers will have origin or destination in Trieste and Rijeka would be highly uncertain [24], so it was decided to cite the data for the sake of completeness and for the sole purpose of taking into account the estimated rates of variation for the purposes of a sensitivity assessment of the forecasts that will be made later.

Summary of the results of the surveys carried out on the Ljubljana – Trieste railway route and on the Trieste – Rijeka bus service

The Italian, Slovenian, and Croatian railway management companies (namely, Trenitalia, Slovenske Železnice, HŽ Putnički Prijevoz) and the Central Directorate for Infrastructure and Territory of the Friuli-Venezia Giulia Region have provided the authors with a series of data on passengers who have traveled cross-border on routes that overlap with the section under examination. Here is a summary of the main data. Table 1.10 displays the monthly trend of travelers who traveled between Italy and Ljubljana in 2022.

Table 1.10: Cross-border rail travelers between Italy and Slovenia in 2022

Gen	Feb	Tue	Apr	Mag	Below	Jul	Aug	Set	Oct	Nov	Dec	2022
718	1.034	1,662	3.105	3,770	5.202	13,987	14,600	7,729	5,636	2,457	1,766	61,666
Daily average values												
23	37	54	104	122	173	451	471	258	182	82	57	169

Source: Yes, Trenitalia

The data shows an annual average daily basis of 168 cross-border travelers, with peaks exceeding 450 in the months of July and August. In total, over 61,600 passengers have traveled on the trains between Italy and Slovenia in both directions. Although it is not possible to reliably estimate the number of travelers who would use these trains on the Pivka-Trieste section alone, which overlaps with the Trieste-Rijeka line, the data is still significant as it clearly demonstrates the existence of a seasonal demand, specifically for tourism. This demand, by its nature, is triggered and varies based on the travel opportunities offered, unlike a purely functional demand that only increases with new contextual conditions (population growth, new job opportunities, etc.). However, a purely functional demand would lack seasonality (and decrease during the summer months). Therefore, these data indicate the existence of unexpressed tourism demand that could be directed towards the direct (non-stop) Trieste-Rijeka train once it is realized, similar to what has already happened with the direct train between Trieste and Ljubljana, which experienced significant demand once it was implemented under the Crossmoby project.

Estimation of travelers between Trieste and Rijeka using public bus services.

[24] It should be noted that the "gravitational" model used for another part of this chapter and described in annexes 1 and 2 is not reliable in this case since the data must refer to at least one defined point of arrival or departure, while in this case the data are related to two areas with numerous potential points of origin and destination.

Since it has been observed that a significant number of passengers use bus and shared taxi services, an attempt was made to estimate the number of such passengers in two ways: a) by observing boarding and alighting at selected random weekdays and holidays and counting the number of passengers, b) by calculating the minimum number of passengers that, considering the fares, makes the proposed number of scheduled trips economically viable.
The number of buses operating on the route was considered for both the bus company and the shared taxi service. The average operating costs and fares were also estimated. According to our calculations, in order for the bus service to be economical and profitable, an average saturation rate of at least 45% on daily trips is necessary, considering that each vehicle makes multiple trips per day. According to our estimates, this translates to an average value of approximately 90 passengers per day in each direction (thus a total of 180 passengers per day).
However, we have found that this service is irregular, as some trips are canceled with relatively short notice. Furthermore, additional services are offered in the summer months, so the value of around 180 passengers per day in both directions can be considered conservative. It should also be noted that this type of survey does not capture group travelers who rent buses from private companies, such as the company Nomago, which serves the Trieste-Pula and Trieste-Rovinj routes but not the Trieste-Rijeka route. However, we have received reports of buses from this company being used for charter services on the Trieste-Rijeka route.

1.3 Conclusions

From the analysis of documentation and previous studies directly or indirectly related to the Trieste-Rijeka railway route, we believe the following points are particularly relevant:

Relevance of the connection and plans for improvement and infrastructural increase

Croatian development plans dedicate ample attention to the doubling of the railway section between Rijeka and Šapjane (currently a bottleneck) and the modernization of the facilities. Furthermore, there is still a reference in the territorial plans to a new railway connection that would link Rijeka to the railway of the Istrian Peninsula through a tunnel crossing the Učka mountain to connect the railway to Lupoglav. Beyond the realistic timeframe for such a connection, the fact that it is mentioned is indicative of a policy direction clearly oriented towards enhancing the railway routes connecting Croatia to the city of Trieste. A similar direction emerges from the Slovenian railways for the section between the Italian border and the direction to Ljubljana.

Existing significant demand and expected strong growth

Data collected by the Croatian, Slovenian, and Italian railway companies show the existence of already significant passenger traffic in separate sections of the Trieste-Rijeka journey in 2022. The most substantial flows are observed on the Ljubljana-Trieste section and have a marked seasonal character. The presence of significant commuter traffic seems to be indicated by the fact that there are numerous local trains on both the Slovenian and Croatian routes. The data we have received suggest a concentration between Villa Opicina and Divača and between Šapjane and Rijeka. According to the predictions of a study by HŽ Infrastruktura and Institut Igh, the local suburban and regional traffic in these areas is expected to grow by up to 300% by 2030.

Predominantly seasonal demand

The available monthly data series show that travel demand has a strong seasonal component. This means that it is primarily tourist demand, which (unlike functional commuter demand) also varies based on transport offerings and service quality. It is demand that manifests when there is an offering, often in addition to the existing demand (and to a lesser extent resulting from the migration of travelers from cars and buses to trains), arising from the fact that the new transport offering increases the accessibility of the served destinations, thus expanding the pool of potential users and creating a new factor for consideration among the public planning a vacation trip. In this sense, studies conducted through interviews with travelers as part of some INTERREG projects mentioned in this chapter demonstrate a very high propensity to travel between Italy and Croatia, indicating a potential demand that the new offering can certainly help realize. In this regard, Chapter 3 will also address the attractions near the stops, which can act as a catalyst for this potential demand.

Potential for cycle tourism

In our search for previous contributions, we noticed that there are studies dedicated to cycle tourism[25], but none of them quantify the demand for cycle tourism in any way. This is understandable because a systematic survey of this phenomenon, capable of providing reliable numbers on the number of people engaged in cycle tourism in the area, would require a particularly complex and focused analysis, including field investigations. The examined territory can attract a considerable number of railway passengers with bicycles. Confirmation of this can be seen in the data relating to bicycles disembarked and embarked in Trieste for the Austrian railway (OBB) train that connects Trieste to Ljubljana and Vienna (Table 1.11).

Table 1.11: number of passengers and bicycles disembarked and embarked in Trieste on the OBB train to and from Vienna

OBB EC 134 From Vienna, via Ljubljana, towards Trieste	The trims.	II quarter	third quarter	fourth quarter	Annual total
Travelers	91	903	1829	371	3194
Bicycles	15	121	256	32	424
OBB EC 135 From Trieste via Ljubljana to Vienna	**The trims.**	**II quarter**	**third quarter**	**fourth quarter**	**Annual total**
Travelers	99	440	924	256	1719
Bicycles	11	418	912	72	1413

Source: OBB, through the Regional and Local Public Transport Service of the FVG region

Notes:

a) The data provided only pertains to passengers boarding/alighting at Trieste Centrale station (passengers boarding/alighting at Villa Opicina station are not included). Therefore, the data provided is partial for the analysis of the demand served by the railway carrier to and from Trieste.

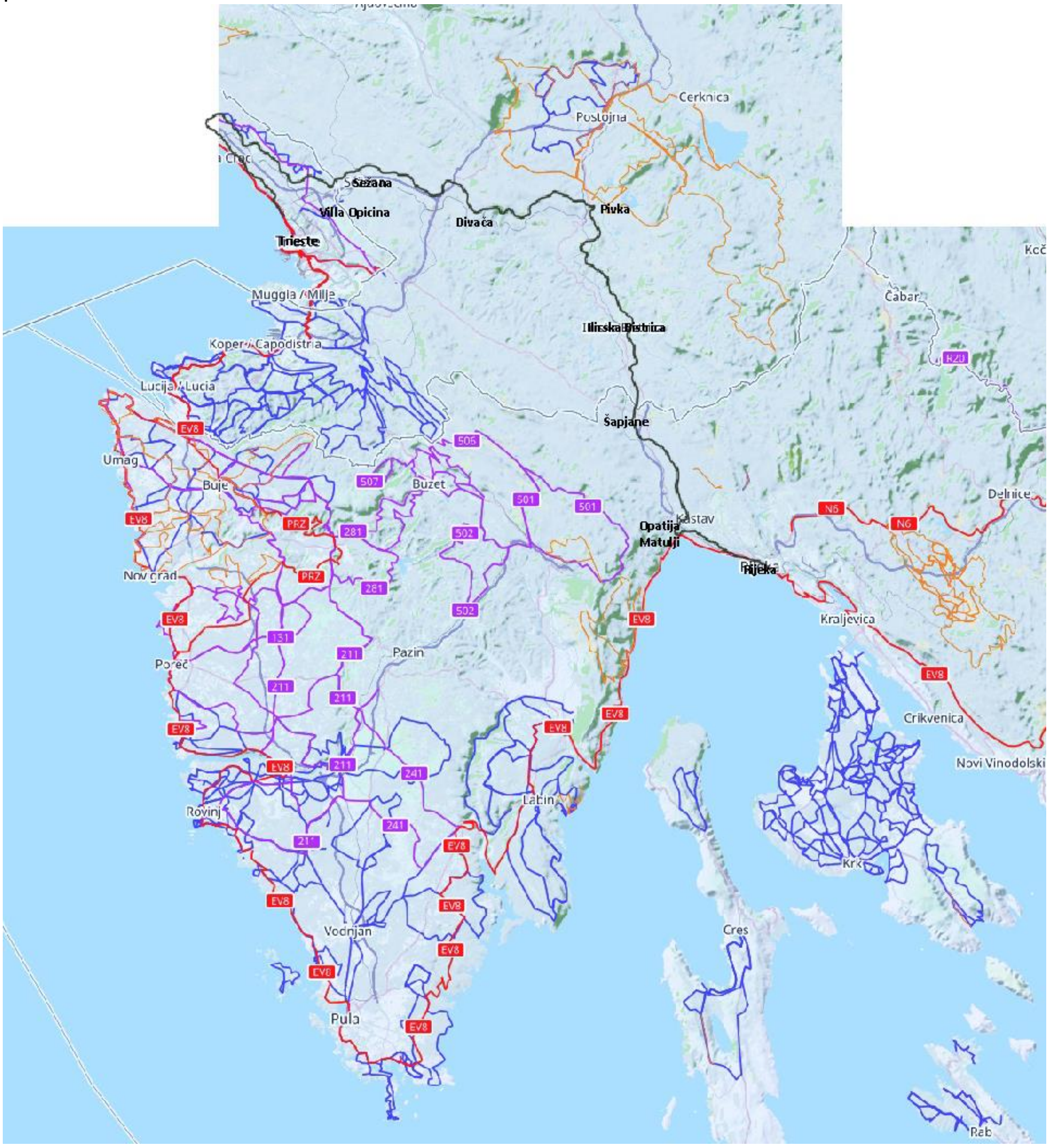
b) A partial asymmetry is observed between outbound and return journeys in some connections due to various factors, including: 1. the presence of alternative routes for connecting to Vienna (via Udine-Tarvisio, although in this case without direct railway connections), and consequently the possibility of making the outbound and return trips on different routes; 2. on the Trieste-Ljubljana route, the presence of the Cross-Moby service that complements the service provided by the OBB train Trieste-Vienna; 3. the possibility that cyclists traveling in one direction may choose to travel through the regional territory by bicycle, and therefore may not be captured in the train ridership data.

c) Trenitalia does not sell tickets for the service provided by this train.

In this regard, it is worth considering the large number of cycling routes officially marked in areas adjacent to the railway route. Figure 1.7 shows the mapped cycling routes and tourist sections in the Istrian Peninsula, the islands accessible from Rijeka, and in the vicinity of Rijeka, Trieste, and Pivka. However, additional cycling opportunities mapped on specialized platforms (such as Komoot) should be added to these. These platforms include additional user-reported routes. In particular, it is worth noting that the Opencyclemap in Figure 1.7 does not include routes near Ilirska Bistrica, which are instead listed on the Komoot platform (see also Figure 3.74 in Chapter 3). During our site visit, we observed some signs of these routes. Furthermore, this area features an extremely pleasant landscape that is minimally affected by buildings and infrastructure, and in our opinion, it offers ample opportunities for the development of cycling tourism.

[25] For instance. Poljičak, Šego, & Periša (2021); Medved, Gavrić & Vukojević, (2020).

Figure 1.7: cycling routes reported by Opencyclemap in the areas close to the railway line and in the Istrian peninsula.



Source: Opencyclemap

2. Current situation - Analysis of the existing offer

The travel options between Rijeka and Trieste observed between April and May 2023 consisted of indirect train routes (requiring transfers), a direct bus line (Flixbus), and a shared rental service with a driver (Go-Opti).

Traveling by train involves transferring at Pivka and utilizing a combination of international services operated by Trenitalia, ÖBB (Austrian Federal Railways), and Slovenske Železnice (SŽ - Slovenian Railways) on the Trieste-Ljubljana and Ljubljana-Rijeka routes with a transfer at Pivka. However, the available solutions between Trieste and Rijeka are not competitive as the minimum duration of the entire journey exceeds 5 hours and 30 minutes, primarily due to a long layover at Pivka. For comparison, the direct bus connection between Trieste and Rijeka takes between 1 hour and 45 minutes to 2 hours and 25 minutes, while the car journey can be completed in 1 hour and 25 minutes to 1 hour and 45 minutes (see Figure 2.1).

Figure 2.1: Main public transport connections existing between Trieste and Rijeka

Source: our survey of booking sites of public transport companies operating in the area. Survey carried out between April and May 2023.

2.1 Analysis of the present offer of railway transport between the regions

Tables 2.1 - 2.3 present the current values of certain key transportation demand factors that could be relevant to the use of the Trieste Centrale - Rijeka railway line. The tables respectively provide the distances, times, and costs associated with traversing the distances between the railway stations at the endpoints of the Trieste Centrale - Rijeka line. Specifically, in cases where multiple alternative routes are possible, Tables 2.1 and 2.2 display the minimum distances and times.

Table 2.1: Road/railway distances in km between the stations at the ends of the sections of the Trieste Centrale - Rijeka line

	Trieste C.		**See Opicina**		**Pivka**	
	street	railroad	street	railroad	street	railroad
Trieste C.	0					
See Opicina	7	29	0			
Pivka	44	71	45	42	0	
Rijeka	74	126	73	97	54	55

Table 2.2: Journey times by car, bus and train between stations at the ends of the sections of the Trieste Centrale - Rijeka line

	Trieste C.			See Opicina			Pivka		
	car	bus	train	car	bus	train	car	bus	train
Trieste C.		0:00							
See Opicina	0:11	0:26	0:28		0:00				
Pivka	0:50		1:16	0:35		0:42		0:00	
Rijeka	1:15	1:45	3:05	1:15		2:35	0:55		1:37

Table 2.3 displays three levels of automobile usage costs along the minimum distance routes: fuel costs only, marginal costs (including capital share, fuel, tires, and repairs), and total costs (including marginal costs plus a share of fixed costs assuming an annual mileage of 50,000 km). These costs have been calculated using the following per-kilometer costs provided by the ACI website for a widely used car like the 2020 Volkswagen Golf VIII 1.5 TSI - 150CV ECO ACT gasoline model:

- Fuel cost: €0.1145/km
- Marginal costs (including capital share, fuel, tires, and repairs): €0.3660/km
- Total costs (including marginal costs plus a share of annual fixed costs) range from €0.4361/km (for 50,000 km/year) to €1.0665/km (for 5,000 km/year).

Please note that Table 2.7 does not account for any toll fees, which significantly increase the cost of the journey. Regarding railway costs, the table provides ticket prices for adult passengers in second class.

Table 2.3: Minimum costs for the use of cars, coaches and trains between the extreme stations of the sections of the Trieste Centrale - Rijeka line (motorway tolls are not included)

		Trieste C.			See Opicina			Pivka		
		car	bus	train	car	bus	train	car	bus	train
	Fuel	0.8								
See Opicina	Marginal	2.56	1.4	3.65		0				
	Overall	3.05								
	Fuel	5.04			5.15					
Pivka	Marginal	16.1		3.60	16.47		3.6		0	
	Overall	19.19			19.62					
	Fuel	8.47			8.36			6.18		
Rijeka	Marginal	27.08	9.90	1.60pm	26.72		10.60	19.76		6.00
	Overall	32.27			31.84			11.55pm		

Regarding railway connections, during the survey period (April-May), the ones relevant along the Trieste - Rijeka route are illustrated in Figures 2.2 and 2.3. Apart from the role played by the Pivka station as a "dividing point," it is evident that even long-distance trains (bound for Ljubljana, Vienna, Trieste) effectively provide local service as they make stops at intermediate stations. It is also worth noting that many of these trains offer bicycle transportation services.

Figure 2.2: railway connections surveyed in May 2023 on the Trieste-Rijeka section in the direction of Rijeka

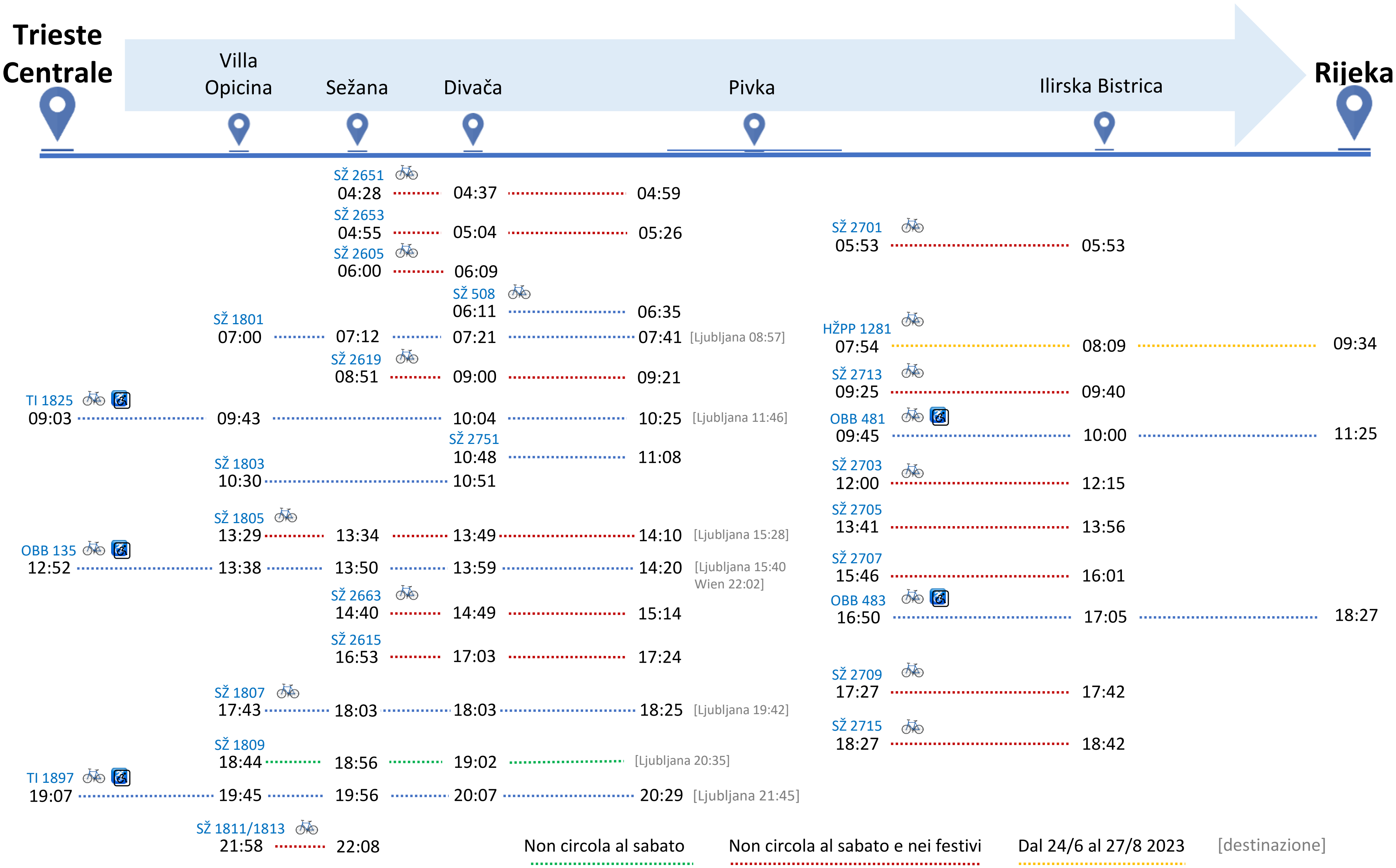
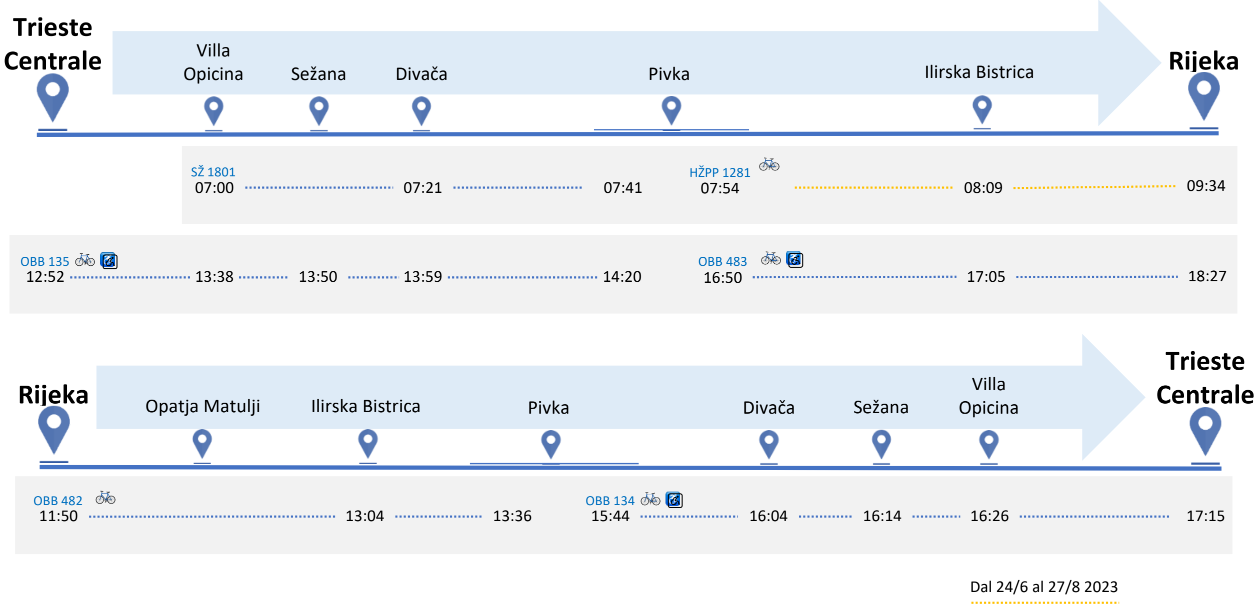


Figure 2.3: railway connections surveyed in May 2023 on the Trieste-Rijeka section towards Trieste

The timetables in Figures 2.2 and 2.3 were recorded between April and May 2023. The data was collected from railway company websites and by consulting the station boards, which were photographed during site visits. It was found that the paper timetables displayed at the stations are often incomplete, as they do not indicate the final destination of the trains, particularly beyond the border (this issue is described in Chapter 6, issue A1.2).
Another significant factor that emerges is that the current journey times between Trieste and Rijeka are primarily affected by the lack of schedule coordination (poor timetable harmonization, issue A2.8 in Chapter 6). In reality, there is only one daily opportunity in each direction to travel by train from Trieste to Rijeka. The travel times in both cases exceed 5 hours and rely on the OBB service (Figure 2.4).

Figure 2.4: useful timetables for the Trieste-Rijeka railway journey



Cross-border connections are limited between Slovenia and Croatia, and in the case of Trieste, there is also a lack of connections with Villa Opicina. We have observed only three trains per day in each direction between Trieste and Villa Opicina, one of which is the OBB train to Vienna. The travel time between Trieste and Villa Opicina represents another factor of discontinuity. As an example, we have highlighted a route that would allow travel from Villa Opicina to Rijeka in just over two and a half hours (Figure 2.4). While this time is certainly longer than what one would typically spend by car, it is not far off from the actual time required during periods of heavy traffic in the spring and summer months, especially on weekends.
The minimum ticket price for the entire journey between Trieste and Rijeka, or vice versa, is €13.60, compared to a theoretical minimum cost for a direct bus (Flixbus) of approximately €10 (excluding booking fees). The cost of traveling by car, as mentioned earlier (Table 2.3), includes expenses that are not typically considered by motorists. Fuel alone costs around €9, but the total cost exceeds €32, which can increase further depending on whether one chooses to take the two-lane road E61 or use fewer toll roads. Although toll roads are longer, they offer shorter travel times in cases of heavy traffic. On average, and without considering travel time, at current prices, rail travel is more economical than traveling by car for up to two or three passengers. However, the existing rail service is not competitive compared to bus travel.
In conclusion, for completeness, Figure 2.5 provides a summary of the main aspects regarding the state of the infrastructure of the mentioned route and the Istrian route, which we have seen to be a potentially significant driver of demand for the Trieste-Rijeka line. Additionally, it is considered helpful to provide an overall overview of interconnected railway routes, particularly the Istrian route, highlighting all intermediate stations, for a potential evaluation of the trade-off between increasing the number of stops (and potential passengers) and increasing travel time (thus potentially decreasing demand). Figure 2.6 shows the distances and levels of the two sections into which the Trieste-Rijeka line is currently divided (Trieste-Pivka and Pivka-Rijeka). Figure 2.7, on the other hand, displays the diagram of the line connecting Divača to Pula.

Figure 2.5: summary of the state of infrastructure on the Trieste-Rijeka section and connection with Istria

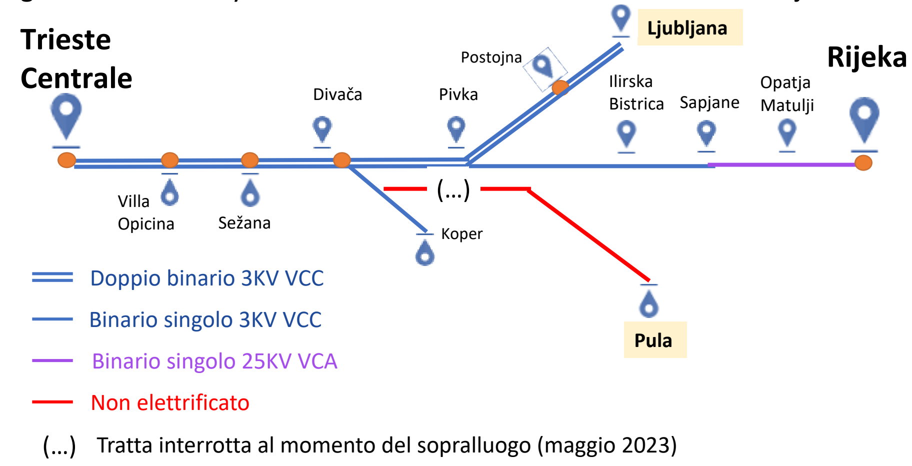


Figure 2.6: Diagram of the Pivka - Rijeka and Pivka - Trieste Centrale railway lines

Sources:
https://it.wikipedia.org/wiki/Ferrovia_San_Pietro_del_Carso-Fiume
https://it.wikipedia.org/wiki/Ferrovia_Meridione

Figure 2.6: Diagram of the Divača – Pula railway line

Source: https://it.wikipedia.org/wiki/Ferrovia_Istriana

3. Analysis of the general context and "trip generation"

3.1 General context of the reference area[26]

The cities of Trieste and Rijeka share several relevant aspects from a historical and socioeconomic point of view. Among these, we highlight the following: a) they are both home to important commercial ports, b) they are both home to prestigious universities, c) they both have a significant intercultural character, as evidenced by the presence of significant Italian, Slovenian, and Croatian communities beyond their borders.

Both cities have a long historical background in port activities, which has contributed to the development of a strong commercial and maritime tradition in both places. This has shaped the character of both cities, which remain open to multiculturalism and traditions, making them vibrant centers with a lively social life. Today, both ports are important nodes for international trade and serve as crucial routes connecting Central and Eastern Europe with the Near and Far East. In fact, both ports are geographically positioned to potentially facilitate naval and land traffic with a large part of Central-Eastern and Southeastern Europe. Specifically, among the countries of Central Europe, Rijeka (together with the nearby terminals of Sušak and Bakar) offers the shortest maritime connection to the Central, Middle, and Far East.

The European TEN-T network includes both Trieste and Rijeka in the Mediterranean corridor, which also includes Venice, Trieste, and Koper, connecting them with Zagreb and Budapest. The Rijeka-Zagreb railway network, in particular, became part of the "Rail Freight Corridor 6"[27] initiative in 2013. This corridor largely overlaps with the Mediterranean TEN-T corridor and aims to ensure interoperability and competitiveness of European rail freight traffic. It is worth noting, however, that the TEN-T network does not include a direct connection between these two cities but rather a "comprehensive network" connection between Rijeka and Pivka.

Both regions to which these cities belong, Friuli-Venezia Giulia (FVG) and Primorje-Gorski Kotar County (PGC), with Trieste and Rijeka as their respective capitals, are centrally and potentially crucially positioned for the integration of the Danube region, the Adriatic area, Central Europe, and Southeast Europe.

Comparing two main parameters statistically correlated with mobility propensity (per capita income and level of education), in both cases, the reference regions surpass the national average. Theoretically, this should be related to a higher propensity for mobility and travel compared to the average. The FVG region has one of the highest per capita GDPs in Italy (€31,000, ranking seventh among Italian regions), and the percentage of the population with a university degree exceeds 30%. PGC has the highest percentage in Croatia of people with a university degree or equivalent (24%), and it ranks third, after Istria and the Zagreb urban area, interms of per capita GDP (approximately €14,800, an index of 81 compared to the EU28 average). This moderately optimistic picture is reinforced by the fact that PGK County is also the second, after Istria, in terms of the share of Italian tourists (on average, 24% of Italian tourism in Croatia between 2019 and 2021)[28].

Rijeka is the main city of Primorje-Gorski Kotar County and currently has a population of approximately 108,000 inhabitants (one-third of the county's total population). Over the past twenty years, the region's population has decreased by about 5%, reaching approximately 281,000 residents. The net migration balance of the region is close to zero, resulting from a balance between emigration and immigration, with over 4,000 individuals entering and leaving each year.

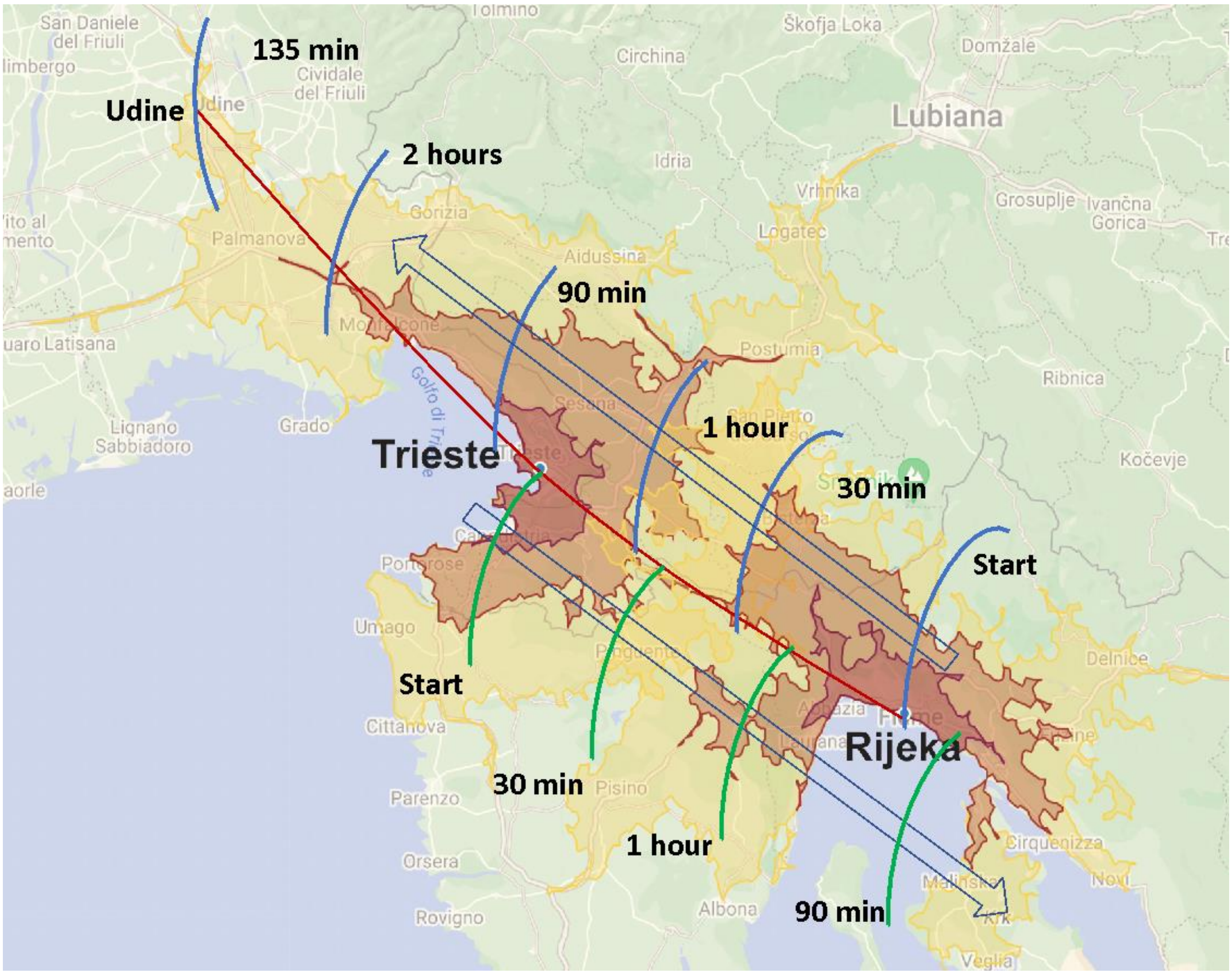
The car journey between the cities of Trieste and Rijeka is relatively short and typically takes between 1 hour and 20 minutes to 1 hour and 35 minutes (Figure 3.1) under normal conditions. These travel times are now much more certain following the elimination of border controls as a result of Croatia's entry into the Schengen Area.

[26] For the socio-demographic and economic information used for this section, it comes from the following sources: DŽS, ISTAT, Regione FVG, Eurostat. For more information on the aspects potentially causing barriers to cross-border mobility, see chapter 6 of this report.

[27] Regulation (Eu) No 913/2010 Of The European Parliament And Of The Council of 22 September 2010 concerning a European rail network for competitive freight

[28] Source: MIMOSA Project, D. 3.1.1. Quantitative analysis of the existing demand.

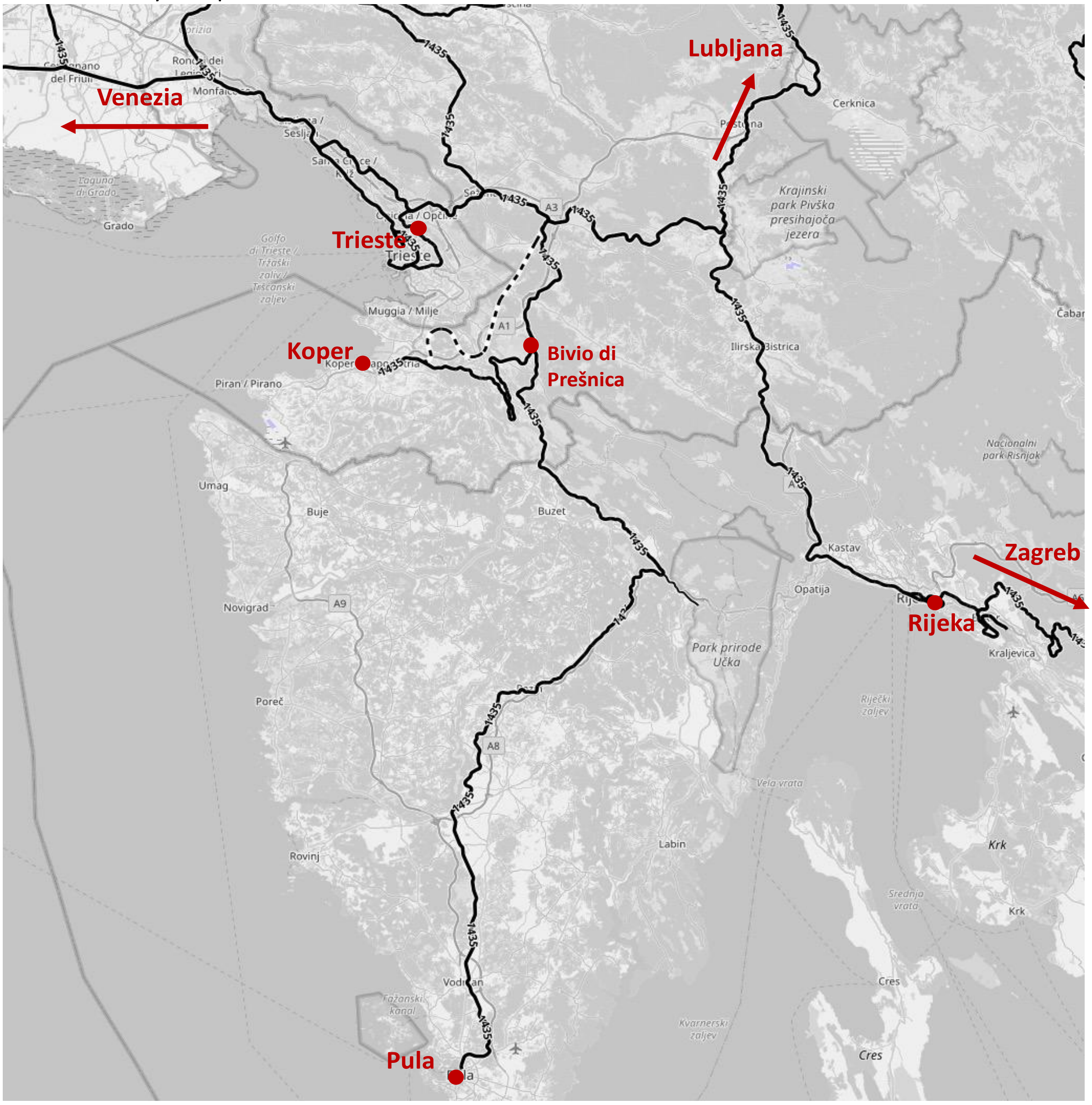
Figure 3.1: isochrones related to the areas reachable by car from the railway stations of Rijeka and from Trieste for different travel times



It should be noted that the theoretical times indicated in Figure 3.1 are highly variable because the connecting road (E61) is classified as a "state road" (EU Class "A" - extra-urban road), and it is predominantly a single-lane road for each direction of travel (thus two lanes), which easily congests with even a slight increase in traffic.

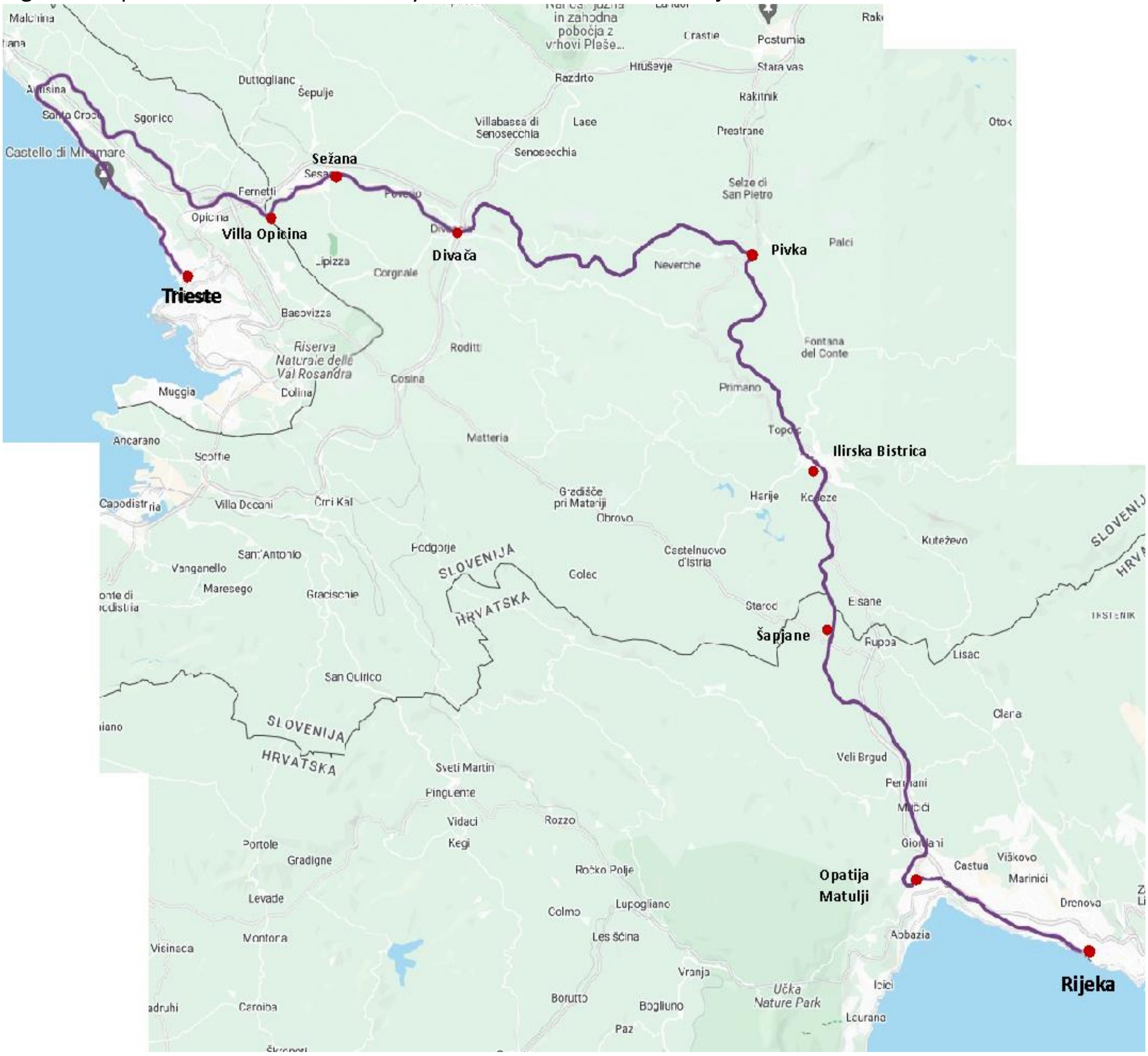
The territory affected by the railway route of the new railway service is depicted in Figure 3.2. The specific route is part of a broader interconnected network that includes the cities of Venice, Ljubljana, Zagreb, as well as Koper and the Istrian railway that extends to Pula (Figure 3.2). It is worth noting that, starting from the Prešnica junction, the southbound route is currently not electrified. Furthermore, as we saw in Chapter 1, some traffic forecasts made in the past by railway companies and the Croatian Ministry of Transport were based on the enhancement of this Istrian route, which would have a significant impact in terms of passenger traffic (see, for example, the Ministry's forecast for the Divača-Pivka section by 2030 in Table 1.4).

Figure 3.2: railway line present in the reference area and main connections



The train route between Trieste and Rijeka is currently only possible along the route indicated in Figure 3.3. For the purposes of this study, it is assumed that a series of intermediate stops, as shown in the figure, will be served, which are already stops for regional services. While there are other stations along the route, through interviews and the evaluation of the relevance of the locations, it is believed that the indicated stations are the most likely candidates to serve as intermediate stops. It should be noted that the infrastructure between Rijeka and Šapjane is a single-track and the speed is limited to between 50 and 75 km/h. Projects and procedures are underway for the modernization and doubling of this section. Naturally, the two major urban centers (Trieste and Rijeka) are home to functional attractions (universities, maritime transport hubs, hospitals, airports), but all the locations served by the train route are in proximity to various tourist attractions. In the following paragraphs, for each station, the main points of interest have been considered, focusing on those clearly identified by a locality or specific location, in order to calculate relatively accurate travel times to and from the reference stations. Therefore, for example, the surrounding area of Ilirska Bistrica, which has great potential for hiking and cycling tourism, has not been included among the "points of interest" simply because it is not identifiable as a specific "point."

Figure 3.3: planned route of the railway line between Trieste and Rijeka



In paragraph 3.3, an overview of the main connections for each of the served stations will be provided. The summary of the main connections considered is depicted in Figure 3.4.

Figure 3.4.: summary of the main points of interest near the railway route

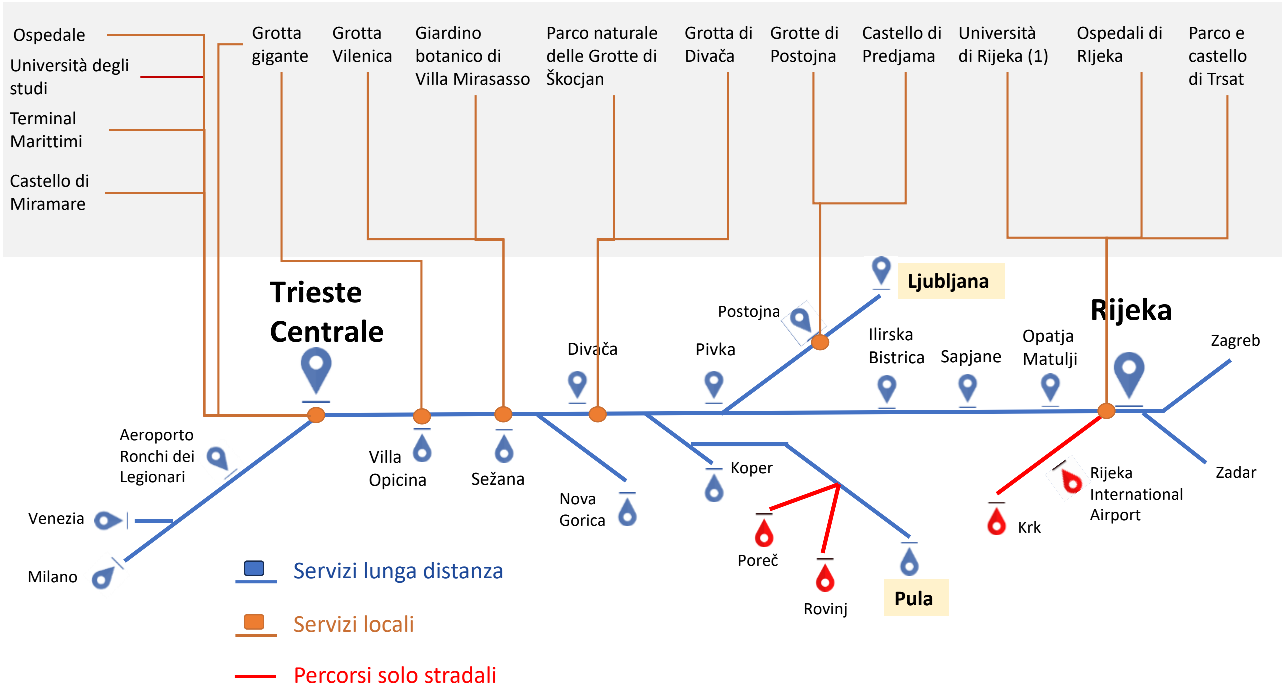


Table 3.1: reference data relating to the population of the localities served by intermediate stations on the Trieste - Rijeka section

	Resident population°	Survey year	Estimate of the accident population within a 15-minute radius of the railway station (net of overlaps)* for different modes of travel				
			Car	Bus	Bikes	Standing	Reference point coordinates
Trieste	198.417	2023	197.246	172.120	151.078	32,569	45.657218, 13.772283
Villa Opicina #				16,129	13,226	4,973	45.694075, 13.791464
Sežana	13,842	2022	26,353	12,338	6,756	3.122	45.704432, 13.86354
Divacha	4,371	2022	16,561	4.007	2,355	1.206	45.681783, 13.965409
Pivka	6,230	2022	12,868	6.003	3,609	1.302	45.675083, 14.191719
Ilirska Bistrica	13,399	2022	12.135	7,545	6,802	3,533	45.569521, 14.236224
Sapjane	10,771	2021	4.307	1,734	1.026	158	45.476666, 14.244051
Opatija- Matulji	10,589	2021	45,965	43.196	15,399	3,694	45.364943, 14.321708
Rijeka	107,338	2021	154,910	125,667	88.088	15,530	45.330426, 14.430627

With reference to table 3.1, the following is specified:
° The resident population is taken from the Italian, Slovenian and Croatian national statistical institutes
The population of District II of the municipality of Trieste which includes Villa Opicina , Banne , Trebiciano, Padriciano , Gropada and Basovizza was 10,619 inhabitants in 2022
Settlement Layer (GHSL) system of the European Commission, updated to dates between 2015 and 2018 (https://data.jrc.ec.europa.eu/ collection / ghsl), calculated using the isochrones generated by the Openrouteservice service (see the methodological note at the end of chapter 1 of this report).
^ The areas that included within 15 minutes by car from the stations of Villa Opicina and Trieste overlap almost totally, for this reason only one figure is indicated for both stations. For bus transport, only the additional incident population value is indicated with respect to that of the area already covered by Trieste Central Station are indicated for Villa Opicina. With regard to transport by bike, the effective overlap between the two isochrons is estimated to be less than 13%.
The area within 15 minutes by car of Opatjia-Matulji station overlaps by about 50% of the area and 60% of the population with that of the Rijeka station. The bus is estimated as a hypothetical urban service in each direction with idle time equal to 20% of the journey time

With regard to the intermediate stations, it should first of all be noted that:
- Šapjane , Sežana and Villa Opicina are border stations;
- Sežana is very close to the border with Italy and is a potentially interesting stopover for cross-border workers working between Slovenia and Italy.
- Divača is a point of potential interconnection with the railway lines of the Istrian peninsula;
- Pivka is an interchange station and interconnection point for lines heading to Ljubljana.
- Ilirska Bistrica and Pivka are of significant tourist interest both for their proximity to Postojna and for a particularly valuable landscape which lends itself to cycling and trekking itineraries.

3.2 Mapping of the potential catching area of the railway stations on the route in question

To map the destinations along the route of the railway service under examination, the following steps were taken:

- Examination of the cartographic survey of the station area.
- On-site verification of the served stations, with visual and photographic survey of the infrastructure, connections, and any distinctive aspects of the different destinations along the route.
- Determination of minimum travel times to major long-distance destinations, using published timetables at the stations (where available), as well as to major local points of interest.
- Mapping of the serviced areas within a radius compatible with a 15-minute walk, bike ride[29], urban bus service (hypothetically assumed to be present even where it is not), and car travel. In particular, the feasibility of bike travel was analyzed, taking into account the gradients of the shortest routes.

Table 3.2 summarizes the main characteristics of the stations. It displays, among other data, the "reach factor" for each station, which is a proxy indicator of the accessibility of the reference point. However, it has some peculiarities that are important to understand for proper interpretation.
Essentially, the "reach factor" does not vary based on transportation services but rather on existing transportation infrastructure.
The reach factor is calculated as the ratio between the area of the polygon generated by the actual isochrone of a point (based on the average speed of the means of transportation) and the area of a circle with a radius equal to the distance traveled by the same means of transportation within a unit of time. For example, a "reach factor" of 0.5 for "bike, 15 minutes = 4 km" indicates that with that means of transportation and within that time, destinations can be reached within a polygon that covers half the area of a circle with a radius of 4 km. The reach factor is therefore influenced by the availability of passable routes, topography, and obstacles along the path (rivers, railways, etc.), but its construction makes it manifest in a non-intuitive way. In fact, this indicator varies not only based on available routes but also on other factors, among which the most relevant for understanding its meaning are listed below:
a) Degree of urbanization, as cities usually have more alternative routes to a destination than rural areas. b) Type and positioning of urban infrastructure; for example, a busy and/or high-speed road connection limits pedestrian and cycling paths, reducing the reach factor of the bike and pedestrian route. This phenomenon is clearly seen, for example, in the difference in pedestrian and cycling reach factors for the two stations of Trieste and Rijeka (Table 3.2), both because the former is a terminal station and because the urban configuration of Rijeka, which develops between the coast and the hills, has led to the construction of an important road artery parallel to the station and railway. c) For motor vehicles, the presence of high-traffic arteries in the vicinity, which expands the radius of the reference circle for calculating the reach factor without proportionally expanding the area of the isochrone because it develops linearly along the artery alone. In fact, the use of a faster means of transportation usually results in a lower reach factor since it depends on the actual passability of the routes, and moving on foot or by bike usually allows for more alternative paths compared to, for example, a car.

[29]The cycling times have been calculated for a normal non-electric bicycle.

Table 3.2: main data** of the presumable intermediate stations of the railway service between Trieste and Rijeka

	State of maintenance and comfort of buildings open to the public	Interconnectivity with other means of transport	Sidewalk accessibility at the first platform	Commercial services nearby	Automatic ticket office	Bike / Monop . sharing nearby	Bike Park nearby	Car rental nearby	reach factor Car	Bus	Bikes	Standing
Trieste	Optimal	Very high	YES	Yes	Yes	Yes	No	Yes	0.0414	0.0652	0.6960	0.6640
Villa Opicina	Good	Very Limited	Yes	No	No	YES	No	No	0.0754	0.1073	0.7477	0.4406
Sežana	Optimal	High	Yes	No	Yes, only in Slovenian language	No	YES	No	0.1015	0.1147	0.6842	0.3646
Divacha	Optimal	Good	Yes	No	Yes, only in Slovenian language	No	Yes	No	0.1093	0.1101	0.5790	0.5252
Pivka	Optimal	Limited	Yes	No	Yes, only in Slovenian language	No	Yes	No	0.0903	0.0740	0.6954	0.3005
Ilirska Bistrica	Good	Limited	Yes	No	Yes, only in Slovenian language	No	Yes	No	0.0777	0.0805	0.6475	0.4351
Sapjane	Insufficient°	Absent	Yes	No	No	No	No	No	0.0214	0.0188	0.2082	0.2172
Opatija - Matulji	Insufficient*	Limited	Yes	No	No	No	No	No	0.0572	0.0978	0.7061	0.6057
Rijeka	Insufficient	Very high	Problems detected^	Yes	No	Yes	Yes	Yes	0.0433	0.0816	0.5000	0.4246

° The building is in a precarious state of repair
* At the time of the inspection, the waiting room was closed for renovations
^ At the time of the inspection, the waiting room was not accessible, the road accessible to the platforms was blocked by parked cars
** Unless otherwise specified, the spatial information and maps in this chapter were obtained through data processing on one or more of these platforms: Openrouteservice , Openstreetmap , Openrailservice , Geojson , Google Maps.

Trieste Central Station

Trieste Central station exhibits characteristics in line with the best European standards in terms of all the main evaluated aspects. The maintenance and comfort of the buildings open to the public are excellent (Figures 3.5 and 3.6), with high interconnectivity (Figure 3.8), including a direct connection between the bus station and the main station building (Figure 3.7). Additional bus stops are located near the entrance of the station, including the Flixbus services. The accessibility on foot and by bike is very good, among the highest of the examined stations (reach factor of 0.66 and 0.69, respectively) (Table 3.2).

In the perspective of promoting train usage, the connectivity of the stations with other locations and local attractions is of fundamental importance. In this regard, Figure 3.8 summarizes the minimum distances to the main destinations connected by long-distance services, as well as the major functional points of interest and two historical-naturalistic attractions: Miramare Castle (with almost 254,000 paying visitors in 2022, along with an unspecified but significantly higher number of visitors to the freely accessible park) and the Grotta Gigante (for which we do not have recent data on visitor numbers).

Figure 3.5: exterior of Trieste Central station

Figure 3.6: Interiors and waiting area of the Trieste Central station

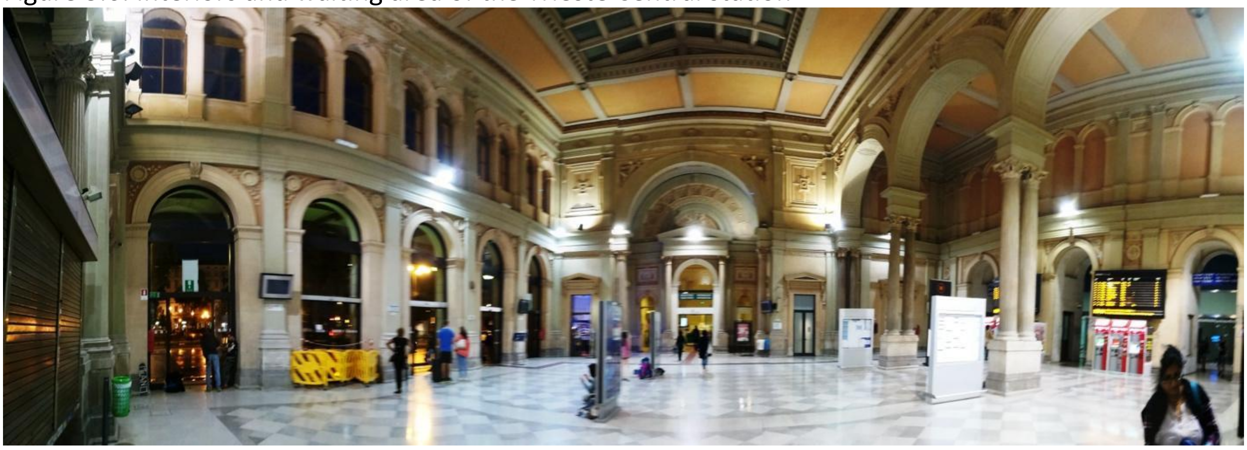


Photo source: Wikimedia Commons:
https://commons.wikimedia.org/wiki/File:Interno_della_Stazione_Centrale_di_Trieste_13.jpg

Figure 3.7: Trieste station: general picture of connectivity with urban transport buses

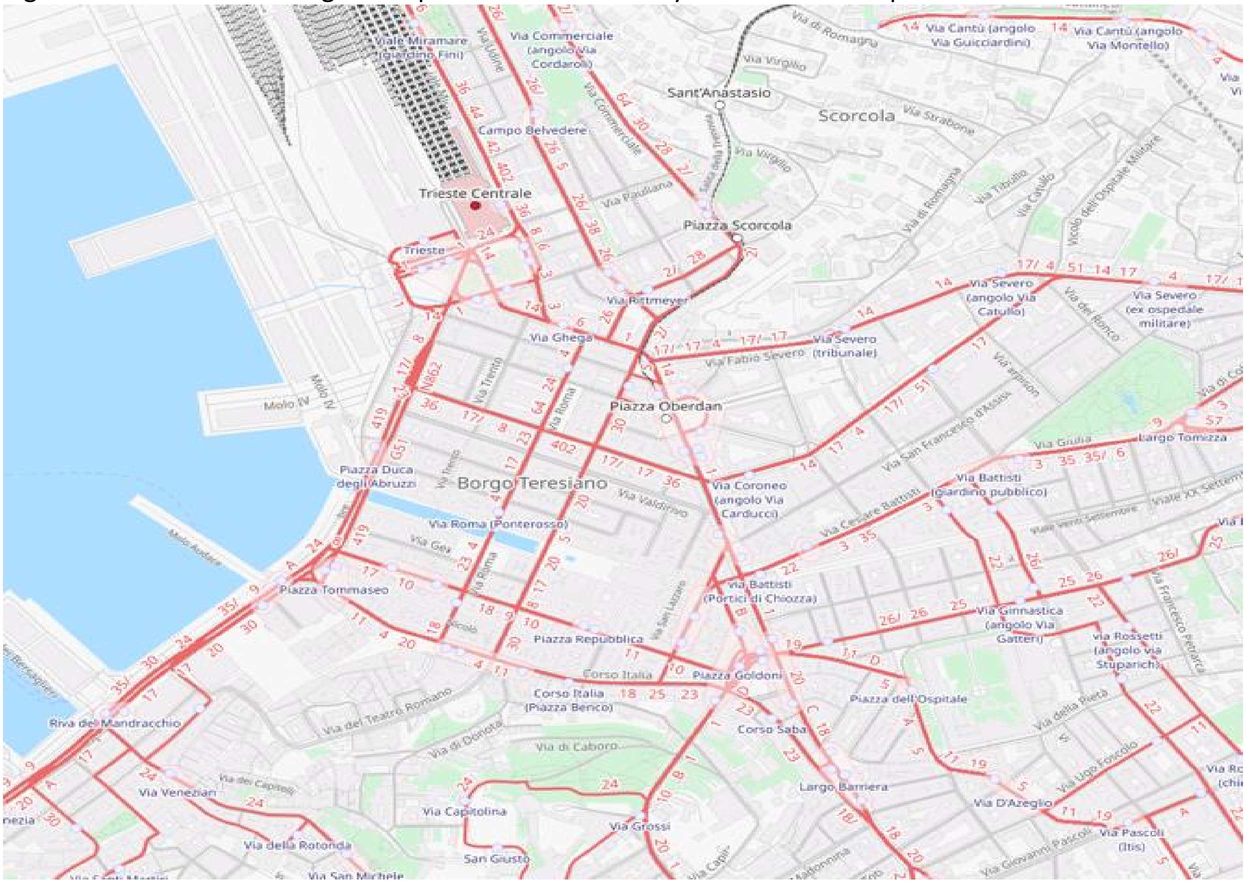
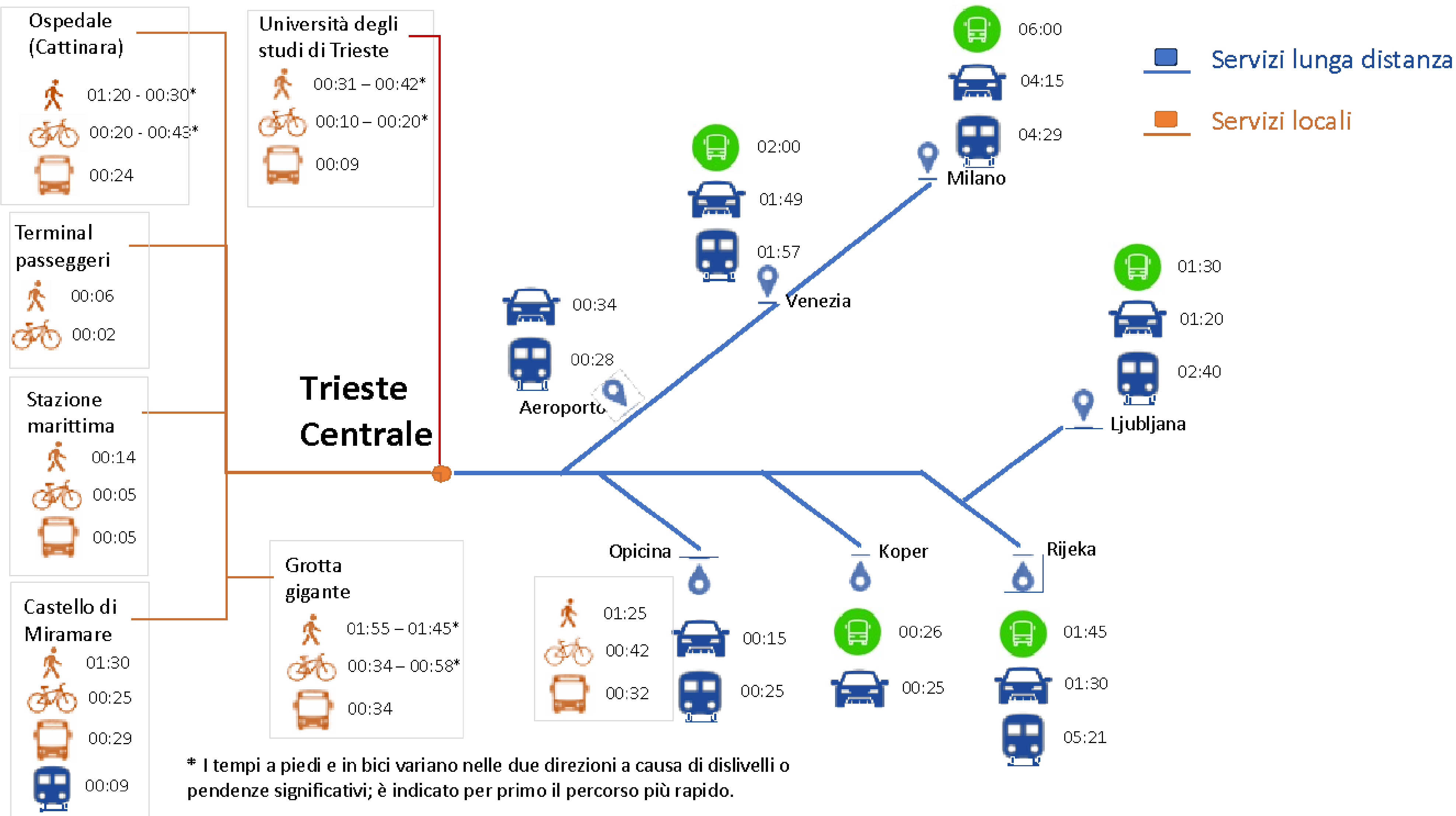


Figure 3.8. – Trieste station: detailed overview of connectivity with urban transport buses.

Fig. 3.9: Trieste station: minimum travel times between the main destinations and main local points of interest, including any changes and, for local bus routes, any walking distances between the railway station and the bus stop bus.



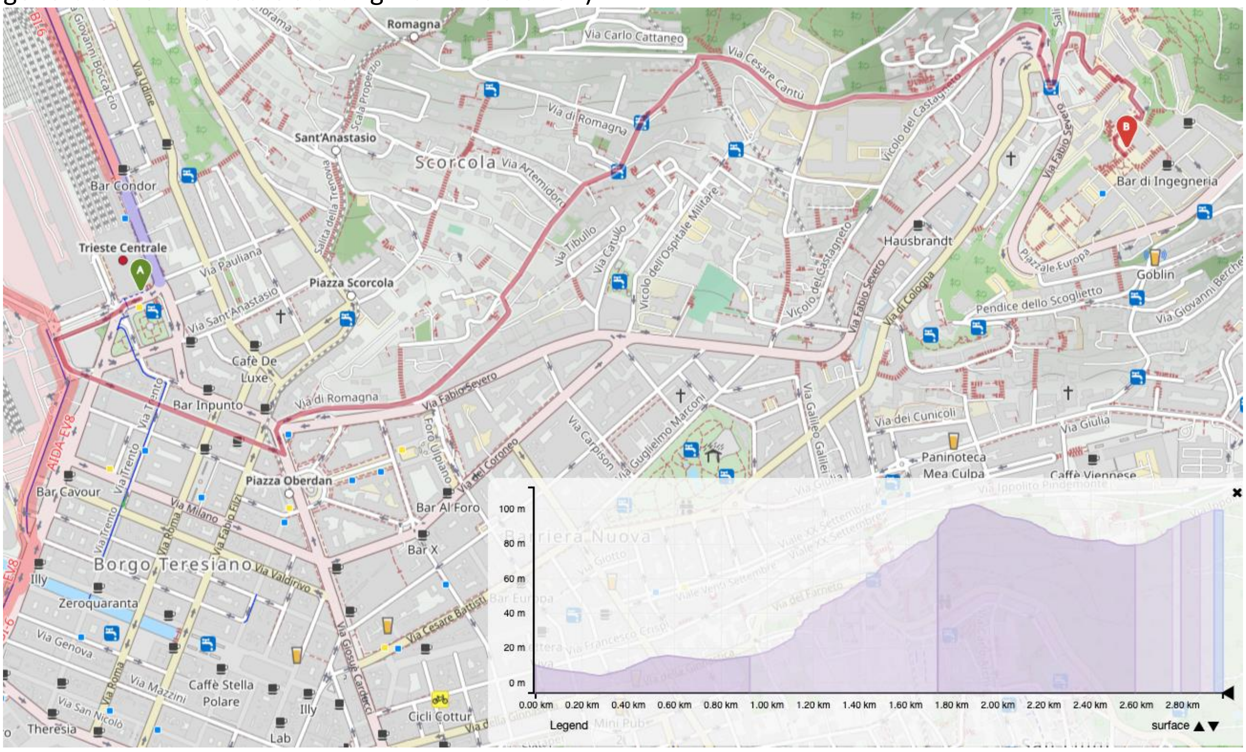
* I tempi a piedi e in bici variano nelle due direzioni a causa di dislivelli o pendenze significativi; è indicato per primo il percorso più rapido.

There are numerous points of interest that can be reached on foot or by bike within reasonable times, as well as using public transportation. We particularly highlight, among those presumed to have higher traffic, those that could be easily reached using electric bikes or electric scooters:

- The University of Trieste, at a relatively short distance both on foot (about half an hour) and by bike, with a path of about 1 km and an average slope of 8% (Figure 3.10).
- Miramare Castle and its park, which can be reached from the station on a predominantly flat route.
- The Grotta Gigante, which has a short distance to cover (just under 10 km), but reaches an elevation of about 340 meters with a long path of about 2 km and a slope of approximately 12%, as well as a section of about 300 meters with a slope of around 13% (Figure 3.11).

These three attractions, among others, have been highlighted because they attract a large number of visitors annually who could particularly benefit from electric micro-mobility services. Moreover, the slopes of the mentioned routes are such that they discourage the use of non-assisted bicycles for most visitors, especially during the summer.
The distance between Trieste-Villa Opicina and Sežana configures the three locations (excluding the state borders between Italy and Slovenia) as part of a single polycentric section with a significant overlap of peri-urban areas. This can be observed by overlaying the 15-minute bike isochrones (Figures 3.12 and 3.13), while the overlap is even greater for bus and car routes. It should be noted that the bike route from Trieste to Villa Opicina is realistically feasible only with an electric bike since it includes a path of about 3 km with slopes of approximately 13%.

(Figure 3.10) Detail of the cycling route linking Trieste central station and the University (altimetry generated for the route starting from the station)



(Figure 3.11) Detail of the cycling route linking Trieste central station and the Grotta Gigante (altimetry generated for the route starting from the station)

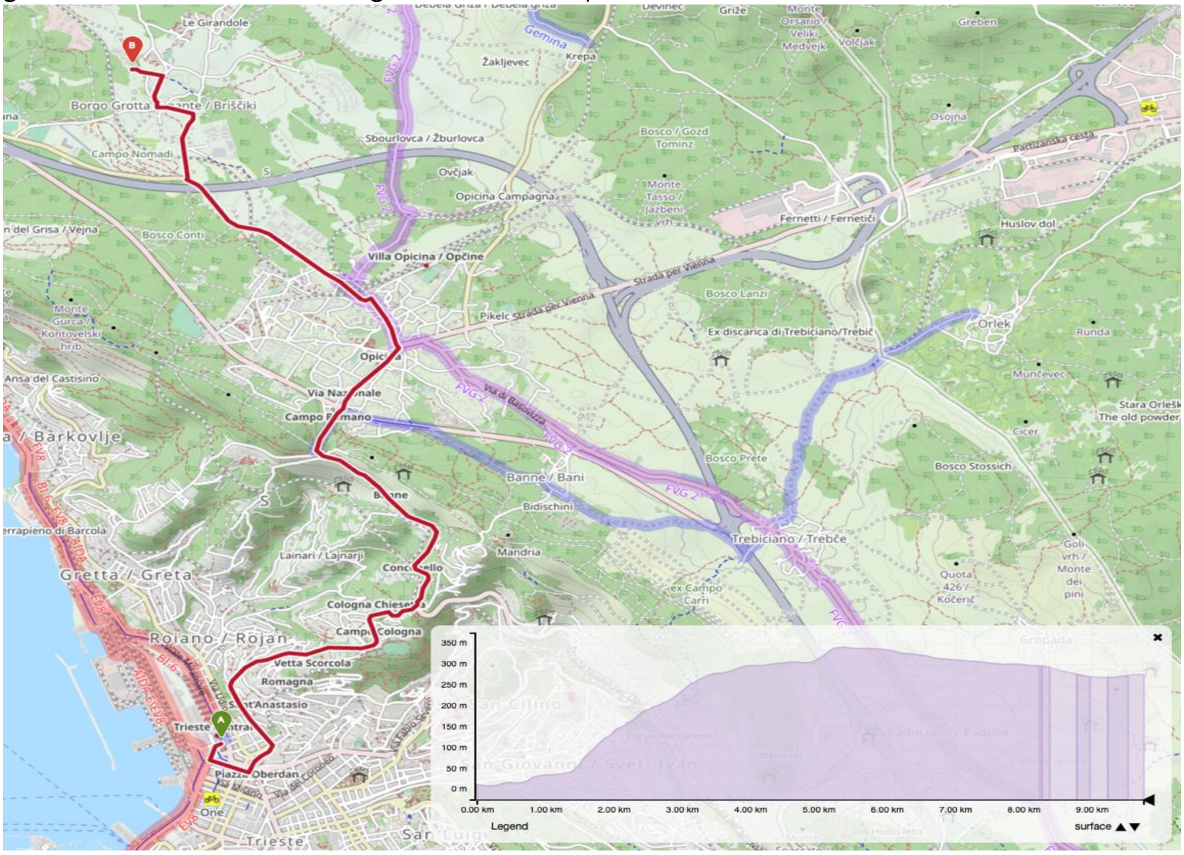


Figure 3.12: Isochrones for 15' walking and cycling routes from the stations of Trieste, Villa Opicina and Sežana

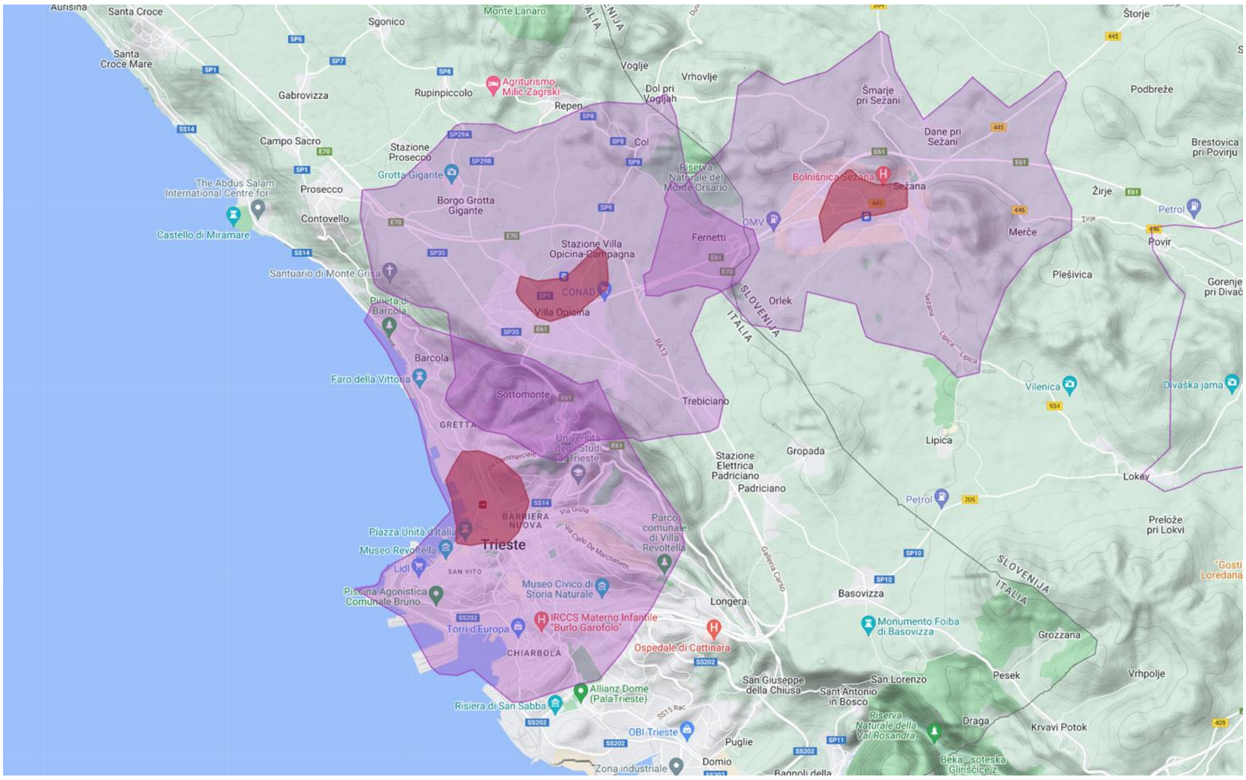
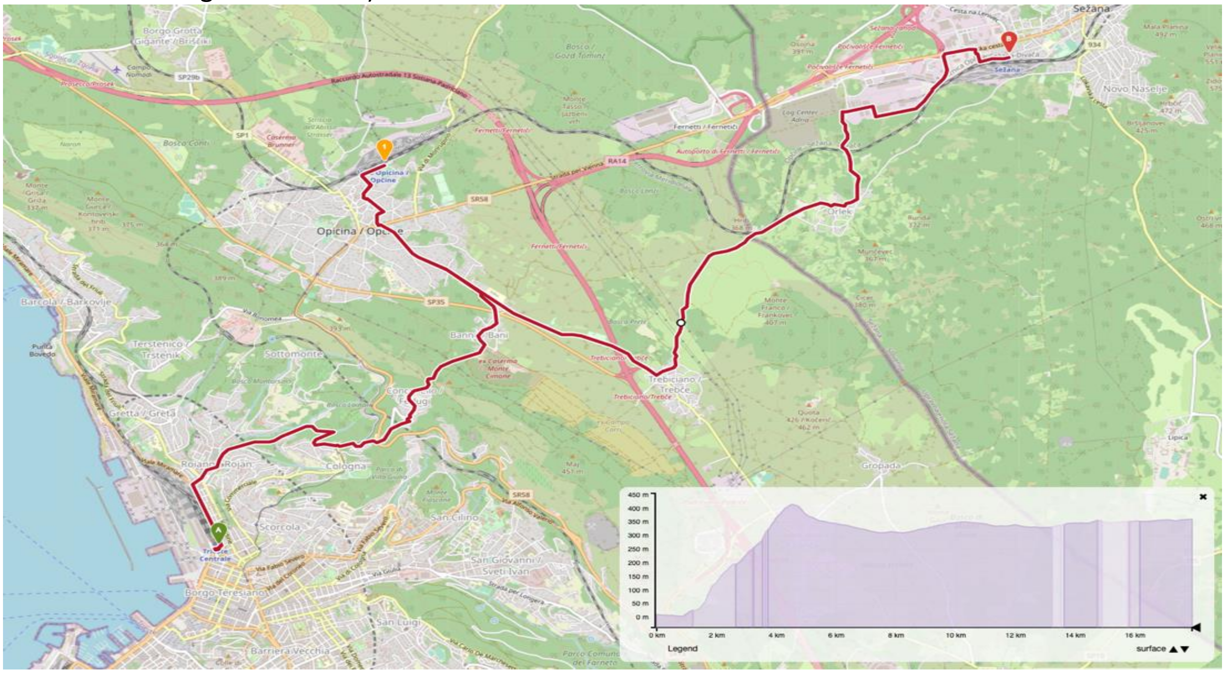
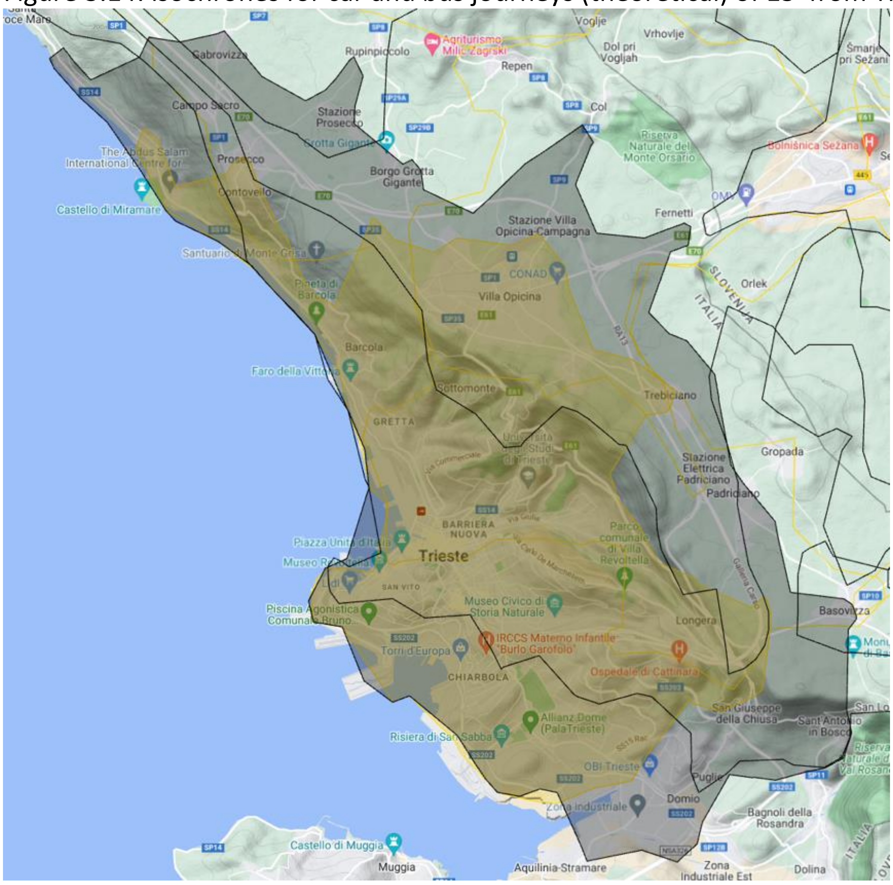


Figure 3.13: Detail of the cycling route linking Trieste, Villa Opicina and Sežana (altimetry generated for the route starting from Trieste)



Within a 15-minute car journey from the central station, it is possible to reach the industrial area to the southeast, beyond Miramare to the northwest, and the border with Slovenia to the northeast (Figure 3.14). Slightly smaller is the area covered by a potential bus service with stops within a 15-minute journey, which in theory could also cover the area near the Villa Opicina station. However, as we will see shortly, the actual travel times are significantly longer due to the distance of the bus stops from the station..

Figure 3.14: isochrones for car and bus journeys (theoretical) of 15' from Trieste central station



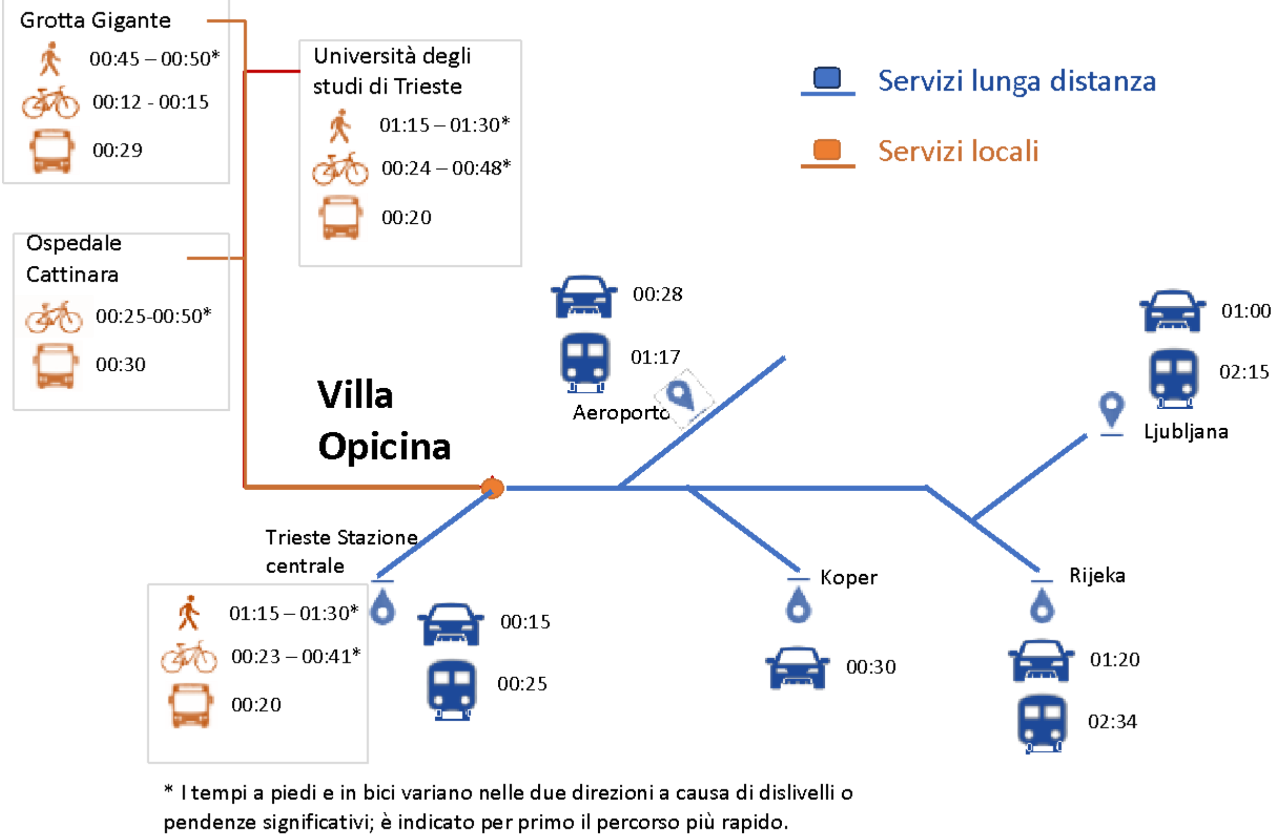
Villa Opicina station

Although the Villa Opicina and Trieste Central stations are only 5 km apart as the crow flies, travel times between these two locations are extended due to the topography of the area. The train journey takes at least 25 minutes, while the car journey takes approximately 15 minutes. The current bus service takes about 32 minutes, including a 16-minute walk (Figures 3.15 and 3.16). In fact, the Villa Opicina railway station is not directly connected to the Trieste station by a regular bus service. Until May 2023, there was a "call" service (Figure 3.20) indicated by signage, which was actually a "reservation" service and has since been discontinued. Therefore, the interconnectivity is very limited, as the nearest actual bus stops are about 550 m away from the station. This poses a significant hindrance to choosing Villa Opicina as a destination.

Overall, the Villa Opicina station offers an adequate level of comfort, although there are no commercial establishments nearby and there is no automated ticket office. As mentioned before, Villa Opicina is close enough to Trieste to be considered a suburban area, falling within a 15-minute car or bus radius of a significant part of the city of Trieste (Figure 3.21).

Finally, it is worth noting that the location of the Villa Opicina station is advantageous compared to the Trieste station when it comes to reaching the Grotta Gigante (an attraction that attracts 70,000 annual visitors[30]) on foot or by bike. The distance is very short (about 3.5 km from the station), and the elevation change along the route is minimal (45 meters to overcome in just under 3 km) (Figure 3.22).

Figure 3.15: Villa Opicina station: minimum travel times between the main destinations and the main local points of interest, including any changes and, for local bus routes, any walking routes between the railway station and the bus stop bus.



[30]Source: Fabbricatore A. (2013) The Grotta Gigante as an eco-sustainable tourist center and scientific station. https://www.openstarts.units.it/bitstream/10077/9068/1/42_Sessione-VII-SessioneTurismo_Fabbricatore.pdf

Figure 3.16: Villa Opicina station : bus lines connecting to the station

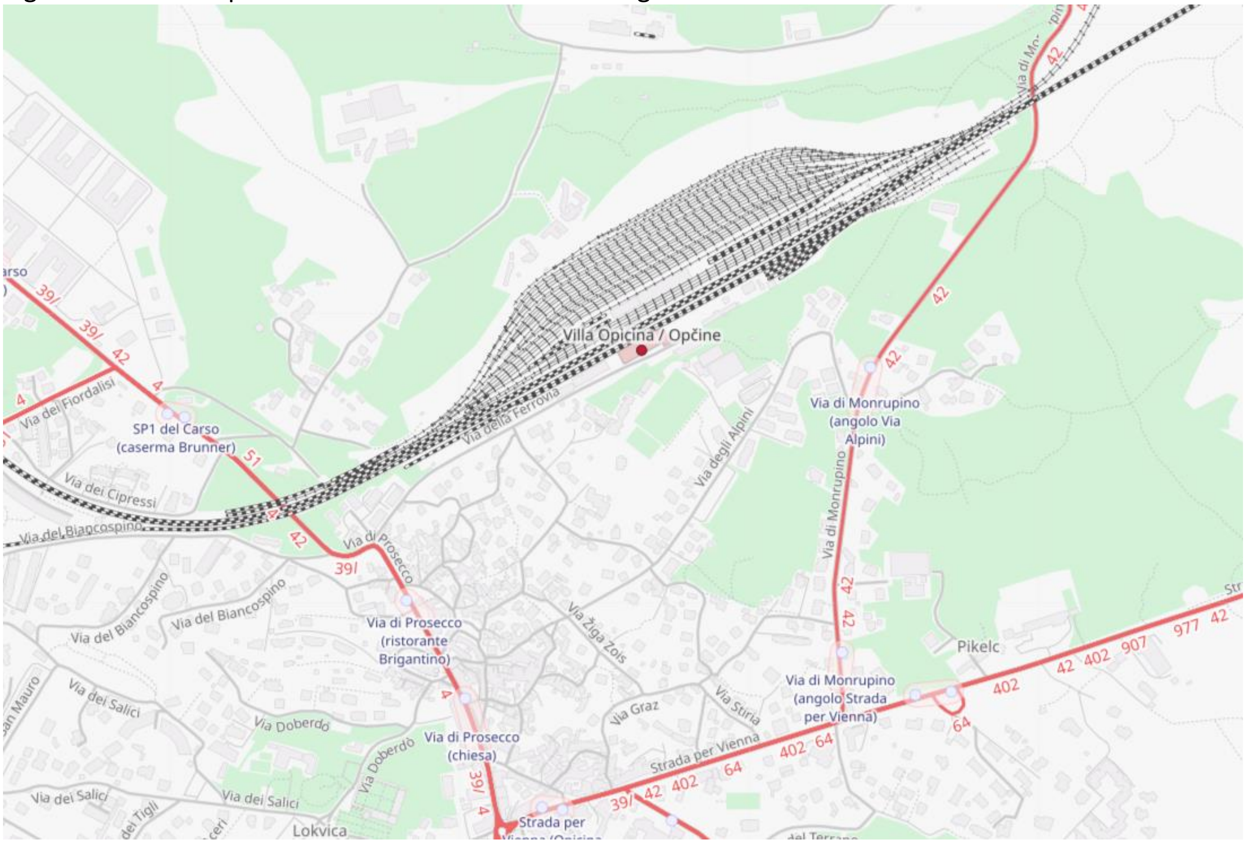


Figure 3.17: exterior of Villa Opicina station

Figure 3.18: waiting room of the Villa Opicina station

Figure 3.19: external track side of the Villa Opicina station

Figure 3.20: sign for the bus on-call service (suspended in June 2023).

Figure 3.21: isochrones for car and bus journeys (theoretical) of 15' from Villa Opicina station

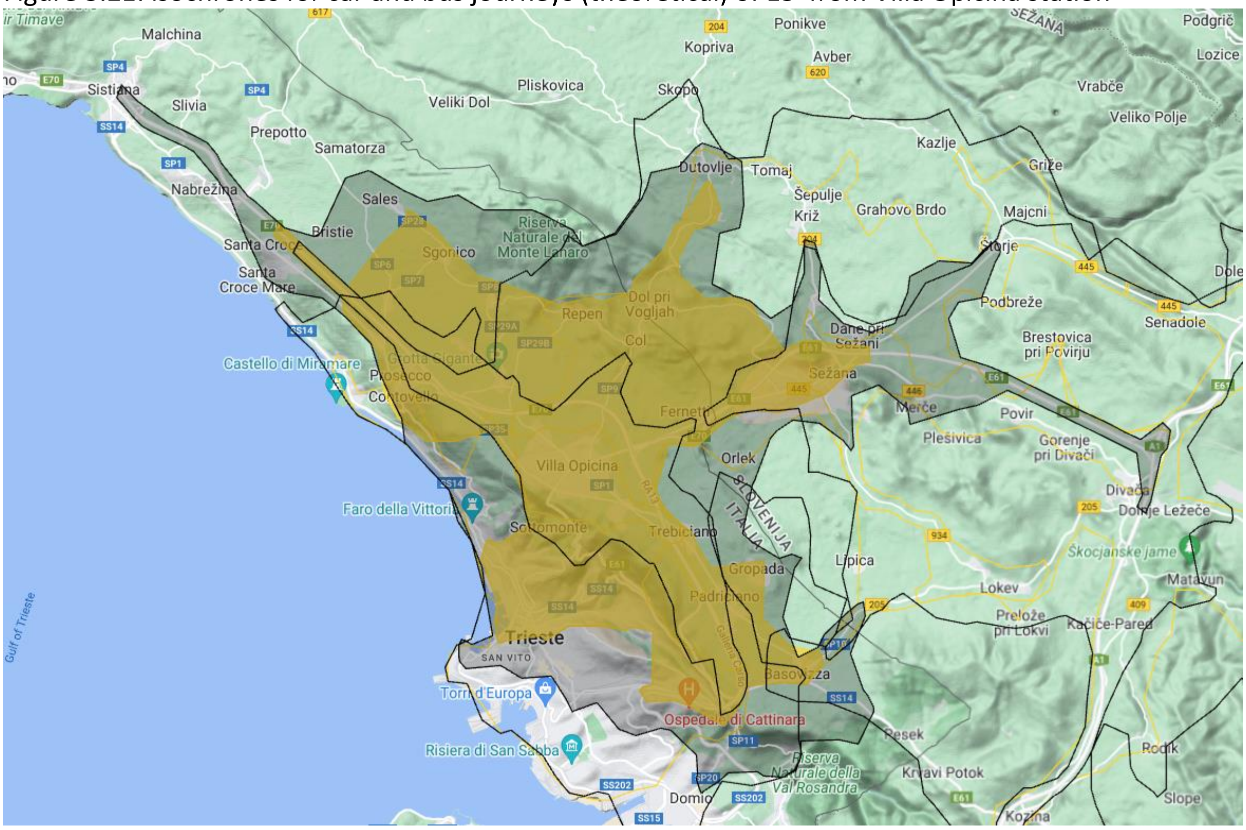
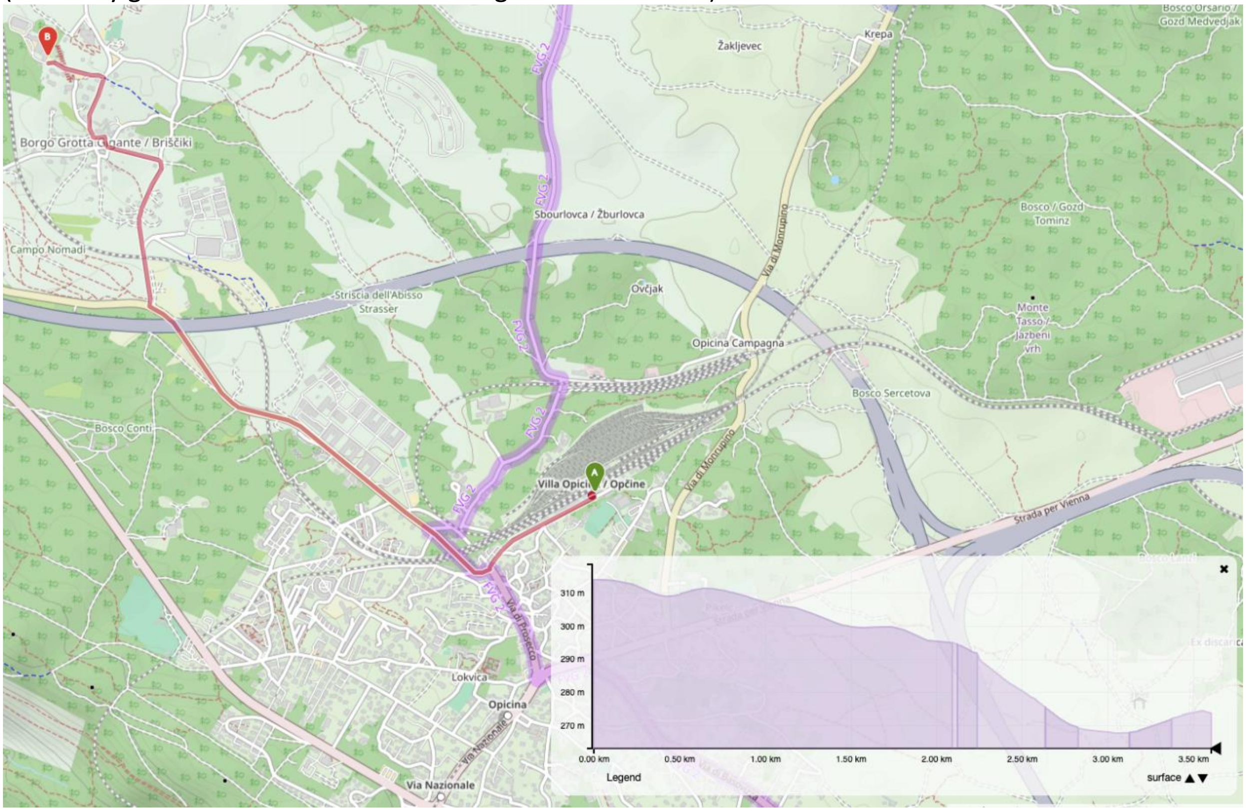


Figure 3.22: Detail of the cycling route connecting the Villa Opicina station and the Grotta Gigante (altimetry generated for the route starting from the station)



Sežana station

The Sežana station offers an excellent level of comfort and maintenance, both in terms of the exterior of the main building and the waiting room (Figures 3.25-3.28). The interconnectivity is very good, thanks in part to the nearby bus station (150 meters from the entrance of the railway station, Figure 3.23). There is also a large bicycle parking area adjacent to the platform of the first track (Figure 3.29). The reach factor for a 15-minute bus journey is the highest among the considered stations. However, the reach factor for a 15-minute walk is very low because the railway effectively cuts through the territory and cannot be crossed until a pedestrian overpass (Bazoviška Cesta) located about a kilometer from the station (Table 3.2).

As in all the Slovenian stations we visited, there are automatic ticket offices (Figure 3.28), which, however, only support the Slovenian language and do not allow the use of other languages.

Sežana is very close to the Italian border, particularly to Villa Opicina, which is currently connected by a bus service taking approximately 12 minutes. An hypothetical bus service connecting Sežana to the University of Trieste and the Cattinara Hospital would take approximately 20 and 35 minutes, respectively.

Among the potential points of tourist interest that can be reached by bike or electric scooters, we highlight the botanical garden (a 15-minute walk) and the Vilenica cave, which is only 6 km away. The route to the cave has few difficulties, except for a maximum elevation of about 140 meters uphill (average slope of 4.3%) and a 700-meter path with a slope of around 6.6% (Figure 3.31).

Figure 3.23: Sežana station, bus lines connecting to the station

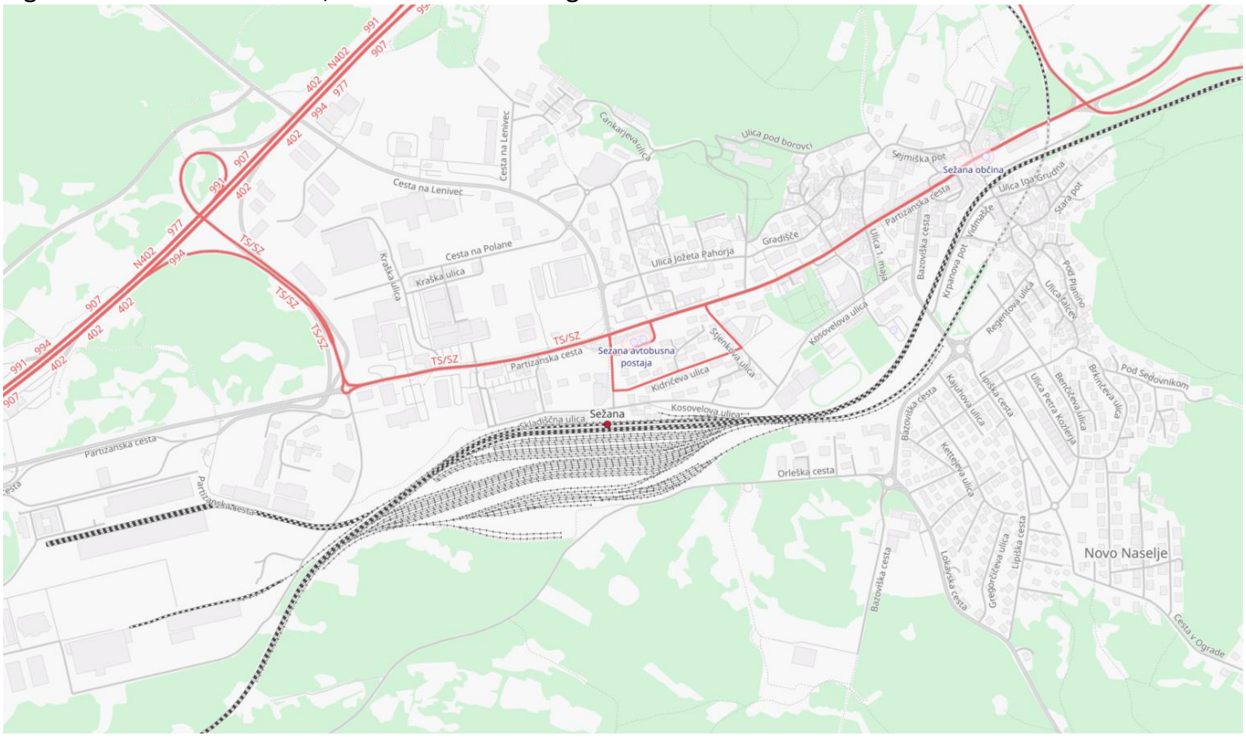
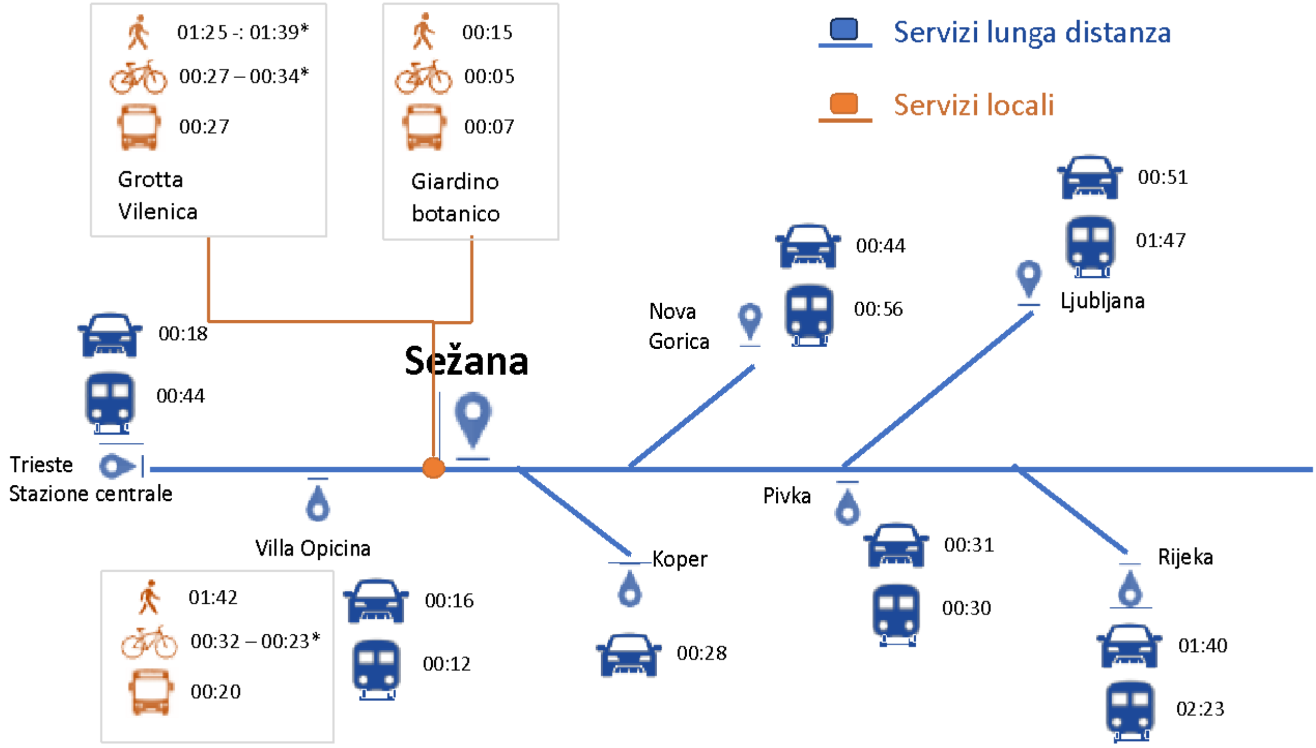


Figure 3.24: Sežana station : minimum travel times between main destinations and main local points of interest, including any transfers and, for local bus routes, any walking distances between the railway station and the bus stop .



* I tempi a piedi e in bici variano nelle due direzioni a causa di dislivelli o pendenze significativi; è indicato per primo il percorso più rapido.

Figure 3.25: exterior of the Sežana station

Figure 3.26: waiting room of the Sežana station

Figure 3.27: Sežana station , track side

Figure 3.28: access to platform one of the Sežana station

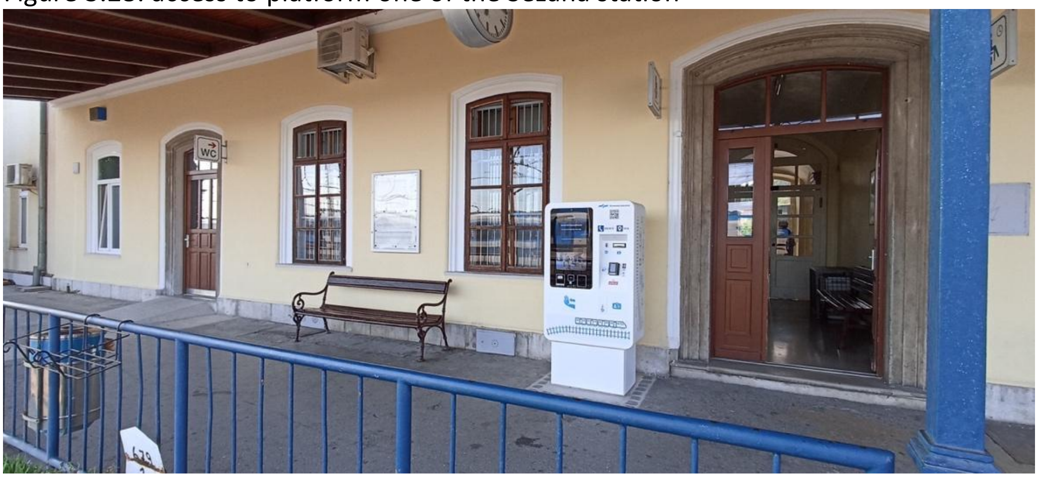


Figure 3.29: Sežana station bike park

Figure 3.30: isochrones for a 15' journey of a hypothetical bus service from Sežana station

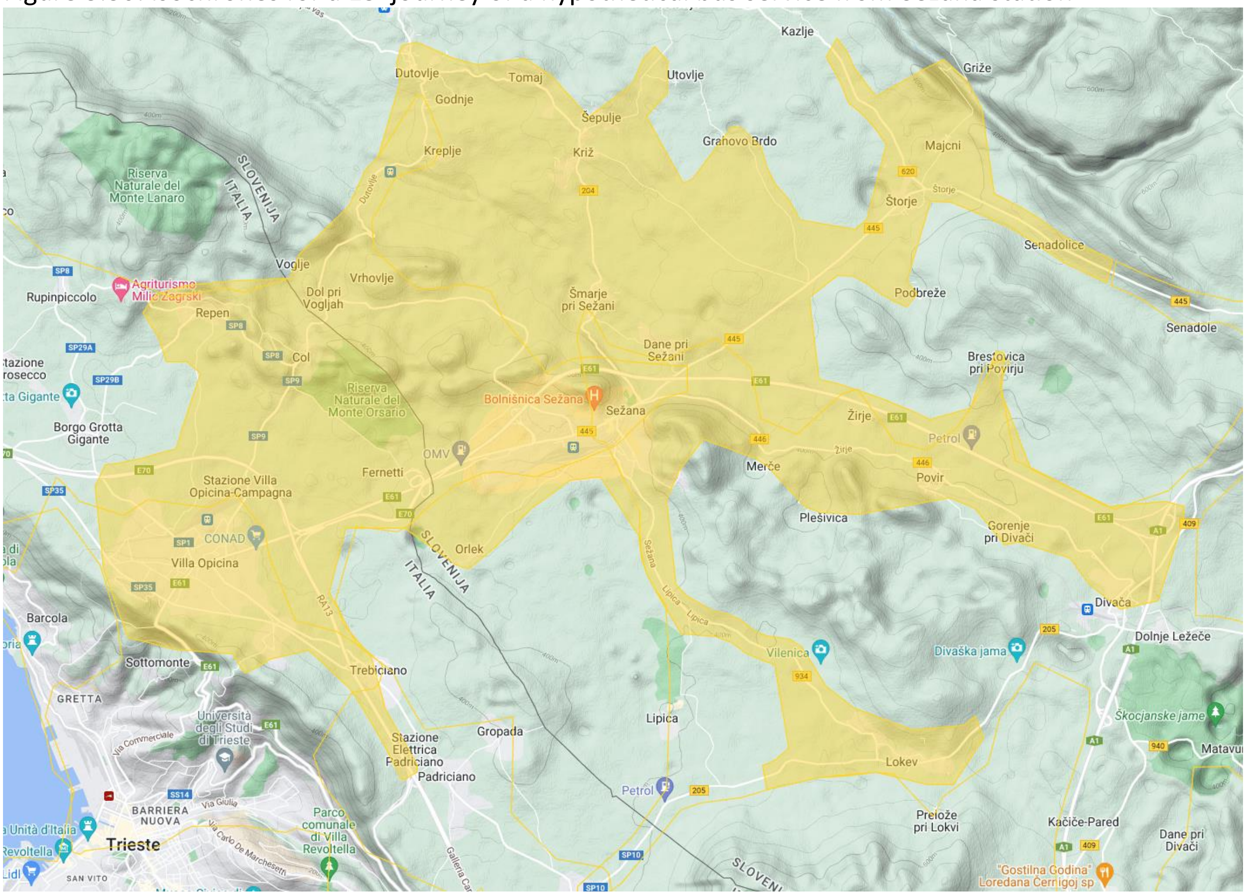
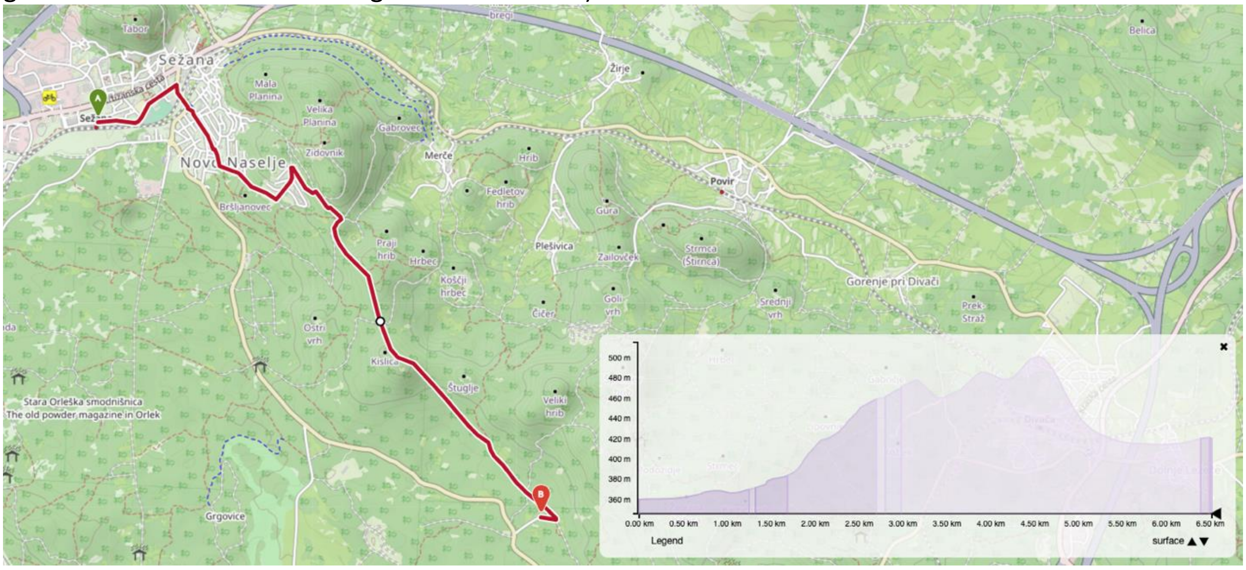


Figure 3.31: Detail of the cycling route connecting the Sežana station and the Vilenica Cave (altimetry generated for the route starting from the station)



Divaca station

Despite Divača being a small town with a population of less than 5,000 inhabitants, the train station boasts a large size and high-quality standards (Figures 3.32 - 3.35). It is the only station equipped with underpasses for accessing the platforms beyond the first one (Figure 3.34), and the station buildings are well-maintained. The displayed timetable boards are in three languages: Slovenian, French, and Italian.

Divača station serves as a connection point for the lines to Ljubljana, Rijeka, Koper, and Buzet-Pula. During the visit, the connections to Koper and Pula were served by buses due to construction works on the railway line. Figure 3.37 shows the minimum travel times for the main connections, although it should be noted that the times indicated for the train between Divača and Koper, as well as Divača and Pula, are based on schedules prior to the interruption of train services.

The main points of interest in the area are the Škocjan Caves Regional Park and the Divača Cave. The former is particularly well-known and can be reached by bike via a route of approximately 4.5 km with minimal elevation (around 40 meters; Figure 3.38).

Within a 15-minute radius of a hypothetical urban bus service from Divača station, both Sežana and Basovizza are located (Figure 3.39). In practice, Trieste Central Station could be connected by an urban bus service with a travel time of about half an hour.

Figure 3.32: Divača station

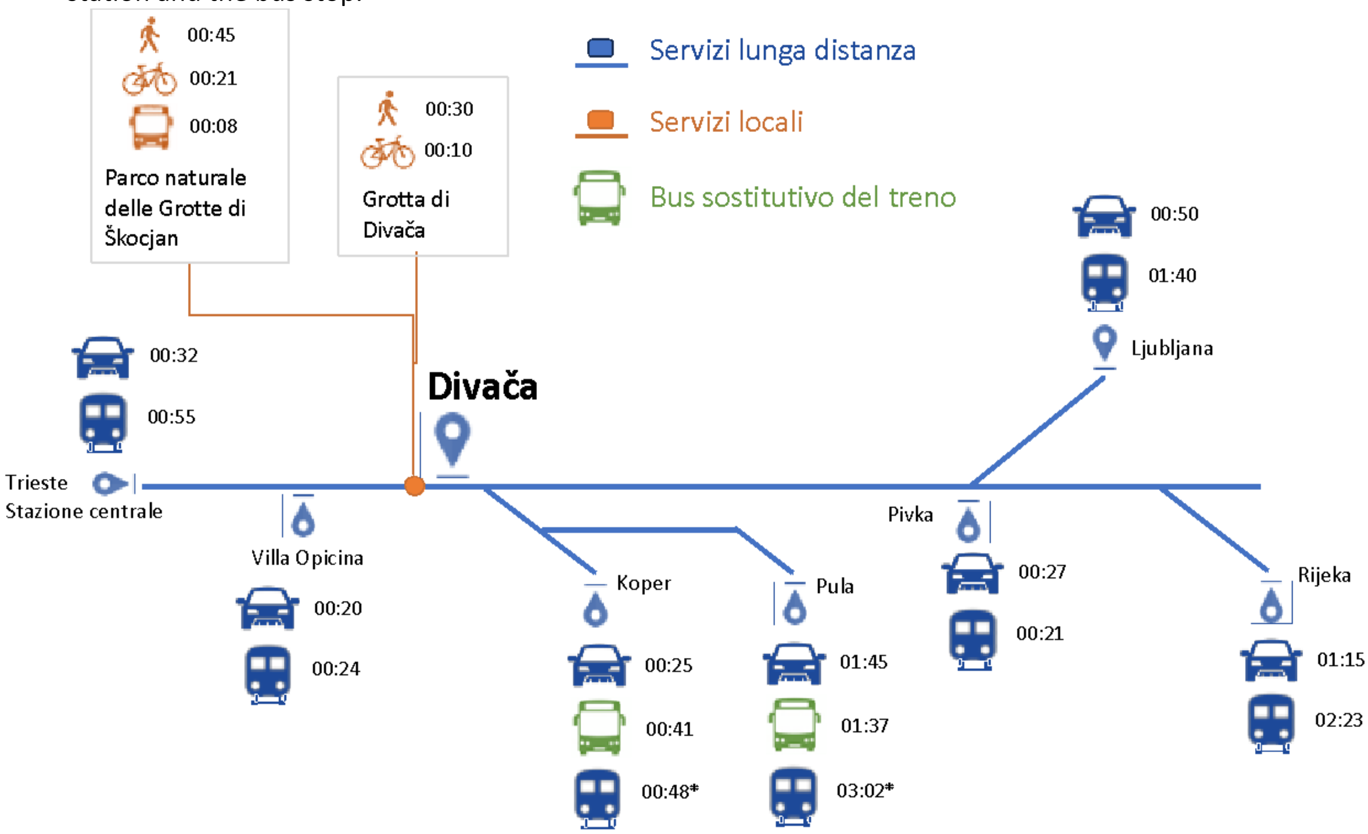
Figure 3.33: waiting room of the Divača station

Figure 3.34: platform one of Divača station and entrance to the underpass

Figure 3.35: Divača station , track side.

Figure 3.36: Bus lines connecting to Divača station

Figure 3.37: Divača station : minimum travel times between main destinations and main local points of interest, including any transfers and, for local bus routes, any walking distances between the railway station and the bus stop.



*Al momento del sopralluogo (maggio 2023) la linea ferroviaria risultava temporaneamente interrotta per lavori, il tempo indicato è in base ad orario precedente l'interruzione

Figure 3.38: Detail of the cycling route connecting the Divača station and the Škocjan Caves Nature Park (altimetry generated for the route starting from the station)

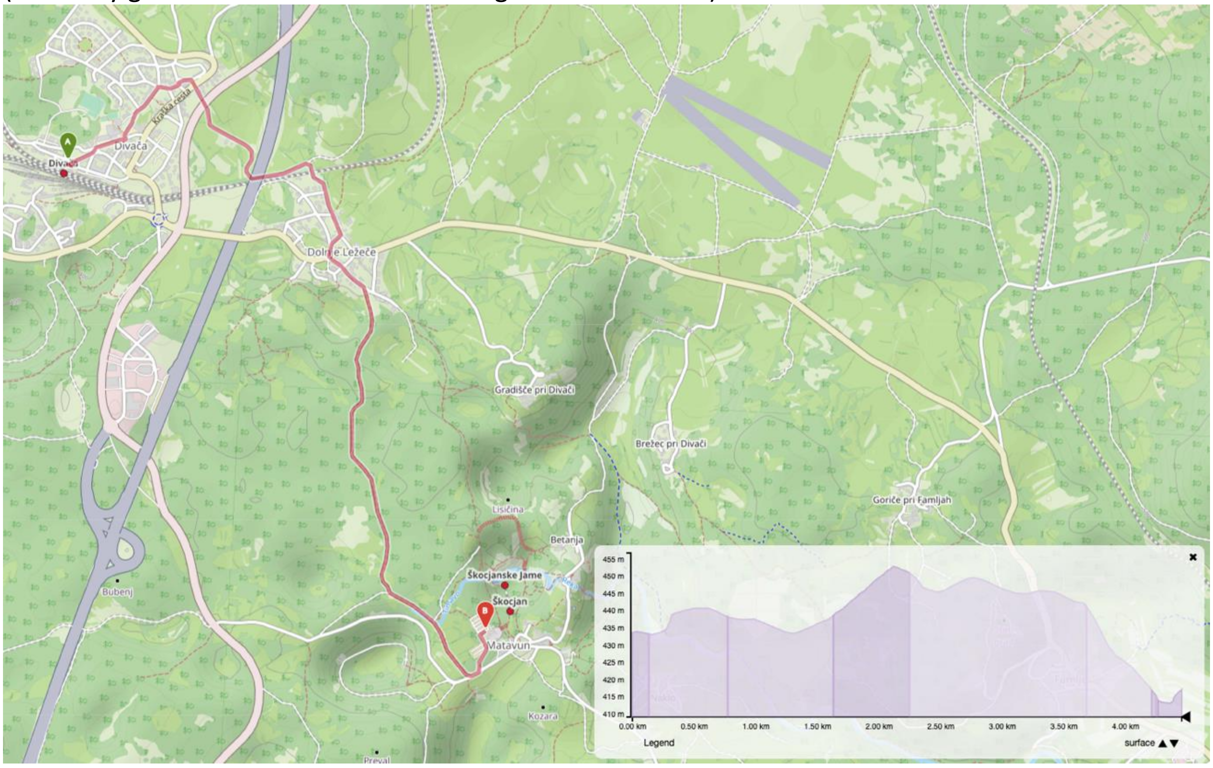
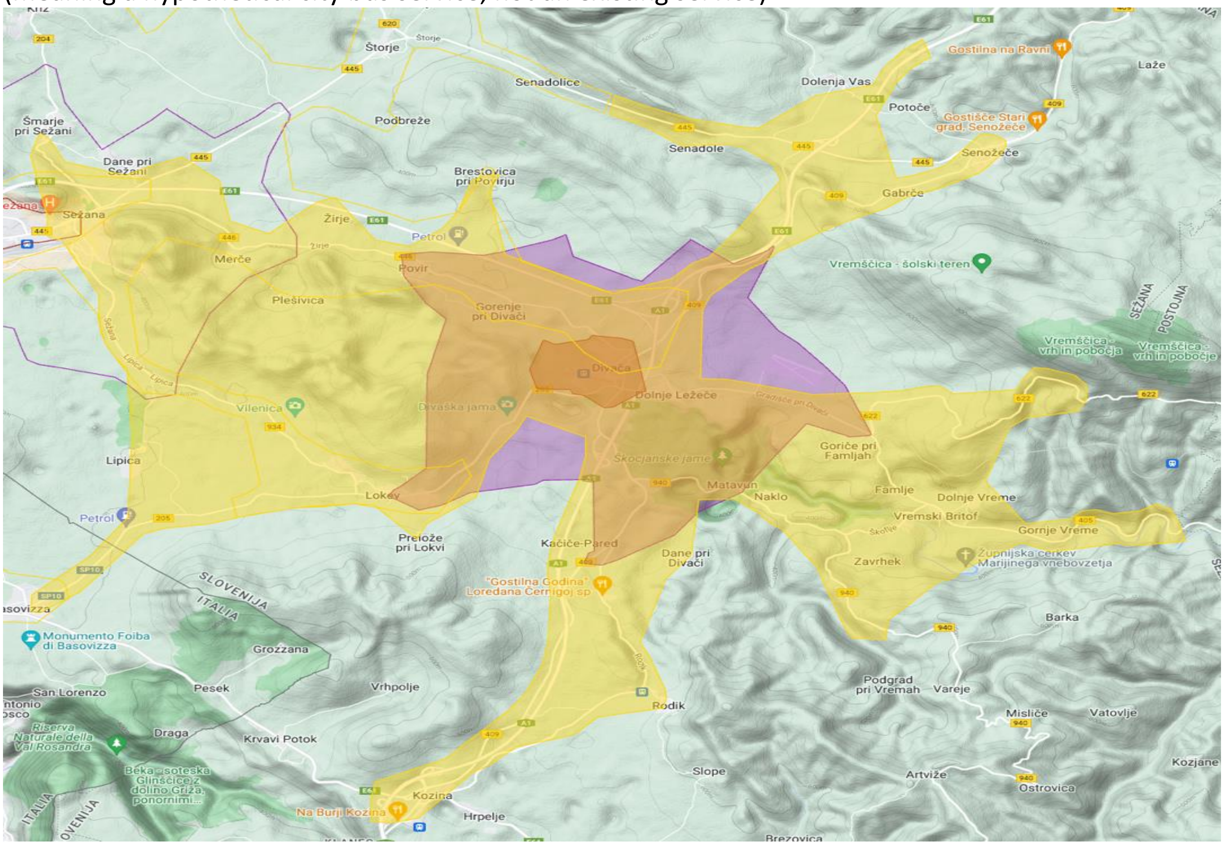


Figure 3.39: isochrones of a walking, cycling and bus journey for a 15' journey from Divača station (meaning a hypothetical city bus service, not an existing service)



Pivka station

Pivka station holds particular importance as it serves as a junction where the secondary and single-track section branching towards Rijeka separates from the main line between Ljubljana and Trieste. Furthermore, Pivka station is the closest one to Postojna, whose caves attract over a million visitors each year.

The station building and waiting rooms are in excellent maintenance condition (Figures 3.40-3.42), and the timetable signs are, once again, in Slovenian, French, and Italian. Adjacent to the first platform, there is a spacious bicycle parking area accessible directly from the road in front of the station. The station's connectivity with other transportation modes is hindered by the topography and infrastructure development (Figure 3.43), as the station and railway are situated alongside a single road artery, enclosed between two elevations. Moreover, a significant portion of traffic traveling from Istria and southern Croatia to Ljubljana concentrates along this road.

The cycling route from Pivka station to Postojna caves is approximately 15.5 km long and features a maximum elevation of 70 meters, with slopes reaching a maximum of around 5% (Figure 3.45). Within walking or cycling distance, the Petelinje Lake is marked as a tourist itinerary, located about 5 km away with a maximum elevation of 55 meters and a maximum slope of around 7% (Figure 3.46).

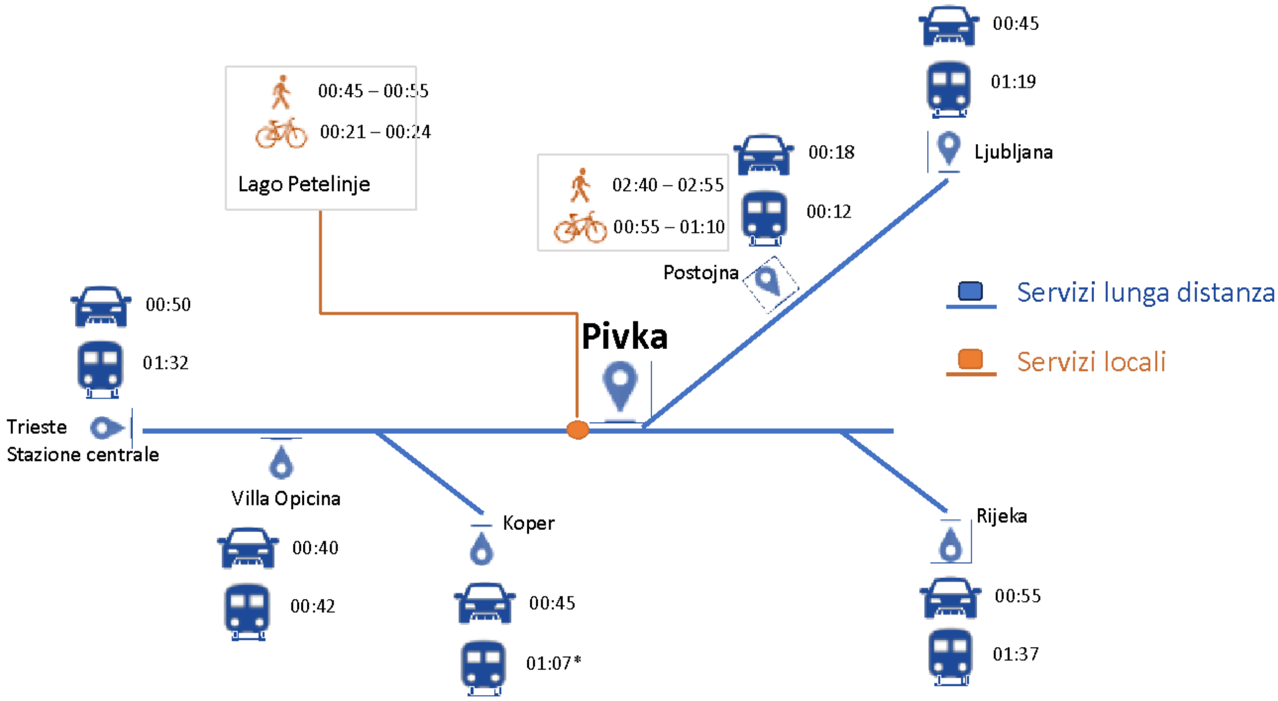
Figure 3.40: Pivka station exterior

Figure 3.41: Pivka station waiting room

Figure 3.42: exterior of the station on the track side

Figure 3.43: bus lines near Pivka station

Figure 3.44: Pivka station : minimum travel times between main destinations and main local points of interest, including any changes and, for local bus routes, any walking distances between the railway station and the bus stop .



*Al momento del sopralluogo (maggio 2023) la linea ferroviaria tra Divača e Koper risultava temporaneamente interrotta per lavori, il tempo indicato è in base ad orario precedente l'interruzione.

Figure 3.45: Detail of the cycling route between Pivka station and Postojna cave

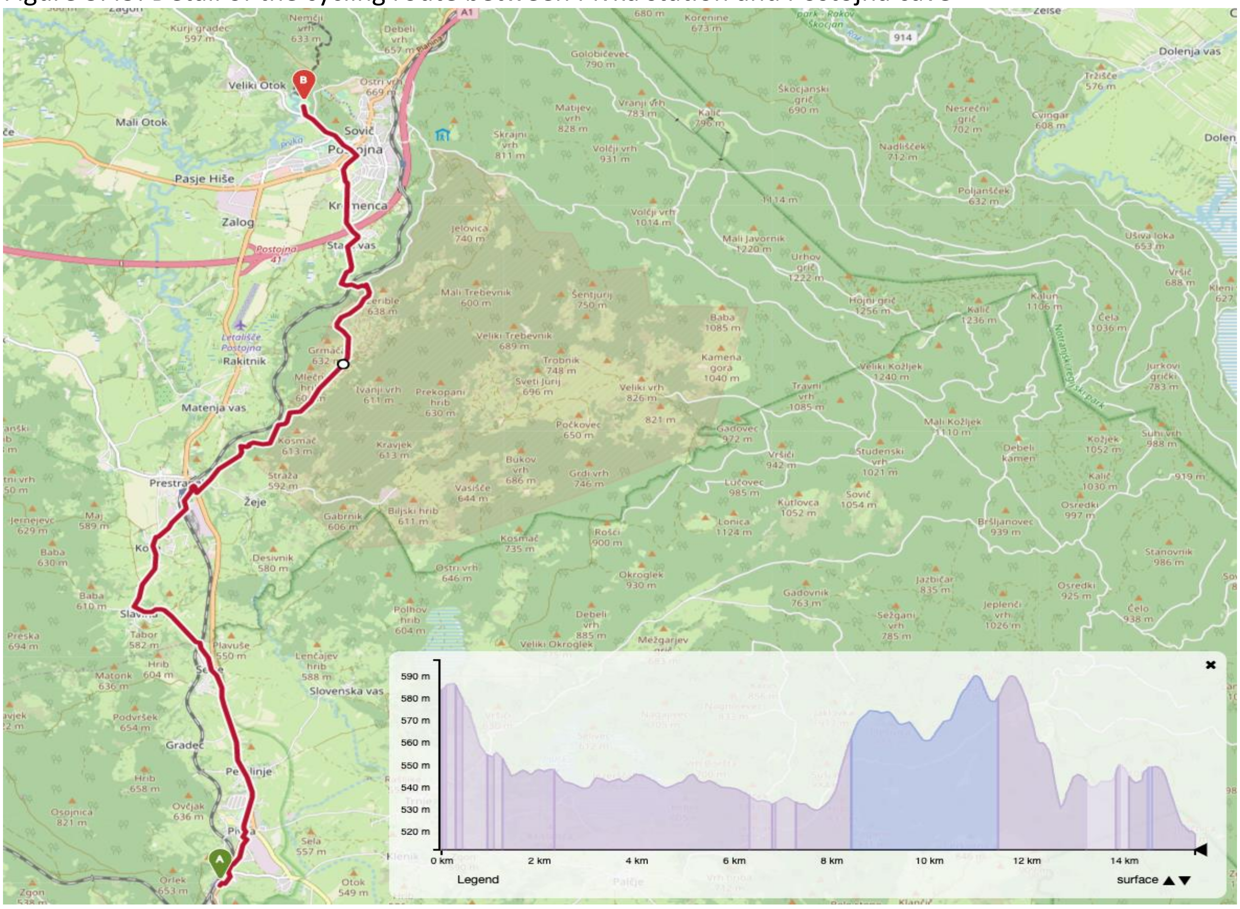
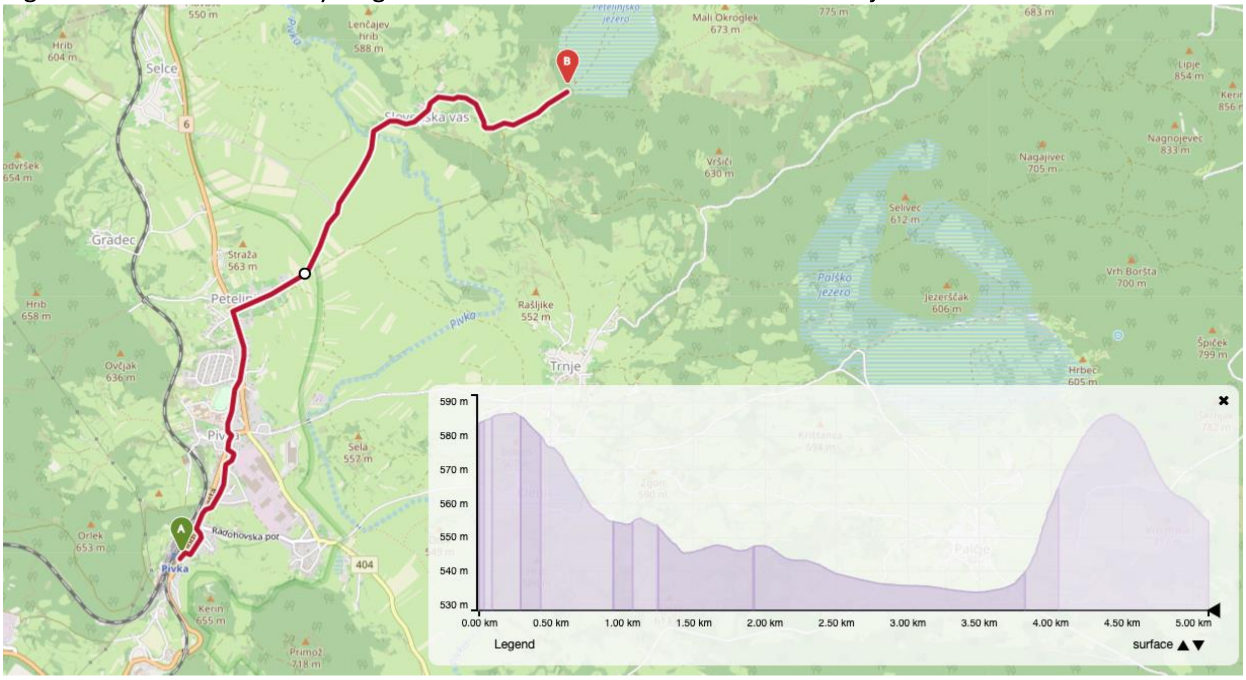


Figure 3.46: Detail of the cycling route between Pivka station and Petelinje lake



Ilirska Bistrica Station

Ilirska Bistrica station has good comfort and maintenance conditions (Figures 3.47-3.50). The first waiting room (there are two adjacent ones) is equipped with timetable display screens (Figure 3.54), and there is an automatic ticket machine (as in the other Slovenian stations along the route) that operates only in the Slovenian language.

Similar to Pivka, Ilirska Bistrica also has limited connectivity with other transportation services (Figure 3.51), as well as with the rest of the main railways, since the station is located on a secondary line compared to the main Trieste - Ljubljana route, and the entire section between Pivka and Rijeka is single-track. As a result, the destinations accessible from this station are limited (Figure 3.52).

Figure 3.47: exterior of the station Ilirska Bistrica

Figure 3.48: waiting room of the station Ilirska Bistrica

Figure 3.49: platform one of Ilirska Bistrica station

Figure 3.50: exterior of the Ilirska Bistrica station

Figure 3.51: Bus lines near Ilirska Bistrica station

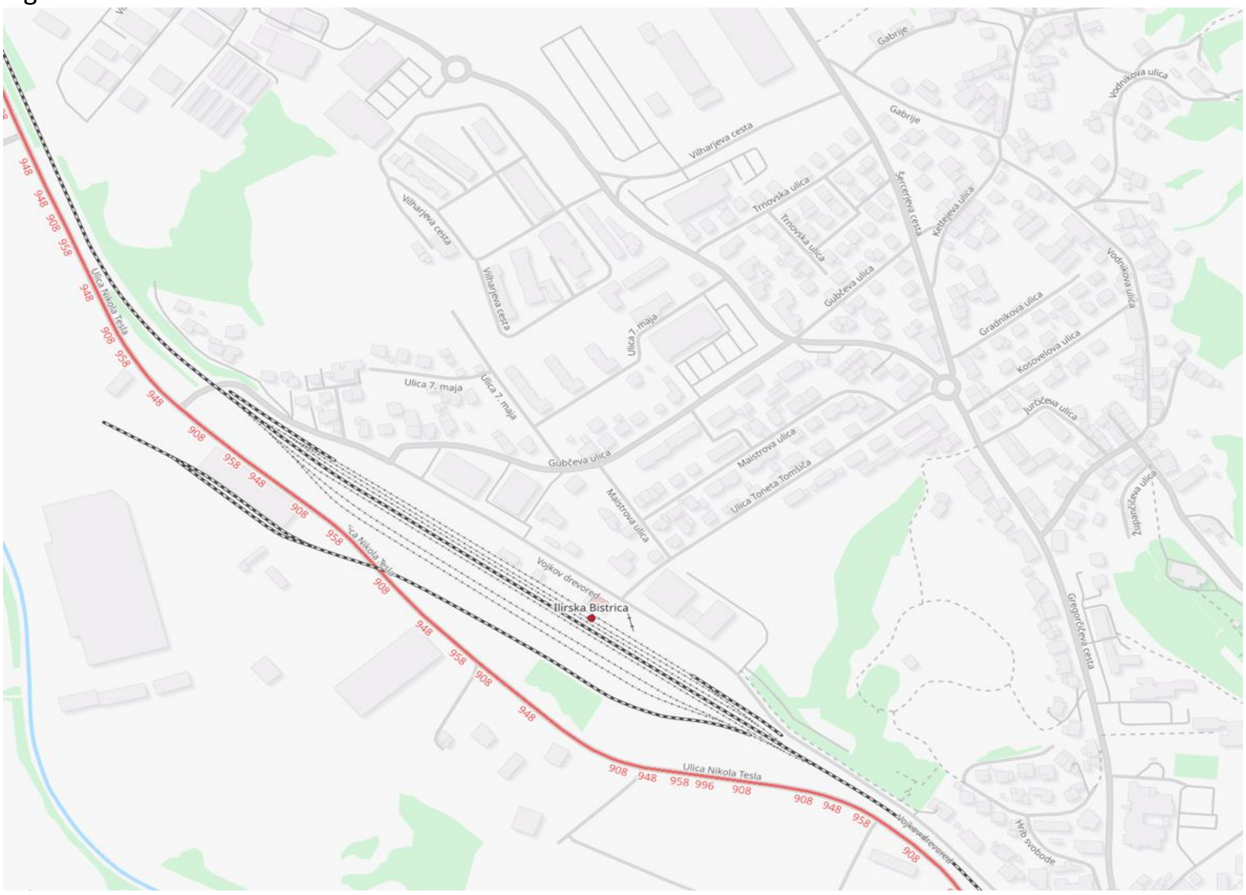
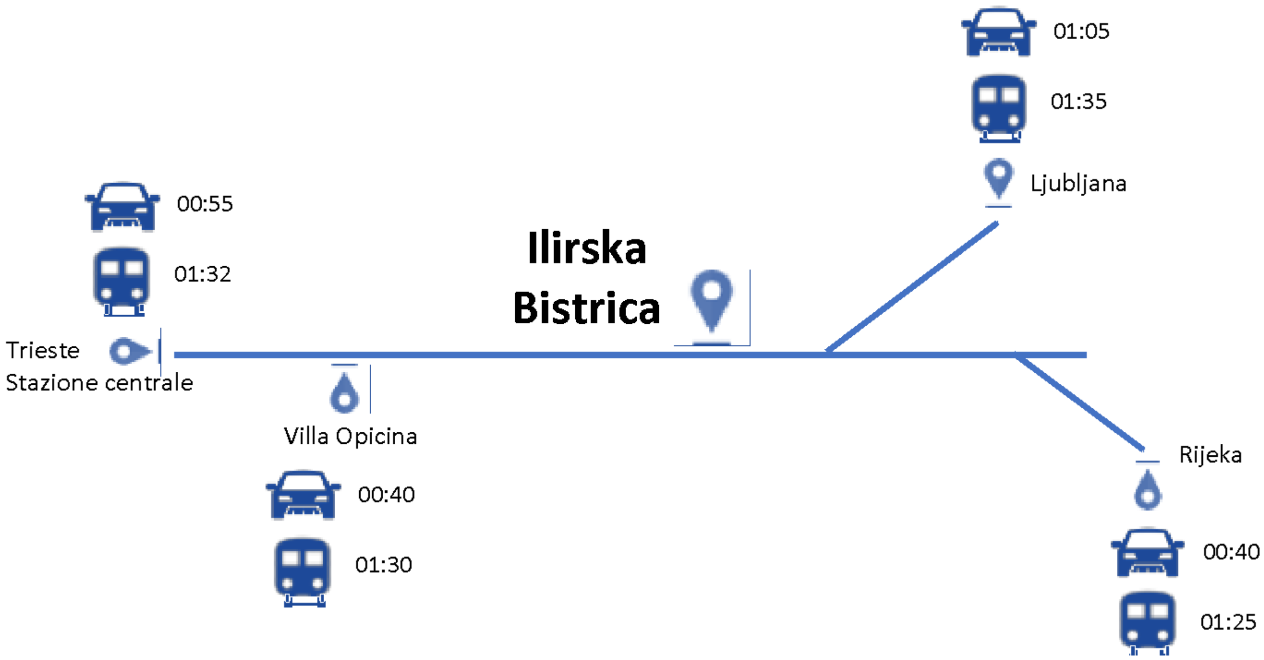


Figure 3.52: Ilirska station Bistrica : minimum travel times between the main destinations and the main local points of interest, including any changes and, for local bus routes, any walking distances between the railway station and the bus stop.



Sapjane station

Šapjane station is the border crossing between Slovenia and Croatia, and it is also where the change of overhead line voltage occurs (from 3kV DC to 25kV/50Hz AC, Figure 3.56). The station building and the waiting room (which is very small) are in sufficient comfort and maintenance conditions (Figures 3.53-3.55). Among the intermediate stops on the line between Trieste and Rijeka, the town of Šapjane is the second most populous (just under 11,000 residents) after Sežana. However, the station is located over a kilometer away from the town, accessed via an unsignaled road (Figure 3.53), and there is virtually no connectivity with other modes of transportation (Figure 3.57). This station has the lowest average reach factor among all the stations considered in this study (Table 3.2). In terms of accessibility, there is a significant difference in minimum travel times when considering the entire train route from Šapjane to Villa Opicina (minimum time 1h59') compared to the arrival at Trieste Central Station (minimum time 4h28') due to the lack of coordinated train schedules (Figure 3.58).

Figure 3.53: Šapjane station exterior and access road

Figure 3.54: Šapjane station waiting room

Figure 3.55: platform one of Šapjane station

Figure 3.56: point of interruption and reprise of the overhead line in correspondence with the voltage change.

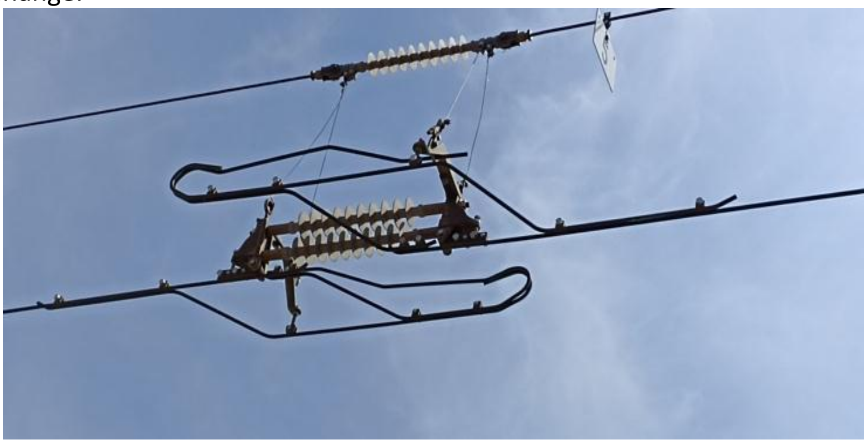


Figure 3.57: Bus lines near the Šapjane railway station .

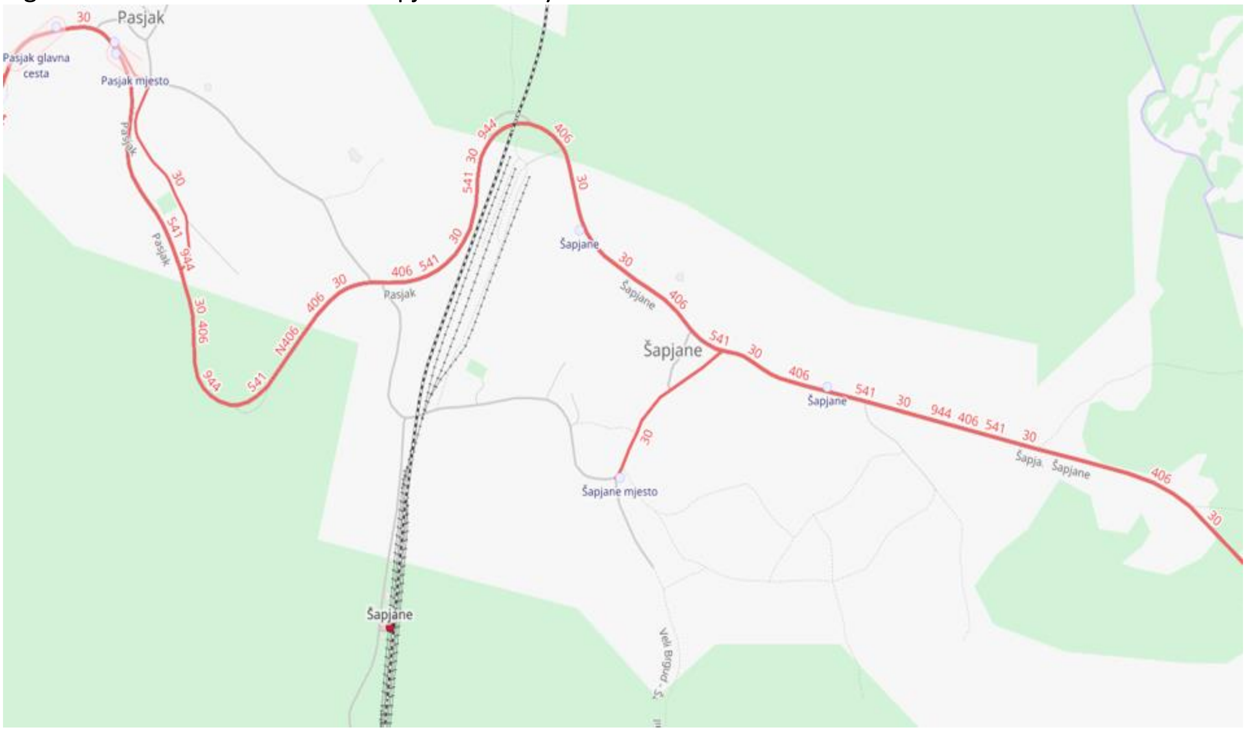
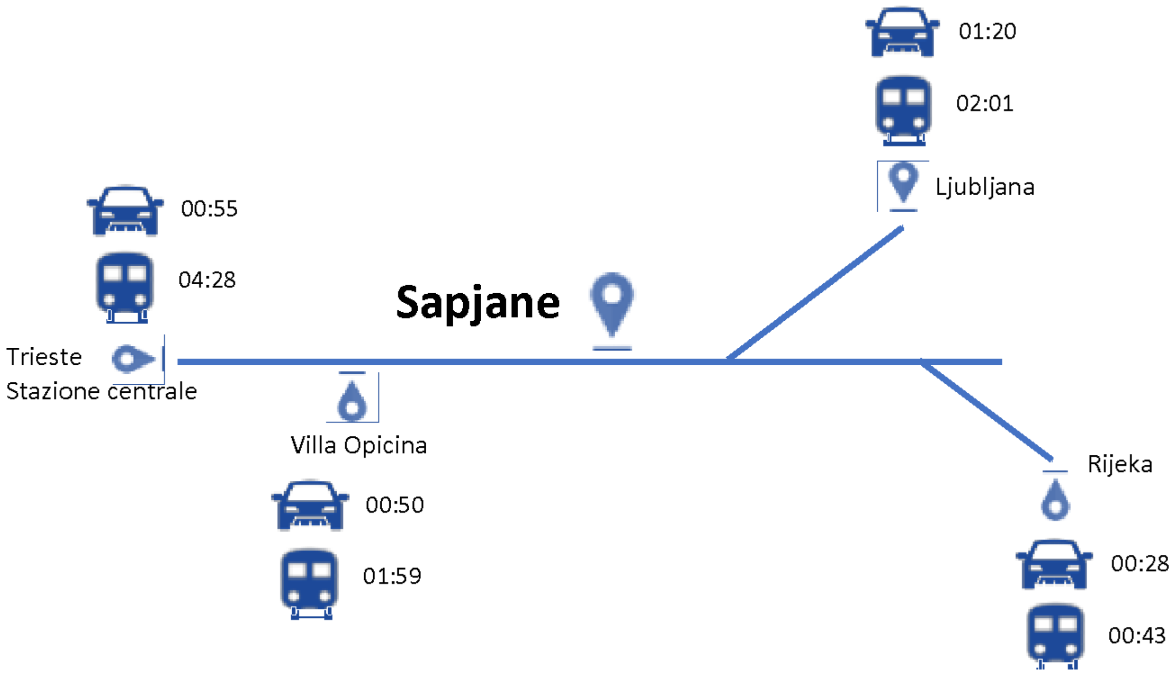


Figure 3.58: Šapjane station : minimum travel times between main destinations and main local points of interest, including any changes and, for local bus routes, any walking distances between the railway station and the bus stop .



Opatija - Matulji station

Opatija-Matulji station is located approximately 2.5 km from the center of Opatija, the main tourist destination on the eastern coast of Istria, known for its approximately 6,000 guest beds. It is a high-quality resort in terms of both landscape and tourism offerings. The area is home to prestigious hotels, and during the tourist season, the town is bustling with numerous activities and events.
During the station visit, the exterior of the building on the roadside was in good condition (Figure 3.59). However, the waiting room was closed to the public due to maintenance work (Figure 3.60), and the platform of the first track was in a precarious condition (Figure 3.61).

Figure 3.59: exterior of the station of Opatija- Matulji

Figure 3.60: waiting room of the station of Opatija- Matulji

Figure 3.61: platform one and track side of the Opatija- Matulji station

Opatija-Matulji is the closest station to Rijeka in the northeast direction. The distance between the two stations by road is 11.5 km, which can be covered in just over 15 minutes. The rail connection between them is a single-track line. The station has good connectivity to and from Rijeka (Figure 3.62). The public service offers 19 daily bus routes in each direction, with three between 6:45 AM and 10:30 PM, which are reduced to 11 routes on Saturdays and holidays. The bus journey takes between 20 and 25 minutes. In addition, there are 8 daily train connections (on weekdays) with Rijeka, as well as other connection services provided by private bus companies, although they offer fewer daily connections. The nearest bus stop is about 650 meters from the station, while the main bus station in Opatija, which offers more connections to Rijeka and other cities, is located just under 5 km from the train station. Furthermore, there is an elevation difference of about 200 meters between the center of Opatija and the train station (Figure 3.64). It is also worth noting the connection operated by Flixbus from Trieste, with four daily trips to Rijeka (at the time of the survey, the ones at 5:15 PM from Trieste and 10:00 AM from Rijeka). Rijeka and the center of Opatija are relatively close (Figure 3.65). To travel from the center of Opatija to the central station in Rijeka, there is a coastal section of secondary road, approximately 12 km long with a maximum elevation difference of less than 50 meters, but it does not have dedicated bicycle lanes (Figure 3.66).

Figure 3.62: Bus lines near the Opatija- Matulji station

Figure 3.63: Opatija- Matulji station : minimum travel times between main destinations and main local points of interest, including any changes and, for local bus routes, any walking distances between the railway station and the bus stop 'bus.

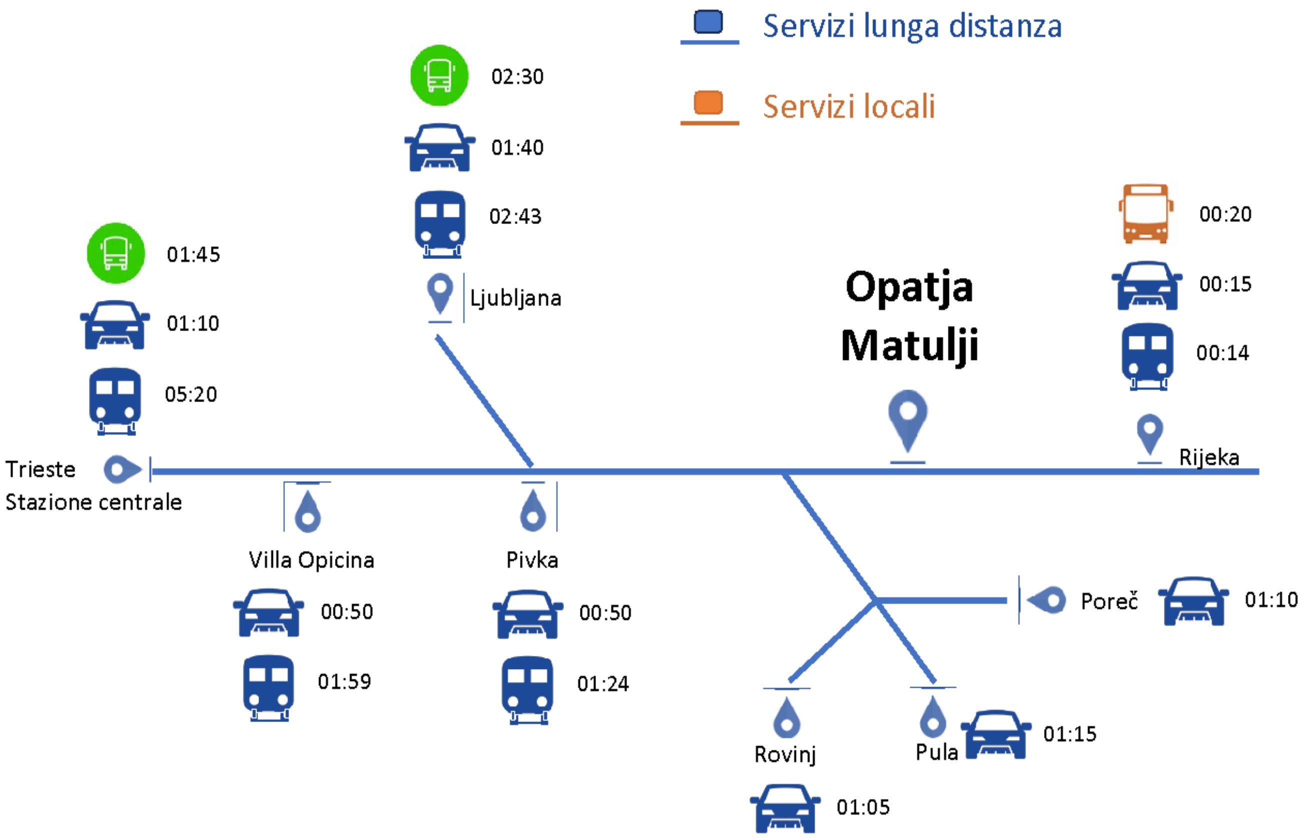


Figure 3.64: Detail of the shortest route between the Opatija- Matulji railway station and the Opatija main bus station.

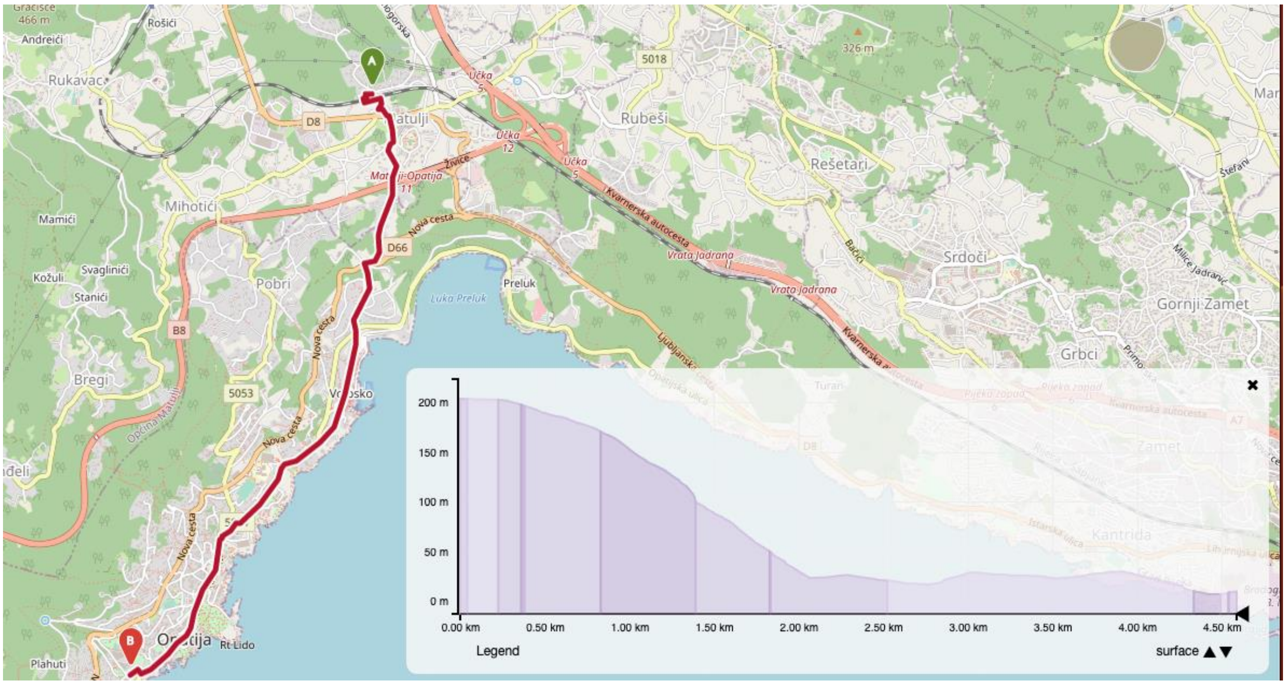


Figure 3.65: isochrones relating to journeys of 15' on foot, by bike and by bus from the stations of Opatija-Matulji and Rijeka

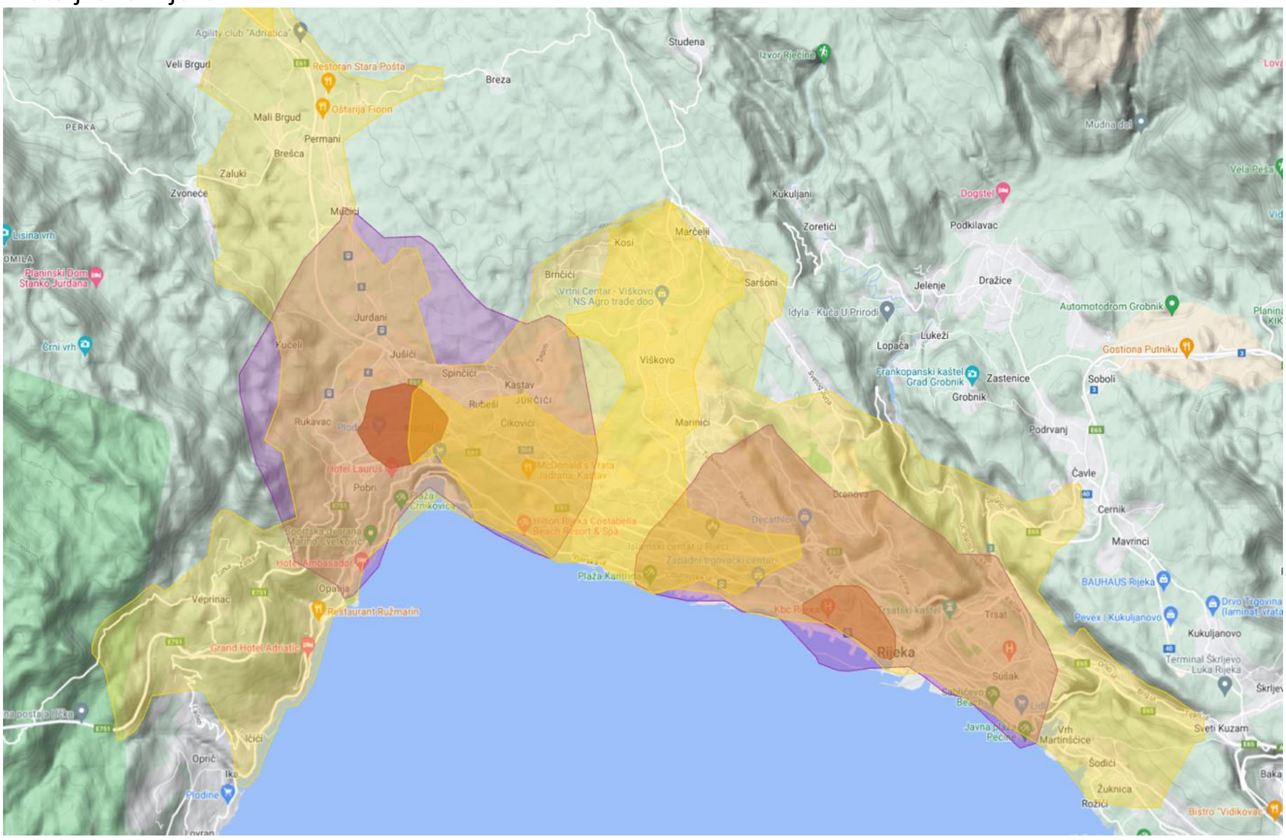
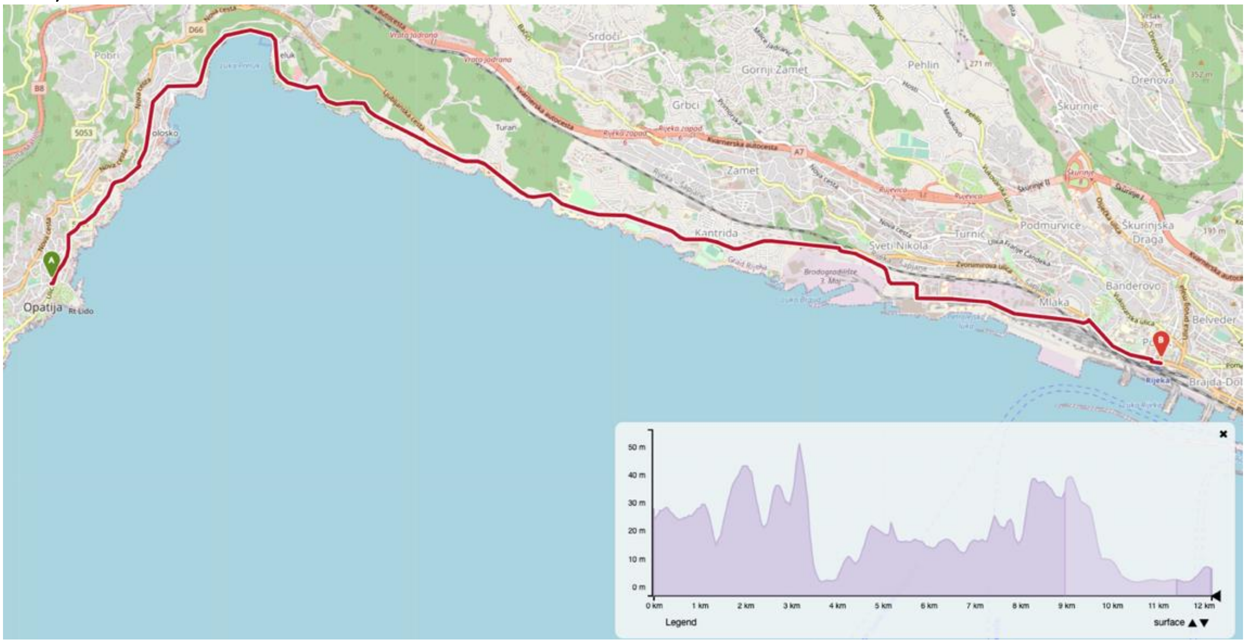


Figure 3.66: detail of the shortest route between the center of Opatija and Rijeka station (route without a cycle lane).



Rijeka station

The railway hub of Rijeka is at the center of attention in all the planning and development documents we consulted, both for its role in handling goods to and from the Port of Rijeka and as a connecting point for the lines from and to the south (Zadar, Sibenik, and Split) to the capital city of Zagreb, and from there to the international European network towards Ljubljana and Vienna. The station appears to be in excellent condition externally (Figure 3.67), with paid parking options near the entrance and free long-term parking in a parking lot a few hundred meters away. Outside, but still near the entrance, there are commercial establishments, electric scooter services, and car rental services. Internally, the structure is in very poor condition due to ongoing construction work. The waiting room is open to the public, but its conditions were rather precarious at the time of the site visit (Figure 3.68).

Figure 3.67: exterior of Rijeka station.

Figure 3.68: waiting room in Rijeka station and detail of the work-in-progress area

The connectivity of Rijeka station with the hinterland is excellent (Figure 3.69). All major urban bus lines pass through and stop in front of the railway station. The terminus for long-distance buses (such as Flixbus) is located approximately 700 meters east of the railway station entrance. The accessibility of the waiting room and the platform of the first track is problematic for people with mobility difficulties. In fact, access to the station from the main road side is hindered by two steps (Figure 3.70). There is a possibility to access the first track through a path that bypasses the main building, but at the time of the site visit, it was impractical for a disabled vehicle as it was being used as a parking area.

Figure 3.69: Overview of bus connections near Rijeka station

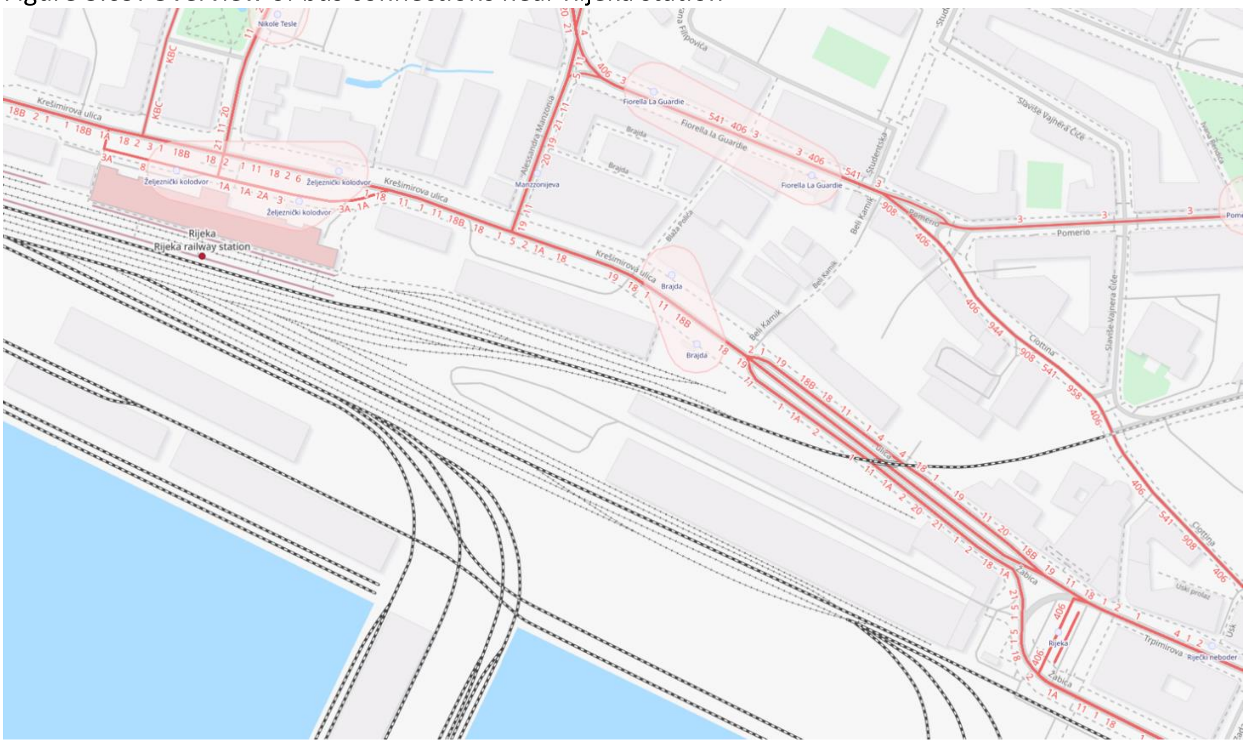


Figure 3.70: the access from the main road to the waiting room

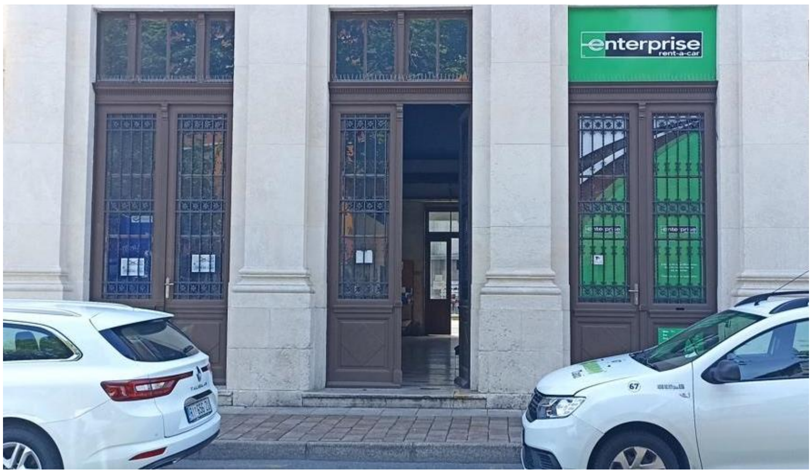
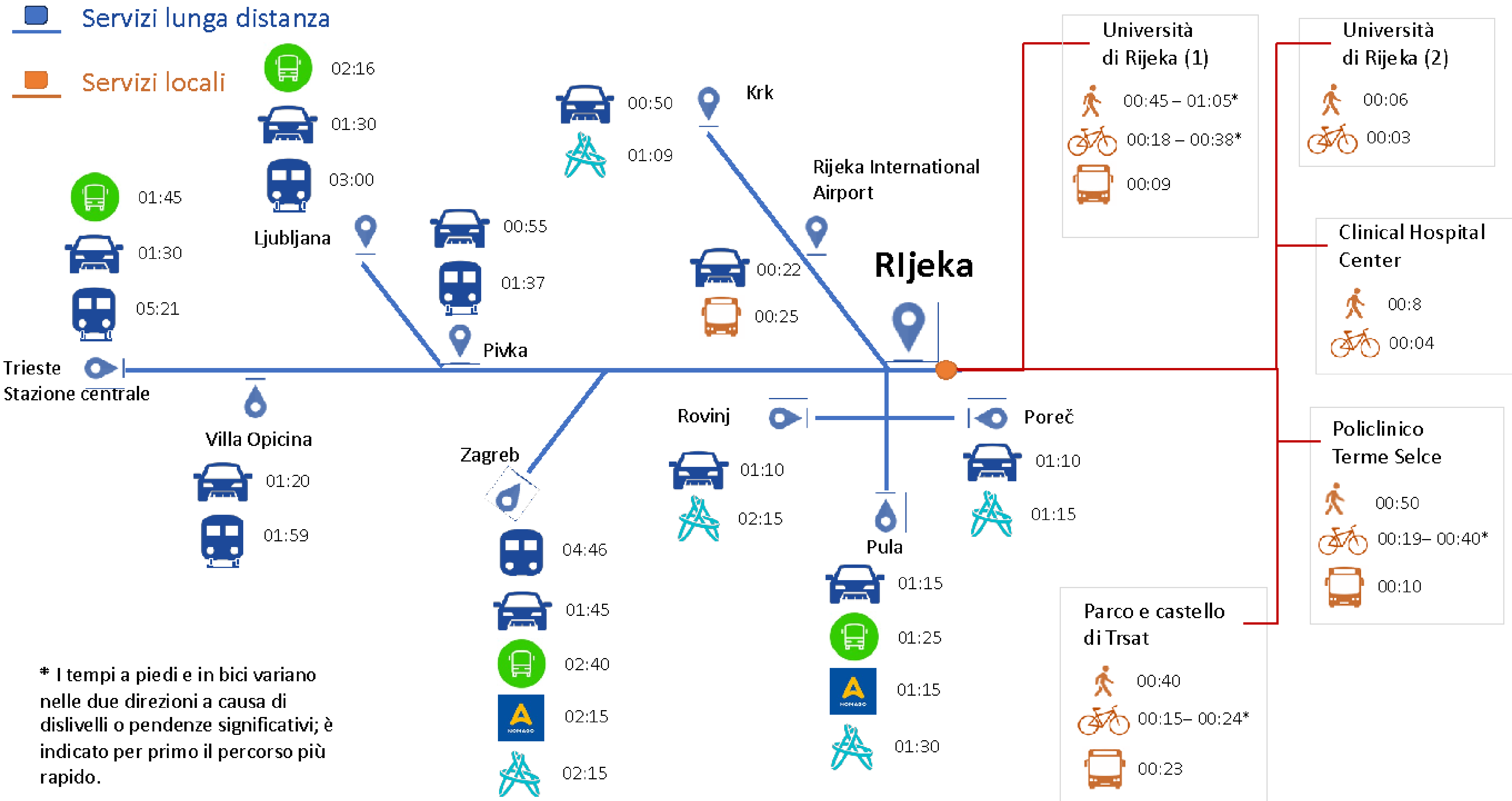


Figure 3.71: platform one of Rijeka station

Rijeka and the main locations in Istria are also connected by bus services, and we will now mention the two main companies that provide regular service.
The company Nomago operates 7 daily trips between Rijeka and Pula in each direction (5 on pre-holiday Saturdays and 6 on Sundays). The direct trip takes 1 hour and 15 minutes, while the trip with more intermediate stops (17) takes 2 hours and 15 minutes.
The company Arriva (part of the Deutsche Bahn group) provides connections between Rijeka and the main locations in Istria, specifically: 6 daily trips in each direction (4 on weekends) to and from Pula, 5 trips to and from Rovinj (4 during weekends), and 5 or 6 trips during the week to and from Poreč (4 on weekends). In this case as well, the duration of the trips varies depending on the route and the stops, which differ for the different trips made on the same day.

Figure 3.72: Rijeka station: minimum travel times between main destinations and main local points of interest, including any changes and, for local bus routes, any walking distances between the railway station and the bus stop .



* I tempi a piedi e in bici variano nelle due direzioni a causa di dislivelli o pendenze significativi; è indicato per primo il percorso più rapido.

3.3 Conclusions

The main conclusions that we can draw from the set of considerations that arise from the mapping of the attraction areas of the stations are summarized below.

Improving communications on existing timetables and services .

Examining the available information at the stations, we have noticed that the information is clear and easy to find only for domestic destinations served by direct trains, while sometimes it is not evident that there is the possibility to travel internationally through intermediate connections.

We believe that in order for train travel to be considered by travelers, it is necessary to simplify and coordinate the information regarding schedules and fares. In particular, it is necessary to standardize the way information is conveyed (see Chapter 6 of this report for more details on these issues). Currently, in some stations, timetables and notices are only in Slovenian or Croatian, and the encountered automated ticket machines operate only in Slovenian. Moreover, the timetables are often presented in sequential order (by departure time) and not in a way that highlights possible connections across multiple routes. In some stations, the timetables only show fragments of the route, making it even difficult to check if the destination is beyond the national border.

This issue also affects public transport services, which we found to be communicated at the stations (where present, with the exception of Trieste) exclusively in the local language.

We have also observed that independent route planners available on the web are not a solution because they are often not up to date (for example, in the case of the temporary interruption of the railway line between Divača and Koper, served by replacement buses) or they display trains for which there is no corresponding information on the websites of national railway operators.

Therefore, it would be advisable, in perspective, to consider: a) an integration of the information services that includes, at least for international routes, a multilingual and coordinated communication format that clearly conveys the message to all involved operators, at the stations, and on websites; b) a truly integrated information and ticket purchasing platform.

Improved interconnectivity

We have highlighted how some stations have limited or even absent interconnectivity (e.g., Šapjane). Among these, Villa Opicina is the most critical in terms of travel choice because it is the first Italian border station and would allow reaching Trieste much faster than the train if it had a synchronized bus connection. Such a connection is certainly important for tourist traffic, but it is vital for cross-border commuters as it can be a determining factor in choosing to work or study in Trieste. The contribution of commuting can indeed be significant, as explained in more detail in the following section.

Potential contribution of work and study commuting.

If we exclude the two main cities and the stops immediately adjacent to them (thus Trieste and Villa Opicina on one side, Rijeka and Opatija-Matulji on the other), the resident population in the intermediate locations is relatively small. However, the current offering of local trains by the Slovenian Railways (especially on the Pivka-Villa Opicina route) is significant (see also Chapter 2), leading to the belief that there is a commuter traffic, including cross-border commuting. Previous studies and data from Slovenian and Croatian railways indeed confirm that commuter traffic has a certain consistency on some intermediate routes (see Chapter 1 in this regard). It should be noted that daily commuting traffic (for work, study, or functional purposes) can constitute a significant portion of the overall travel volume (a single commuter theoretically makes about 400 trips per year on a route compared to the two trips of an occasional tourist). Naturally, this type of traffic depends on the existence of cross-border job opportunities, and in this sense, both Trieste and Rijeka are natural attractors for locations within their respective territories, being university centers and having a high density of economic activities compared to the surrounding area.

A crucial factor in triggering commuter demand and diverting it from cars is determined by schedules, even more so than fares. Furthermore, it is likely that there are trade-offs between the possibilities/opportunities of attracting functional commuter traffic compared to better serving potential tourist demand. Therefore, it would be beneficial to have information on the ways in which the demand manifests for these two macro-segments, considering that some stations are conveniently located to reach tourist attractions.

Potential contribution of points of interest near stations.

Indeed, some of the identified points of interest (Figure 3.4) have great potential for attracting tourists due to their easily accessible locations from the nearest railway stations. We refer specifically to Miramare Castle and Park, Grotta Gigante, Škocjan Caves Park, Postojna Caves, and Predjama Castle. If a set of tools could be identified and implemented to communicate and enhance the intermodal accessibility to these destinations, the contribution of travelers to the railway line could significantly increase. This could include a range of tools that are often already tested and implemented, including train+bike options, electric bike-sharing, coordinated shuttles with trains, targeted communication, and guided tours for schools, among others. Electric bike-sharing, in particular, would make these points of interest accessible to a broader audience, including those who may not have traditional bikes. It is also important that these opportunities are communicated clearly and specifically, not only at the stations. In some Slovenian stations, we found infographics about places of interest, but they had a rather outdated style and, in some cases, were only available in Slovenian (Figure 3.73). It would be appropriate to consider tailored communication for web channels and social networks, targeting specific segments (such as schools, cycling tourists, cave enthusiasts, etc.).

Figure 3.73: infographic of Ilirska Bistrica places of interest in Slovenian-language, many of which are easily accessible by bicycle.

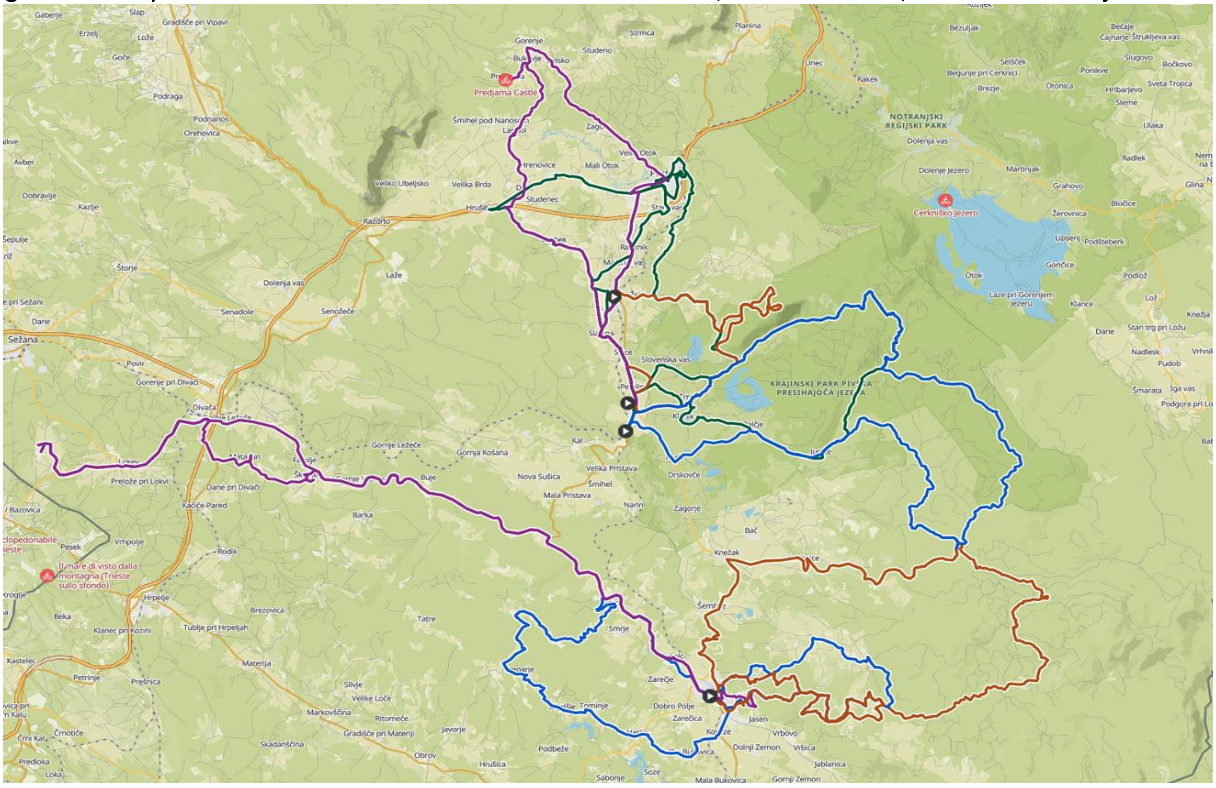
Potential mutual benefits between rail and cycle tourism.

An important phenomenon is that of cross-border cycling tourism (see also the concluding remarks of Chapter 1 in this regard). This aspect is not fully captured in the mapping of stations because: a) it is not detected by official sources and therefore cannot be quantified without direct surveys, and b) it encompasses wide areas rather than specific locations. Similar to the Istrian Peninsula, the area between Divača, Ilirska Bistrica, Pivka, and Postojna is traversed by several cycling routes (Figure 3.74). In particular, the entire area between Opatija and Ilirska Bistrica boasts an environmentally valuable landscape with hilly terrain that is well-suited for cycling tourism accessible to a wide range of people.

In this regard, a train equipped for bike transport could offer an opportunity to expand the number of people who engage in this form of sustainable tourism. The Trieste-Rijeka train could be considered as the primary means of transportation, serving as an alternative to cars, to connect cycling itineraries between Trieste and Rijeka. These itineraries could replicate, at least conceptually, the model of the "San Candido-Lienz" route, known for its successful cycling tourism promotion.[31]

[31]https://www.sancandido-lienz.com/

Figure 3.74: Cycle tourism routes in the area between Divača , Ilirska Bistrica , Pivka and Postojna



Source: Komoot

Concluding Remarks .

The territory covered by the railway route under examination undoubtedly possesses untapped tourism potential, for which the train could act as a value catalyst. Being more aligned with the values of "sustainable" tourism, the train is a more suitable mode of transportation compared to cars, aligning well with the landscape and points of interest near the stations along the route. In essence, the presence of the train itself could generate travel demand along the route that is currently not evident. Furthermore, previous studies and observations by railway operators (as discussed in Chapter 1) demonstrate that there is already a certain demand for the railway route, or at least for its intermediate sections, with a portion of it likely attributed to commuting (evident in the Rijeka-Šapjane and Ilirska Bistrica-Sežana sections). It is reasonable to assume that the availability of a train that completes the route in a reasonably competitive time compared to cars could increase functional cross-border demand. This would consist of commuters deciding to study, work, or simply maintain relationships beyond the border.

The train could also enhance opportunities for cultural initiatives, such as school visits or group outings to places of interest during the school year. This initiative would also help counterbalance the decrease in demand that occurs outside the summer season.

A crucial prerequisite for all of this is: a) implementing last-mile connectivity between the stations and major attractions, especially in the case of Villa Opicina and the center of Trieste; b) addressing the available passenger information, both on-site (at the stations) and off-site (websites, social media, etc.), addressing the previously summarized challenges.

4. Analysis of current and potential demand

4.1 Analysis of the data available from the surveys carried out in previous studies and from the management companies of the national railways

In Chapter 1, previous studies were presented that provided observations and estimates on the number of passengers traveling on the Trieste-Rijeka route. In this paragraph, we provide a summary of the available data from these studies, including observations, estimates, and data derived from the original studies, which will be used for our traffic forecast.

Table 4.1 summarizes the data that we deemed most useful for determining the current demand, which will serve as the basis for the specific estimation of the new Trieste-Rijeka service. As you can see, the observations, estimates, and projections are quite heterogeneous for several reasons: a) they are almost always related to intermediate routes (which, as we will see in Chapter 5, practically forced us to adopt an additive linear estimation model presented in Chapter 5); b) not all projections (for 2040 or 2030) are accompanied by a starting observation, and even when they are, it is often far removed in time from the projection (e.g., observation in 2009 and projection in 2030 for one of the sources used). Since the most recent observations for some routes date back to 2022, while the projections span from 2024 to 2030 and beyond, in order to ensure uniformity in the input data for the model, the projections had to be adjusted to a single year, and the year chosen was 2024. The criterion is simply to consider linear demand growth over time. This is actually a simplification since there are assumptions that some factors may create discontinuity from one year to another, but it is the most reasonable criterion that can be used with the available data. Furthermore, this assumption effectively assumes a decreasing percentage growth rate over time, which is a somewhat pessimistic assumption, especially considering that the GDP projections for the three countries show growth. However, this aspect will be addressed in the sensitivity analysis section (Section 5.3). With all this in mind, we estimated rail demand for some main routes included in the Trieste-Rijeka corridor, and the results are presented in Figure 4.1.

Specifically, the values in Figure 4.1 were obtained as follows:

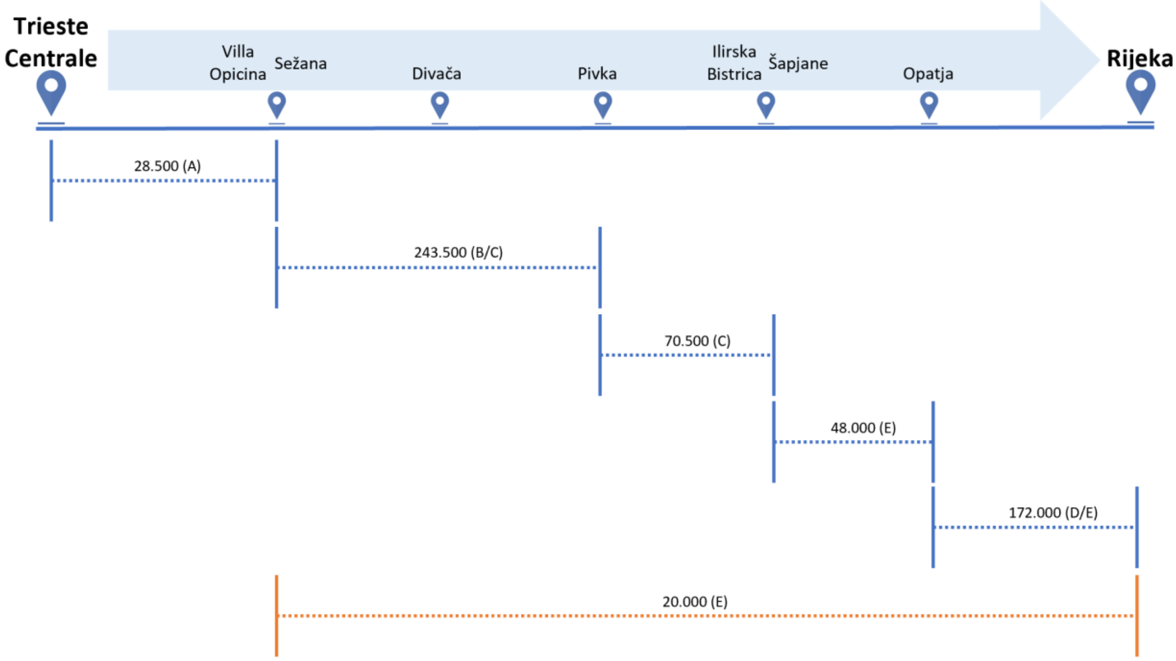
- Trieste-Sežana route: The data from source A was updated to 2024 based on the growth of the Italian GDP.
- Villa Opicina-Sežana-Pivka route: The data from source C was updated to 2024 by linear regression after removing the estimates for travelers to and from Koper and Pula, and taking into account that the passenger numbers from source C include passengers from source B.
- Pivka-Ilirska Bistrica DM route: The data from source C was updated to 2024 by linear regression.
- Šapjane DG-Opatija route: The data from source E was updated to 2024 by linear regression, considering the estimated annual growth rates by the Croatian railways.
- Pazin-Rijeka route: The data from source E was used, taking into account that the passenger numbers from source D include passengers from source D.
- Villa Opicina-Rijeka route: The data from source E was updated to 2024 by linear regression, estimating an intermediate growth rate between the Slovenian and Croatian rates. For this route, only passengers traveling the entire route without boarding or disembarking at intermediate stations are taken into account.

Table 4.1: summary of the main surveys and estimates from previous studies and surveys carried out by the Italian, Slovenian and Croatian railway companies.

Source	Reference period	Drawn				
		Trieste - Sežana				
A. Trenitalia - Crossmoby	Daily estimate 2023 Survey 2022	77 28,000				
			V.Opicina - Pivka			
B. Yes, Trenitalia (international passengers only)	Daily 2022 Survey 2022		169 61,666			
C. Republic Of Slovenia Ministry Of Infrastructure, Transport Development Strategy of the Republic of Slovenia Until 2030 https://www.gov.si/assets/ministrstva/MzI/Dokumenti/Transport-Development-Strategy-of-the-Republic-of-Slovenia -Until-2030.pdf			**V. Opicina - Divača**			
	Daily estimate 2009 Survey 2009		229,813 630			
	Daily estimate 2030 Estimate 2030		986 359,890			
				Divača - Pivka		
	Daily estimate 2009 Survey 2009			1.064 388.185		
	Daily estimate 2030Estimate 2030 *			5,456 1,991,440		
					Pivka - Ilirska Bistrica	
	Daily estimate 2009 Survey 2009				147 53,798	
	Daily estimate 2030 Estimate 2030				211 76,852	
D. Project izgradnje drugog kolosijeka , obnove i modernizacije pruzhne dionics Škrljevo – Rijeka – Jurdani (Šapjane), Hž Infrastruktura , Institut Igh , Granova , public presentation, Rijeka 23 January 2020. https://www.hzinfra.hr/wp-content/uploads/2020/01/2020.01.23-Prezentacija-RI-23.01.20.-V2 -final.pdf						**Opatija- Matulji - Rijeka***
	Daily estimate 2024 Estimate 2024					860 172,000
E. for 2022: HŽPP; for 2020: HŽPP MIMOSA Project, D.4.1.3. Analysis on market potential research – with railway through Istria: route Rijeka- Šapjane In the trade Villa Opicina - Rijeka are considered to be the only passengers who complete the entire route.						**Sapjane - Rijeka***
	Daily estimates 2020 Survey 2020					68 24,720
	Daily estimate 2022 Survey 2022					121 44.216
			V.Opicina - Rijeka			
	Daily estimate 2022 Estimate 2022		51 18,500			
		Trieste - Rijeka				
F. Amanović , S., & Kralj , S. (2016).	Daily estimate 2030 Estimate 2030 *	1,820 364,000				

* As we explain in chapter 1, we have maintained these forecasts as they are significant of the potential brought by the connection between Divača and the Istrian line. However, we cannot at the moment consider them realistic because this link has not been developed in the terms that were expected at the time in which the forecast was formulated.

Figure 4.1. Estimate of passenger rail traffic by 2024 for the main sections of the Trieste - Rijeka route

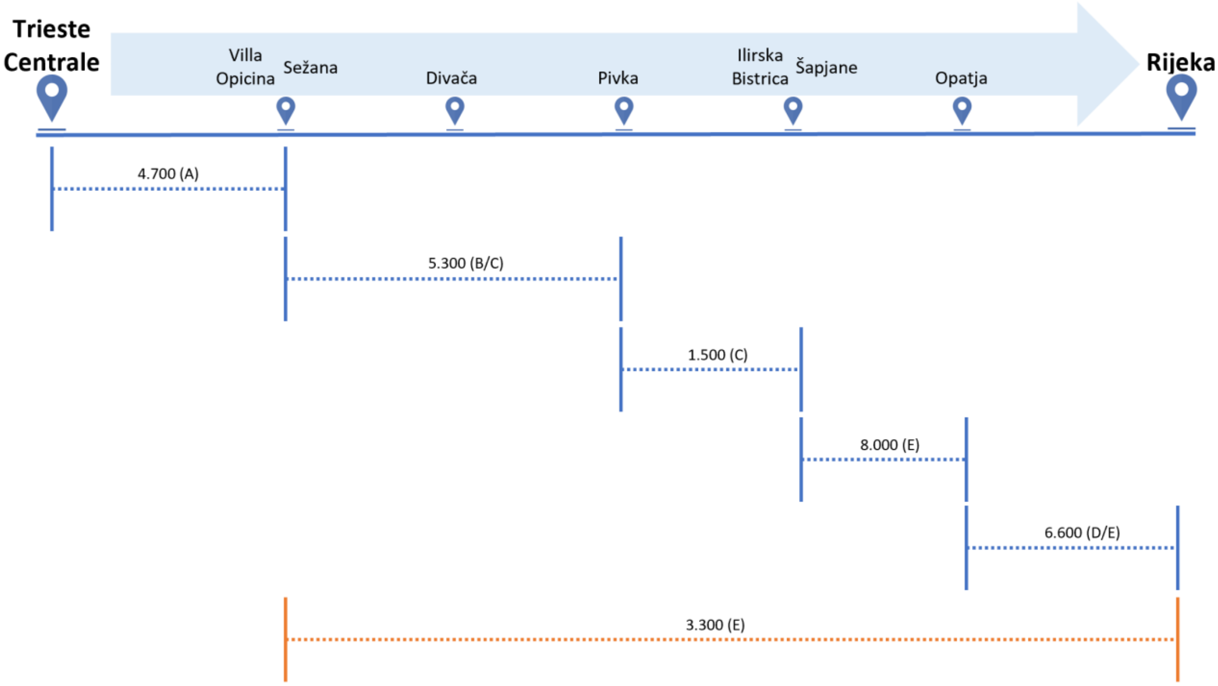


To estimate the number of passengers who could use the new railway service from Trieste to Rijeka, a more conservative assumption is made compared to the one formulated in [Holmgren_2007], where it is stated that the direct elasticity of public transportation with respect to the number of vehicle-kilometers provided by the service is slightly higher than one.

On the routes between Trieste and Rijeka, a varying number of local trains are in operation, and it is reasonable to assume that a portion of "intermediate" passengers will also utilize the new service. However, it would be optimistic to assume that these passengers would distribute themselves evenly among the available trains, for at least two reasons: a) the trains used by commuters are predominantly those during the early morning and late afternoon hours, so a train operating during non-peak hours realistically couldn't absorb the same proportion of commuters as the morning trains; b) the new train should include subscription fares, which are predominantly used by commuters. It is therefore assumed that the new service captures half of the average number of passengers using local trains. Conversely, it is assumed to capture the same proportion as the average number of passengers using international trains. With this assumption, we can calculate the passengers for a train that travels the entire route without transfers, capturing both the travel demand of those traveling from Trieste to Rijeka (or vice versa) and portions of local passengers using the train for intermediate stops. The results (rounded) are indicated in Figure 4.2. Overall, an estimated 29,400 annual passengers are included, including those boarding and disembarking at intermediate origins/destinations.

It is important to note that this is a starting point, assuming the insignificance of factors influencing modal choice (demand is divided among different trains through mere distribution) and referring solely to the estimated potential demand for 2024, excluding several other considerations regarding the factors underlying modal choice, which will be addressed later. Essentially, it is a conservative estimate that does not consider the following factors: a) The new demand activated upon the introduction of the service, which will depend on numerous factors that have been partly discussed and can be summarized by the capacity of the offering to operate synergistically with local connectivity and the opportunities provided by major attractors. An approximate estimation of this additional demand can be obtained indirectly through the questionnaire survey conducted for this study, which will be discussed in the following paragraph. b) The modal shift that could occur from cars if the service has certain characteristics. This point will be revisited when discussing demand elasticity. Here, we note that this number of passengers is equivalent to approximately 8% of the total number of Croatian and Slovenian travelers for whom it is estimated that Trieste served as an origin and destination in 2022 for locations served by the railway in question, based on data provided by the MIMOSA survey using phone tracking records[32].

Figure 4.2. Additive estimate of the number of potential annual passengers for a railway service which in 2024 will complete the Trieste Rijeka section without changes, on equal terms with the current offer and in the absence of a change in demand induced by the new service and in the absence of a modal shift.



4.2 Analysis of potential demand through a survey using questionnaires

4.2.1 Survey results .

For this study, a survey was conducted using questionnaires administered to a population residing in or connected to the regions of Trieste and Rijeka.
Specifically, the following groups were involved:

- Residents of Trieste (city and province).
- Residents of the provinces of Gorizia, Udine, and Pordenone (Friuli-Venezia Giulia Region) who travel to Croatia via Trieste.
- Residents of Rijeka (city and administrative area).
- Residents of locations along the catchment area of the Rijeka-Trieste railway line.
- Residents of other Croatian locations who travel to Italy via Trieste.

The questionnaire was administered in two languages (Italian and Croatian), and in the following paragraphs, reference will be made to the Italian and Croatian subgroups. However, this does not refer to the nationality of the respondents but rather to their residency in Italy, indicating their interest in the Trieste-Rijeka route and vice versa (Italian subgroup) or their residency in Croatia, indicating their interest in the Rijeka-Trieste route and vice versa (Croatian subgroup). Since Italian residents in Rijeka and Croatian residents in Trieste were also interviewed, their responses are included among the

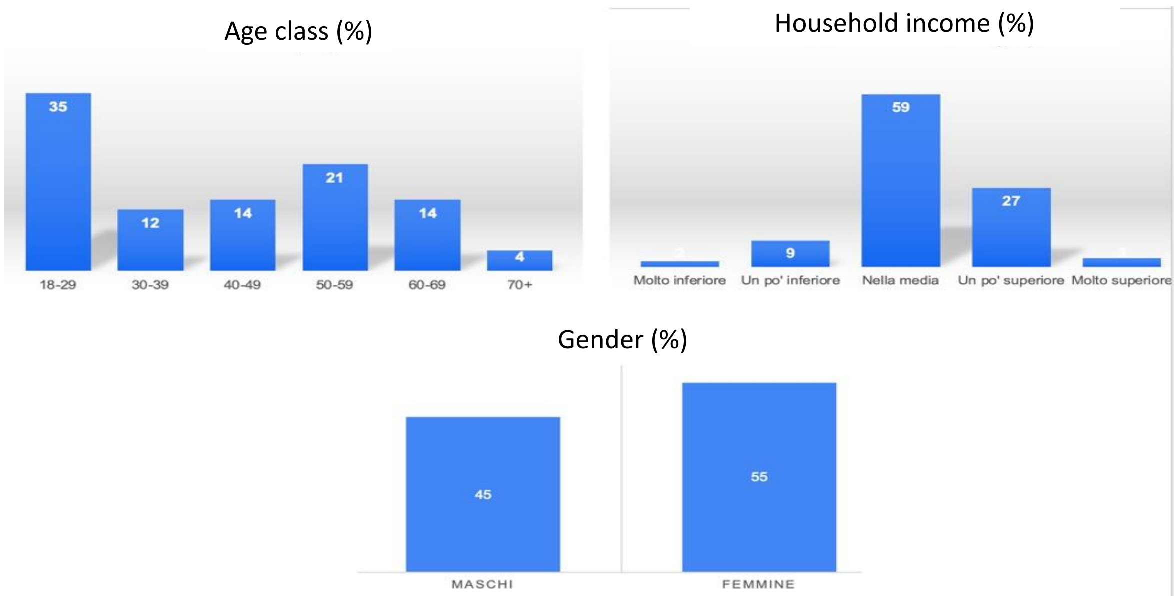
[32]MIMOSA Project, Annex to Deliverable D.3.1.1. Cross-border movements analysis based on mobile phones.

responses of "Italians" and "Croats," respectively, based on their country of residence and not their citizenship or ethnicity.
The Italian questionnaire was subjected to a validation test by a group of volunteers to identify any ambiguities or interpretive problems in the questions. It was uploaded to Google Forms. Once the identified ambiguities were corrected, the Italian version was translated into Croatian, checked by native collaborators, and the created links were disseminated through the following channels:

- Personal emails to private contacts residing in the project areas.
- Messages sent to mailing lists owned by the CAMI research center, which included individuals who consented to be contacted for questionnaire completion and who are residents of Trieste, Rijeka, or neighboring areas.
- Emails sent to operators in the HoReCa sector (hotels, restaurants, cafes) operating in the project areas.
- Posts on both professional (e.g., LinkedIn) and non-professional (e.g., Facebook) social network pages. In particular, posts were made on Facebook groups related to the project areas or groups focused on travel in Croatia.

The questions were structured based on validated methodological protocols and widely used scales in the literature dedicated to the topic of cross-border and non-cross-border mobility. The approach was flexible enough to allow modifications, if necessary, to make the questions more coherent with the specific objective of the study.
The survey has a simple and user-friendly graphical interface, including smartphone compatibility, as smartphones are currently the most commonly used devices for survey completion.
The presented results are based on 301 valid questionnaires, where a questionnaire is considered valid if the respondent answered all the questions. It should be noted that in some cases, the sum of the percentages may not be 100 due to rounding decimals.
The sociodemographic characteristics of the sample are shown in Figure 4.3.

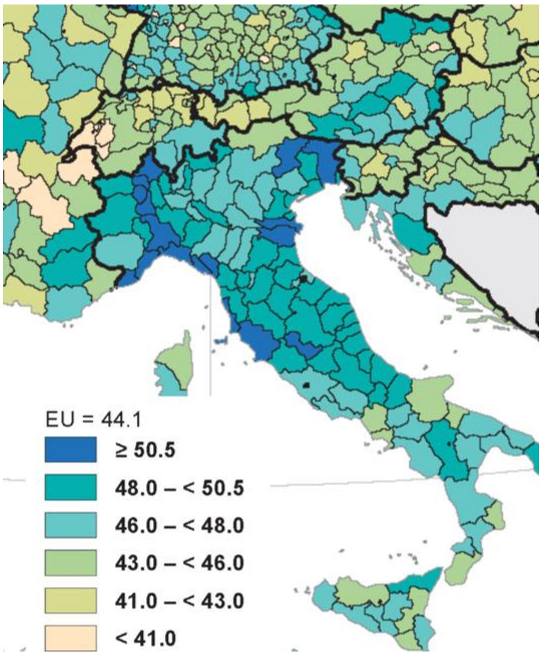
Figure 4.3. Sociodemographic characteristics of the sample



Over 55% of the sample is represented by women. The resulting underrepresentation of the male gender could have an impact because, although these differences are diminishing over time, men are still typically responsible for choosing the means of transportation when it involves multiple people (e.g., couples or families traveling to Croatia/Italy for vacation or recreational purposes).

Regarding the age of the respondents, the sample is representative of the population residing in the project areas, with a good presence of different age groups. The average age of the interviewed sample is 42 years, which is in line with the median age of the EU, which is 44 years (Eurostat data[33]).

Figure 4.4. population median age (2021)



59% of the respondents declare a family income in line with the average of the region of residence, while 11% of the sample declare an income somewhat lower than the average and the remaining 30% a higher income. This data is not surprising, since the subconscious desire not to expose oneself is typical in "sensitive" responses such as those concerning the personal economic situation, thus declaring central and as far as possible neutral values.

The first question asks the interviewees how often they go to the various locations covered by the study, i.e. the cities of Trieste and Rijeka as well as intermediate stops in Italy, Slovenia and Croatia. Table 4.2. shows the results of this question, highlighting the share of cross- border non-travellers or near-non-travellers in yellow tones

Table 4.2: How often do you travel to one of the locations below?*

Italians	Villa Opicina	Sežana	Divacha	Pivka	Ilirska Bistrica	Opatija Matulji	Rijeka
Never	44%	59%	74%	77%	76%	64%	42%
Less than 1 time / year	22%	18%	15%	16%	17%	19%	30%
1-2 times a year	13%	11%	6%	4%	5%	9%	16%
Several times a year	16%	8%	3%	1%	2%	5%	8%
Every month or so	2%	2%	0%	0%	0%	2%	3%
Every week or so	3%	2%	2%	1%	0%	1%	1%
Several times a week	1%	0%	0%	0%	0%	0%	0%

Croatians	Opatija Matulji	Ilirska Bistrica	Pivka	Divacha	Sežana	Villa Opicina	Trieste
Never	28%	53%	65%	65%	52%	42%	18%
Minus 1 /year	20%	15%	19%	18%	24%	7%	9%
1-2 times a year	5%	10%	9%	7%	11%	12%	12%
Several times a year	20%	14%	5%	7%	7%	20%	31%
Every month or so	12%	8%	1%	2%	6%	7%	8%
Every week or so	10%	0%	0%	0%	0%	8%	6%
Several times a week	5%	0%	0%	0%	0%	3%	15%

* Percentages are rounded to integers, so 0% can mean a non-zero value but less than 0.5%

In the Italian subgroup, the only two centers where less than half of the sample say they never go are Villa Opicina and Rijeka (44% and 42%, respectively). The localities of Divača , Pivka and Ilirska Bistrica are

[33]https://ec.europa.eu/eurostat/statistics-explained/images/7/73/Median_age_of_the_population%2C_1_January_2021_%28years%2C_by_NUTS_3_regions%29_RYB2022.png

those that report a lower influx of travellers, and for which the percentage of respondents who go there frequently is close to zero, while the numbers are slightly higher for Sežana , close to the border with Italy, and Opatija – Matulji , not far from Rijeka. Considering then trips that have a certain frequency (several times a year, or even greater frequency), it is confirmed as it was presumable to assume that the most popular destinations are Sežana , just beyond the Italian-Slovenian border, and the major centers of Opatija- Matulji and Rijeka in Croatia.
In the Croatian subgroup, however, the case of Trieste stands out, a city where 60% of the interviewees declare that they go several times a year (with 15% even declaring that they go there several times a week).
A second question then analyzed what are the reasons behind the trips in question. The results are reported in tables 4.3.

Table 4.3: What is the main reason for your trips to the locations below?

Italians	Villa Opicina	Sežana	Divacha	Pivka	Ilirska Bistrica	Opatija Matulji	Rijeka
Work	13%	8%	7%	8%	7%	6%	4%
Shopping, leisure outing	41%	54%	48%	26%	32%	25%	27%
Tourism, vacation	15%	20%	24%	54%	41%	57%	50%
Education, business	3%	3%	5%	0%	2%	1%	2%
Visit friends-relatives	15%	5%	2%	3%	7%	9%	12%
Other	14%	11%	14%	11%	10%	3%	5%

Croatians	Opatija Matulji	Ilirska Bistrica	Pivka	Divacha	Sežana	Villa Opicina	Trieste
Work	10%	8%	27%	20%	19%	13%	7%
Shopping, leisure outing	28%	67%	33%	33%	38%	34%	48%
Tourism, vacation	30%	13%	13%	27%	24%	22%	17%
Education, business	3%	4%	13%	7%	5%	0%	4%
Visit friends-relatives	15%	4%	0%	0%	5%	16%	7%
Other	15%	4%	13%	13%	10%	16%	17%

In the Italian subgroup, shopping, pleasure trips and tourism appear to be the predominant motivation for all destinations: specifically, shopping - pleasure trips stand out for the nearest locations (Villa Opicina , Sežana and Divača) and tourism - holiday for the more distant ones (Pivka , Ilirska Bistrica , Opatija– Matulji and Rijeka).
In the Croatian subgroup, on the other hand, the preponderance of motivations linked to shopping and leisure trips clearly emerges (which for trips to Trieste reach 48% of the answers), while tourism - holidays settle on lower values that do not exceed 30% in any destination %.
The next question deals with the theme of the frequency with which different means of transport are used for the journeys in question (table 4.4. in analyzing the results it is necessary to consider the fact that it does not differ for specific destination).

Table 4.4: How often did you use the following means for the trips in question?

Italians and Croatians	Private car	Car sharing	Taxi - NCC car	Motorcycle	Bus	Railroad	Bicycle
Never	10%	87%	93%	84%	57%	51%	ninety two%
Sometimes	18%	10%	5%	9%	28%	21%	7%
Often	15%	4%	1%	3%	9%	13%	1%
Almost always	30%	0%	0%	2%	5%	11%	0%
Always	29%	0%	0%	1%	1%	4%	0%

The private car widely emerges as the preferred means of travel in question, with a marginal percentage of the sample (10%) who never use it compared to 59% who always or almost always use it, a percentage that is even more accentuated in the Croatian subgroup (72%). Solutions that involve traveling by bus or railway are placed far apart, with percentages exceeding 40% of respondents stating that they have used them at least sporadically. Here a difference also emerges between the two subgroups (table 4.5.)

Table 4.5: How often did you use the following means for the trips in question?

Italians	Private car	Car sharing	Taxi - NCC car	Motorcycle	Bus	Railroad	Bicycle
Never	9%	91%	93%	82%	60%	42%	91%
Sometimes	20%	5%	6%	11%	27%	24%	8%
Often	17%	3%	2%	4%	7%	16%	2%
Almost always	28%	1%	0%	2%	5%	14%	0%
Always	27%	0%	0%	1%	1%	4%	0%

Croatians	Private car	Car sharing	Taxi - NCC car	Motorcycle	Bus	Railroad	Bicycle
Never	11%	72%	96%	94%	45%	88%	98%
Sometimes	9%	23%	4%	4%	30%	10%	2%
Often	7%	6%	0%	2%	16%	2%	0%
Almost always	35%	0%	0%	0%	7%	0%	0%
Always	37%	0%	0%	0%	2%	0%	0%

Italians seem to prefer the railway and Croatians who use the bus more frequently. The other solutions contemplated (motorcycles, car sharing and, to an even more significant extent, taxis and bicycles) can be considered as residual alternatives chosen by a niche of respondents. The bicycle, for example, is used almost exclusively by Italians, with only 1% claiming to use it often. Finally, it should be noted that the only other means of transport reported by respondents that reached 1% of the answers was the camper.

As regards the average length of stay at the destination, the responses from the sample show significant differences, although compatible with the different objectives of the trips described above. The vast majority of Croatians operate for short stays (indeed, 81% make a round trip in the day, without overnight stays) while Italians are more inclined to stay longer (25% stay at least 4 days, and 7 % over two weeks).

Table 4.6.: what is, on average, the length of stay at the place of destination?

	ITA	cro
Same day return	52%	81%
2-3 days	24%	16%
4 days – 1 week	10%	1%
1-2 weeks	8%	1%
Over 2 weeks	7%	0%

The second section of the questionnaire was dedicated to specifically analyzing the perspective of the interviewees regarding the creation of a railway service between the cities of Trieste and Rijeka. Tables 4.7 and 4.8 show the percentages of answers concerning the possible use of the line and the frequency of use.

The results of the survey certainly appear encouraging and show a tangible interest in the prospect of an enhanced railway service between the cities of Trieste and Rijeka. There are also substantial differences between the two subgroups, with Croatians who are certainly more inclined to use the service in question (27% in fact declare that they are certain they will use the connection in the future).

Table 4.7: How likely do you think you will use the Trieste – Rijeka train?

	Italians	**Croatians**	**Italians and Croatians**
Not likely at all	13%	12%	13%
Not likely	28%	12%	24%
Likely	37%	30%	35%
Very likely	17%	19%	18%
Certain	5%	27%	10%

Table 4.8: How often do you think he could use it?

	Italians	**Croatians**	**Italians and Croatians**
Never	14%	12%	14%
Less than once a year	24%	13%	21%
Once or twice a year	36%	7%	29%
Several times a year	20%	37%	24%
Every month or so	4%	22%	8%
Every week or so	3%	6%	4%
Several times a week	0%	3%	1%

However, a couple of clarifications are necessary in order to correctly interpret the results emerging from the empirical investigation.

First, such investigations are typically characterized by the so-called *selection bias* , i.e. the psychological mechanism that leads the subjects most interested in the topic of the questionnaire to participate in it. It is probable that the people most interested in the railway connections between the areas covered by the study participated in higher percentages than those who see the theme of the connection between Trieste and Rijeka as something distant and which does not concern their current and prospective habits. The consequence of this is a potential over-representation of favorable responses to the use of the rail service. Furthermore, as a second point, it should be underlined how often people who do not have a well-defined opinion on the topic being investigated position their answer at the center of the scale. In the case of the study in question, part of those who answer "probable" to the question about a hypothetical future use of the train does not yet have a definite opinion on the matter, even if they certainly do not consider themselves a priori contrary to this possible alternative. It is probable that those who fall into this category (35% of the overall sample) are the individuals who will be most interested in the form that the railway service will actually take and what specific characteristics it will have.

Table 4.9: How important are the following conditions for you to consider using the train for your travels in those locations?

Italians and Croatians	**“decisive” + “very important”**	**"important"**	**Priority indicator (1.2/0.9/0.3)[34]**
Duration of the journey	49%	36%	60.0

[34]The synthetic indicator is obtained as the weighted sum of the percentages of the categories "decisive", "very important" and "important" for the weights that express the importance of the answer for the purposes of evaluations of possible use. In this case the "decisive" answer weighs 1.2, the "very important" answer 0.9 and "important" 0.3. The synthetic indicator, therefore, expresses the priorities also according to the relative number of second and third level responses which could have a high overall weight even if overshadowed by a high frequency of the first category. The coefficients are chosen so to emphasize the first two categories to the detriment of the third and at the same time so as to compensate high percentages of the second compared to low percentages of the first.

Frequency	43%	42%	55.8
Price	38%	39%	51.1
Connection with places of interest	28%	40%	39.6
Comfort	20%	36%	30.0
Bike transport	9%	21%	14.7

The "decisive" or almost decisive characteristics are travel duration and frequency, with the latter also referring to the "matching" of schedules with individual needs. Both of these characteristics are even more important than price, and these three attributes collectively serve as the leverage point for modal choice and modal shift.

Specifically, travel duration emerges as the fundamental factor, especially considering that current solutions for the entire journey require transfers at intermediate stations with often long waiting times for connections. This is extremely disadvantageous, especially for those who intend to reach their destination for short periods and therefore need to minimize travel time as much as possible. Frequency also appears as a crucial factor due to the need to ensure an adequate number of trains departing at different times throughout the day. The economic aspect is certainly relevant, but based on the sample responses, it seems to play a slightly more marginal role.

The other characteristics are not equally decisive but should still be taken into account as they express the preferences of specific niches. For example, the comfort level of the trains or connections from stations to potential points of interest (such as the Postojna Cave near Pivka) may rank lower, but they are considered relevant by a significant portion of the analyzed sample, indicating that they are noteworthy segments. The ability to transport bicycles is also important, even though only 10% of respondents consider it a decisive or very important factor on its own. However, this information informs us about the size of this potential demand segment.

Finally, for completeness, some relevant free comments provided by certain respondents are reported. In this case as well, the selection bias results in comments being given only by those who feel particularly involved in the topic. For this reason, inappropriate or misleading comments unrelated to the investigated theme have been omitted.

Box 4.1.: Selection of comments made by interviewees.

I answered because in the past I considered taking the train to go to Croatia, but it was never possible due to the service provided.

I'm interested in a revival of the railway connection from Trieste.

It would be desirable, especially now that Croatia is effectively part of Europe.

Sustainable tourism requires a connection to the western coast of Istria, not the east.

During winter, we fly to Trieste to go to Pula or the western coast, and we have to rent a car because the buses don't have suitable schedules.

Having a train (and there is a station in Pula...) would be a blessing, especially since it arrives under the Arena.

Enhancing railway lines with Slovenia, from Trieste to Ljubljana, is also important.

Providing schedules that allow taking the train in the morning and returning home in the evening (like Trieste-Venice, for example).

We hope for a connection with Croatia.

I hope that the railway connection is implemented as soon as possible to address the substantial isolation between Italy and the Balkan countries.

I consider a railway connection from Trieste to the east important.

Please provide a service regarding connections to the islands of Cres and Lošinj, as there are few connections, and they are beautiful.
For my needs, especially in terms of time, I would "cut" 1/2 intermediate stations.
It would be fantastic if we could load motorcycles to take them to the Rijeka track.
Thank you, the railway connection between Trieste and Rijeka is a necessity both to facilitate travel and for social reasons.
I hope the project can start! A railway connection ITA-SLO-HR would be really nice and useful, providing a valid alternative to the car.
Despite the research purposes of your paper, which clearly focus on the mentioned area and where, based on anecdotal evidence, I believe that most user motivations are related to sustainable tourism choices, the problem unfortunately extends to professional travel to Ljubljana and Zagreb, for which the railway service from Italy is currently non-existent for professionals.
Bombard them with data and, please, give a boost to this matter, as it is a shame that there is no serious railway connection between culturally and socially interconnected realities.
With Croatia joining the European Union and the opening of borders, increasing mobility in both directions is very important.
As a resident of Trieste, I see it as a real added value.
It may be less environmentally friendly, but a bus service equipped for transporting bicycles could also be appreciated.
Maybe trains to other cities in Croatia.
The road is a nightmare in the summer!

4.2.2 Use of results for forecasting purposes .

Using questionnaire results for forecasting purposes is always problematic because the conditions under which the responses are given are only partially controllable. Furthermore, in this specific case, we don't have the possibility to consider the statistical representativeness of the sample based on demographic variables because there are not sufficiently disaggregated statistics at the considered territorial level.
However, the obtained data present important aspects that are worth highlighting:

a) Only 37% of the sample considers it unlikely or very unlikely to use the new service (Table 4.7). Essentially, according to the questionnaires, the potential demand for the service represents 63% of the population represented by the sample. This data is probably overestimated due to the previously mentioned selection bias, but even if the actual potential demand were only one-fifth of that value, it would mean that the potential demand between Trieste and Rijeka is over 40,000 people.

b) 31% of the Croatian sample states that they would use the train with a frequency of almost monthly or higher (Table 3.8). This data, excluding the issue of selection bias, is indicative of a possible use of the route for commuting or quasi-commuting, at least on the Croatian side. This is important because it indicates that beyond the current demand, the new service could trigger a new travel demand that currently doesn't exist or doesn't use the railway.

c) Travel duration is the most important factor (Table 4.9). This also emerges in the elasticity and sensitivity analysis (Chapter 5) and essentially raises the issue of a trade-off between the number of stations served and travel times.

d) Moreover, the connection with places of interest doesn't seem to have a significant role in the sample, but it should be considered that the interviewed sample is focused on residents of the two destination cities and, therefore, doesn't represent the potential tourism demand of the entire catchment area of the line. As we have seen in Chapter 3, the stations of the line allow reaching locations that attract a large number of annual visitors. The potential catchment area of places like Postojna, Miramare, Grotta Gigante, etc., extends far beyond the area affected by the examined line. In conclusion, if we could assert with certainty that the sample is representative of the adult populations of Trieste, Rijeka, and their surroundings (which we cannot say), that 1% of overall respondents who declare that they would use the train multiple times a week would be sufficient to indicate that over 200 travelers would use the train multiple times a week (and each traveler counts for two trips), effectively giving a mathematical value of weekly trips ranging between 800 and 2000. We don't have the possibility to know if this data is realistic, but it signals that the new demand that the service could trigger is almost more important than the existing demand. The increased accessibility of the two cities and intermediate stations constitutes a development factor, difficult to quantify but certainly capable of fueling a travel demand far exceeding the current one.

5. Modal choice and trip assignment

5.1 Evaluation of the elasticity of travel choice with respect to cost, time and characteristics of travel arrangements and potential users

5.1.1 Basic definitions

For the convenience of the reader, some definitions are introduced below which are used in the analysis of the possible variations in the modal choice between alternative transport services for the same origins and destinations.
Modal choice: The decision-making process in which individuals select between different transportation options, influenced by a combination of socio-demographic factors, spatial characteristics, and socio-psychological factors.
Modal split (modal share): The percentage distribution of journeys based on the type of transportation mode used.
Modal shift (modal switching): The decision-making process that leads to a shift or change in transportation modes, particularly towards an increase in the usage of "sustainable" modes.

5.1.3 Modal choice

There are numerous factors that the literature has studied as possible determinants in the modal choice. An annotated list summarizing various contributions is presented below [35]:

1. *Sociodemographic determinants*
   - 1.1. Age: Older people tend to use public transport more often.
   - 1.2. Gender: There is no consensus in the literature on the role of gender in modal choice.
   - 1.3. Education: There is no consensus in the literature on the role of education in modal choice.
   - 1.4. Employment: Employment is related to income and car ownership and therefore to modal choice. In addition to the type of occupation and the professional characteristics of the workers, the mobility policy of a company also has an influence on the modal choice of the employees.
   - 1.5. Income: ranked among the most important determinants of modal choice. It is generally associated with the use of a private car for short daily journeys
   - 1.6. Composition of the family nucleus: as the size of the family nucleus increases, the tendency to travel by car increases, especially in the presence of children.
2. *Spatial determinants*
   - 2.1. Density: Public transport is used more in high-density areas, which are usually better served than rural ones.
   - 2.2. Diversity (mixed land use): Mixed land use at both the origin and destination of trips reduces the likelihood of self-driving or ride-sharing compared to public transport.
   - 2.3. Proximity to infrastructure and services: proximity to public transport nodal points and the last mile connections are a fundamental determinant that discriminates between car and public transport in modal choice.
   - 2.4. Frequency of public transport: frequency plays a crucial role in the availability and use of public transport and consequently influences modal choice.
   - 2.5. Parking: the guarantee or the high probability of finding a (free) parking space at the final destination of the trip encourages the use of the car. On the contrary, uncertainty in this sense

[35] L. Redman, M. Friman, T. Garling, T. Hartig, "Quality attributes of public transport that attract car users: A research review", Transport Policy 25, 119 – 127, 2013.
A. De Witte, J. Hollevoet, F. Dobruszkes, M. Hubert, C. Macharis, "Linking modal choice to motility: A comprehensive review", Transportation Research Part A, 49, 329–341, 2013.
Tyrinopoulos, Y., & Antoniou, C. (2013). Factors affecting modal choice in urban mobility. *European Transport Research Review* , *5* (1), 27-39.

favors the use of public transport. Furthermore, the presence of car parks near the stations can favor the use of the railway.

3. *Determinants of travel characteristics*
    3.1. Reason for travel: Commuters tend to use public transport more than other types of travelers. Conversely, chauffeuring and shopping are strongly correlated with car use.
    3.2. Distance: car is often the dominant mode of transportation for short commuting distances. For greater distances, the use of the train becomes more attractive.
    3.3. Travel time: travel time is an important factor in modal choice and is often perceived differently by the traveler depending on the reason for the trip and the means used. Transit options involving longer walking distances and longer public transport journey times decrease the attractiveness of public transport. Travelers are also more sensitive to out-of-vehicle travel times than in-vehicle travel times.
    3.4. Cost of travel: public transport passengers are sensitive to price changes, but the amount depends on several factors, such as the purpose of the trip. The availability of passes makes public transport more attractive. However, motorists have little cross-elasticity with respect to public service tariffs.
    3.5. Departure Time: public transport is less attractive during off-peak hours.
    3.6. Trip chaining: the car is usually favored when multiple trips need to be chained together.
    3.7. Weather conditions: adverse weather conditions favor the use of the car because it guarantees a door-to-door journey.
    3.8. Info: the traveler does not want to spend time and effort on the modal choice decision. Where he perceives complexity and uncertainty in timetables and interchanges he is inclined towards the car. This determinant, despite its importance, is however little studied.
    3.9. Interchange: there is a general resistance among people to interchange. This determinant is little studied.
    3.10. Physical condition of vehicles (including frequency of breakdown or malfunction).
    3.11. Aesthetics: the appearance of vehicles, stations and waiting areas influence the perception of effectiveness, efficiency and safety and therefore the modal choice.
    3.12. Travel comfort: travelers rate seat access, noise levels, availability of air conditioning, electrical outlets, tables, and wi-fi.
    3.13. Safety: the perceived safety with respect to possible road accidents (especially commuters) increases the attractiveness of public transport (especially rail). Conversely, the lack of perception of personal safety (e.g., evening or night trains) significantly decreases the attractiveness of public transport.
4. *Sociopsychological indicators*
    4.1. Experience: a positive or negative experience in the past determines the modal choice process in the present.
    4.2. Familiarity: increased familiarity with the entire transportation system reduces barriers to using alternate modes
    4.3. Lifestyle of travelers: this determinant is not frequently studied and was often not found to be significant.
    4.4. Habits: switching to other modes of travel requires learning new routines and this is a factor of inertia which pushes one to confirm the modal choice even in the face of new modal alternatives.
    4.5. Perceptions: people's perceptions of different means of transport are important in the modal choice decision, for example:
        4.5.1. Travel time and cost may be perceived differently for alternative modes of transport.
        4.5.2. Time spent on public transport is perceived more negatively than time spent in a car.
        4.5.3. Waiting times for means of transport are perceived as more expensive than travel time.
        4.5.4. Car costs are often underestimated (only the immediate marginal costs are considered) compared to the price of public transport for the same journey.

From the list of the main determinants that the scientific literature recognizes as the basis of the travel choice, two main aspects stand out. Firstly, socio-demographic determinants are subjective factors that are minimally affected by policies, unless those policies involve restrictions or penalties on car usage. Secondly, other determinants, including perceptual factors, are largely controllable through transport planning. It is crucial that these factors become the focus of policy, to the extent that it can be confidently stated that, in the case of passenger transport, it is the supply that can shape demand even before demand stimulates new supply. This is particularly true for public and collective transport. When properly planned and implemented, public transport becomes a positive determinant itself. However, if it fails to meet the requirements set by other determinants (such as the need for transfers, lack of comfort, difficulty in obtaining information, etc.), it becomes a negative factor. Therefore, if the new transportation offering aligns with the determinants of modal choice, it generates a portion of its own demand. At this point, demand becomes a dependent variable of the offering, rather than vice versa, as some traditional models implicitly assume.

Traditional models, among other things, tell us that: a) transport demand is strongly correlated with the availability of income, of which GDP is a representative proxy; b) the modal split depends on the cross-elasticity measured with respect to the available alternatives (in this case, the car versus the train).

In reality: the modal-split where there are modal alternatives is actually a dependent function of the modal choice but the effects of “income” and “elasticity” are not consistently continuous as commonly assumed. Instead, they can exhibit discontinuous and irregular trends at certain thresholds or intervals. This means that targeted measures such as new services, infrastructures, and incentive policies can induce changes in these trends. Variables perceived as significant, such as travel comfort, journey times, and subscription costs, can substantially influence behavior and, consequently, the modal split. For example, think of two locations served both by train, in 4 hours and 10 minutes, and by plane, in 60 minutes. It could be the case that a reduction of the train journey of 10 minutes (therefore to 4 hours) has a very small effect on the modal choice, while a reduction such as to bring the journey time below 4 hours could trigger a psychological mechanism such as to create a massive migration of travelers from the plane to the train [36].

All of the aforementioned information serves as a preface to highlight the importance of interpreting the numbers presented in this study, which is obviously our primary objective in this study.

It is crucial to emphasize that the effects of "income" and "elasticity" are not automatic. The increase in railway demand in Italy has been observed in regions and sections where significant improvements have been made to railway services in terms of various factors, including travel times, quality of trains, punctuality, and accessibility. In these cases, trains have consistently attracted passengers away from planes and cars, leading to a positive cycle of economic and environmental sustainability. These aspects will be further discussed in the following paragraph, where we address the modal split.

5.1.2 Modal split

The modal split represents the percentage of passenger journeys attributed to different modes of transportation. In our analysis, it is crucial to not only consider the modal split but also examine how the number of passengers utilizing specific modes of travel changes over time. In this context, Table 5.1 presents the modal split for land transport in Italy, Slovenia, and Croatia, comparing it with the average for the European Union. Please note that the 2020 figure is highlighted in red as it is not representative due to the impact of the Covid-19 pandemic.

Table 5.1: Modal split in EU, Italy, Slovenia and Croatia

	EU			Italy			Slovenia			Croatia		
Year	Train	Bus	Car	Train	Bus	Car	Train	Bus	Car	Train	Bus	Car
2011	7.3%	10.2%	82.5%	5.7%	13.2%	81.1%	2.3%	11.0%	86.6%	4.9%	10.5%	84.6%
2012	7.6%	10.3%	82.1%	6.4%	14.7%	78.9%	2.3%	11.1%	86.7%	3.5%	10.7%	85.8%
2013	7.6%	10.4%	82.0%	6.3%	14.1%	79.7%	2.3%	11.4%	86.3%	3.1%	11.5%	85.5%
2014	7.6%	10.0%	82.4%	6.3%	12.9%	80.8%	2.1%	11.6%	86.3%	3.0%	11.9%	85.1%
2015	7.6%	10.0%	82.4%	6.3%	12.3%	81.4%	2.1%	11.8%	86.1%	3.1%	11.0%	85.9%
2016	7.6%	10.0%	82.5%	6.1%	11.9%	82.0%	2.0%	11.8%	86.3%	2.7%	12.3%	85.0%

[36] We talked about these effects in chapter 1 and chapter 3.

2017	7.7%	9.6%	82.7%	5.9%	11.4%	82.7%	1.8%	11.7%	86.5%	2.4%	13.4%	84.3%
2018	7.8%	9.5%	82.7%	6.3%	11.7%	82.0%	1.8%	11.8%	86.4%	2.5%	12.7%	84.8%
2019	8.0%	9.5%	82.5%	6.3%	11.7%	82.0%	1.8%	11.7%	86.6%	2.4%	13.4%	84.2%
2020	5.4%	7.4%	87.2%	3.9%	10.2%	85.9%	1.3%	7.4%	91.3%	2.0%	9.1%	88.9%

Source: Eurostat

In the countries under study, the railway has a lower modal share compared to the European average. However, the trend differs among these countries. In Italy, there has been an increase in train usage from 2011 to 2019, effectively countering the growth of private transportation while impacting the bus service. On the other hand, Slovenia and Croatia have experienced a decline in train demand, with the bus service gaining passengers instead. This indicates that the preference for private transportation is not the driving factor in these countries, but rather the bus service is offering a more favorable alternative to the train. This situation reflects positively on the inclination towards public transportation in Slovenia and Croatia, where the train already possesses subjective advantages for competing. Table 5.2 presents Eurostat data showing the change in passenger numbers between 2010 and 2021 (latest available year) for Italy, Slovenia, and Croatia. The variation is expressed as an index number (2010 = 100) and illustrates that until 2019 (the last pre-Covid year), train usage significantly declined in Slovenia and Croatia, while it increased in Italy both in absolute terms and in relation to the number of kilometers traveled.

Table 5.2: Change in the number of passengers and in the number of passengers / Km served by the railways between 2010 and 2021 (Index 2010 = 100)

	Italy	Slovenia	Croatia	Italy	Slovenia	Croatia
Year	Passengers			Passenger Km		
2010	*100*	*100*	*100*	*100*	*100*	*100*
2011	NA	97	72	NA	95	85
2012	102	96	40	99	90	63
2013	102	101	35	103	93	55
2014	103	91	32	106	85	54
2015	104	90	31	111	86	55
2016	104	86	30	111	84	48
2017	103	82	29	113	78	43
2018	105	83	29	118	78	44
2019	107	84	29	120	78	42
2020	46	50	19	47	46	26
2021	59	74	19	59	69	31

Source: Eurostat

The disparities between Italy, Slovenia, and Croatia can be understood in the context of their distinct trends in land transport demand. Table 5.3 illustrates the evolution of the relationship between land passenger transport demand and real GDP from 2010 to 2021. As passenger transport demand is closely linked to GDP growth, this data provides insights into the overall inclination towards travel.

Table 5.3: change in the ratio between land passenger transport demand (car + train, expressed in passengers/km) and GDP, between 2010 and 2021 (2010 = 100)

	Italy	Slovenia	Croatia
2010	100.0	100.0	100.0
2011	95.3	98.7	97.3
2012	87.8	100.6	101.7
2013	95.0	101.6	102.4
2014	97.1	100.7	102.9
2015	100.6	100.1	100.7

2016	102.6	98.6	97.5
2017	105.9	96.2	95.1
2018	102.6	93.4	89.8
2019	103.5	91.7	86.6
2020	72.4	79.3	71.1

Source: Eurostat

When considering the data from tables 5.2 and 5.3 collectively, we can observe that Italy experiences an overall growth in land transport demand (both road and rail) that surpasses the rate of GDP growth. Moreover, within this trend, the train plays an increasingly significant role. In contrast, Slovenia and Croatia exhibit a slower growth in land transport demand relative to GDP, and the railway's share of this demand is diminishing.

These findings suggest that supply exerts a greater influence on demand than socio-economic factors. Table 5.4 reveals that between 2010 and 2020, the supply of trains on the Slovenian route decreased, while it increased on the Šapjane-Rijeka route in Croatia. It is worth noting that both Slovenia and Croatia have ambitious infrastructure development plans and ongoing efforts to enhance their railway services[37]. As these plans come to fruition, it is reasonable to expect that the modal split will once again favor the train. The Trieste-Rijeka section, as previously discussed, is included in these infrastructure improvement plans and is set to become even more competitive once integrated with the Istrian line.

Table 5.4: Number of passenger trains transited on Sežana – Pivka and Šapjane - Rijeka sections

Drawn	2010	2015	2020
Sežana - Divača	4,465	4,245	3,751
Divača - Pivka	3,884	4.048	3,685
Pivka - Ilirska Bistrica	2,280	2.065	1,610
Sapjane - Rijeka	NA	778	1,600
Rijeka - Sapjane	NA	777	1,600
Ilirska Bistrica – Pivka	2,286	2.053	1,609
Pivka - Divaca	5.058	4,939	3,946
Divacha - Sežana	5,226	4,639	3,776

Source: Eurostat

5.1.3 Modal shift

In this section, we present some elasticity values of transport demand with respect to its determinants, as studied in the scientific literature.

It is important to note that there is a substantial body of literature examining the impact of passenger transport policies on modal switching and providing estimates of elasticity values, which we will outline below. Generally, the findings reported in the literature are consistent with common sense expectations. However, it is crucial to consider these numerical values as estimates of the magnitude rather than precise values, for two main reasons:

a) The distances covered by the Trieste Centrale - Rijeka railway fall between the typical distances studied in the literature, which are either short or long distances.
b) Each case study examined in the literature possesses its own unique characteristics in terms of geography, population, and culture, which can lead to significant variations in modal choices despite similar services and costs.

[37]See chapter 1 on this

For instance, de Jong & Gunn (2001) [38] indicate that the elasticity of the number of car trips in response to fuel price changes is -0.11 for commuters in the Netherlands and -0.55 for Italy. It is evident that survey results vary greatly depending on the country where they are conducted.

Transport policies play a crucial role in influencing modal splits, and different policy levers have varying degrees of effectiveness. Table 5.8 provides an overall assessment of the effectiveness of various passenger transport policies proposed in de Jong et al (2004) in terms of inducing modal switching[39].

Table 5.5: Effectiveness in terms of modal switching of passenger transport policies

Politics	**Effectiveness**
Congestion and road pricing	high
Parking policies	high
Railway and river interoperability	low
Market liberalization (railway)	low
Internalisation of costs	high
Maximum speed limits	high
Harmonization of the rules on speeding	high
Public transport pricing	low
New urban public transport	low
Increase in the price of fuel	high
Population and occupational density variation	low

The indications reported in Table 5.5 have been confirmed in recent years, for example in Urbanek (2021)[40]. The conclusions of this recent study emphasize the significant influence of psychological factors in determining the reluctance to transition to public transport. Achieving an increase in the modal share of public transport in daily commuting necessitates the implementation of coordinated and multifaceted measures. These measures involve not only improving the quality of public transport but also discouraging private car usage. The study highlights the importance of integrated actions in this regard.
Furthermore, the study underscores that solely increasing petrol prices is insufficient to overcome resistance to modal switching, thereby reducing the significance of cost elasticity as a determining factor. It emphasizes the need for comprehensive approaches that go beyond pricing strategies in order to effectively promote a shift towards public transport.
Mode switching resistance also arises because it may require a learning and adaptation period during which the user, especially if commuting, has to build a new mobility routine[41]. the use of private cars offers commuters the flexibility to make intermediate stops for various activities beyond their home-to-work commute. Conversely, trains can provide opportunities for work, reading, and relaxation, particularly during longer journeys and under favorable transport conditions.

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[38] G. de Jong, HF Gunn, “Recent evidence on car cost and time elasticities of travel demand in Europe”, Journal of Transport Economics and Policy, 35 (2), 137-160, 2001

[39] G. de Jong, HF Gunn, and M. Ben-Akiva, M. “A meta-model for passenger and freight transport in Europe”, Transport Policy, 11 (4), 329-344, 2004

[40] A. Urbanek, “Potential of modal shift from private cars to public transport: A survey on the commuters' attitudes and willingness to switch – A case study of Silesia Province, Poland”, Research in Transportation Economics, 85, 101008, 2021

[41] Meinherz F. and Binder CR, “The dynamics of modal shifts in (sub)urban commuting: An empirical analysis based on practice theories”, Journal of Transport Geography 86, 102763, 2020

Based on this premise, the following terminology will be employed throughout the discussion:

- Direct elasticity: the percentage change in transportation demand for a specific mode (e.g., car) in response to a percentage change in a determinant (e.g., cost) affecting that mode.
- Cross-elasticity: the percentage change in transportation demand for a specific mode (e.g., train) in response to a percentage change in a determinant affecting another mode (e.g., car cost).
- Substitution effect (compensation): the phenomenon in which a variation in a determinant (e.g., cost) of one mode influences the modal choice of transportation demand while maintaining overall intensity constant.
- Income effect (non-compensation): the phenomenon in which a variation in a determinant (typically the income of potential service users) of a mode influences the intensity of demand.

Short-term elasticity is primarily influenced by the substitution effect, while long-term elasticity may exhibit an income effect due to the adjustment of demand to new conditions resulting from changes in determinants. For example, inadequate connectivity may lead students to choose alternative educational institutions or commuters to relocate their residences.

The relative significance of the substitution and income effects varies depending on the type of user. For instance, the demand for recreational transportation is strongly influenced in the short term by the presence and frequency of services. Conversely, the demand for commuter and student transportation is more susceptible to the substitution effect, particularly in the short term.

For the purposes of our analysis, we have chosen a study[42] that calculated the values of the elasticity of demand for long-haul travel for passenger transport obtained by applying the Italian National Model System. Tables 5.6-5.8 show some of the most significant values, in particular the average of the elasticities calculated for different values of the percentage variations of the determinants.

Table 5.6: Short-term cost and time elasticities of automobile mode

	Commuter trips	Travel for work	All movements
Direct elasticity of automobile mode			
Cost elasticity	-0.21	-0.15	-0.17
Time elasticity	-0.16	-0.45	-0.25
Cross-elasticity of train mode			
Cost elasticity	0.72	0.99	0.77
Time elasticity	0.58	2.56	1.12

Table 5.7: Short-term elasticity with respect to the cost and times of the train mode

	Commuter trips	Travel for work	All movements
Automobile mode cross-elasticity			
Cost elasticity	0.03	0.08	0.10
Time elasticity on board	0.10	0.27	0.15
Waiting time and connection elasticity	0.06	0.03	0.04
Elasticity of access time and arrival at destination	0.04	0.04	0.03
Direct elasticity of train mode			
Cost elasticity	-0.16	-0.76	-0.66

42 P. Coppola, A. Cartenì, "A study on the elasticity of long-range travel demand for passenger transport", in: European Transport / European Transport, VII, 19, 32-42, 2001.

Time elasticity on board	-0.54	-2.55	-0.99
Waiting time and connection elasticity	-0.30	-0.26	-0.28
Elasticity of access time and arrival at destination	-0.21	-0.37	-0.20

Table 5.8: Short-term elasticity with respect to socio-economic determinants

	Commuter trips	Travel for work	All movements
Direct elasticity of automobile mode			
GDP/person elasticity	-0.70	1.00	0.43
Elasticity number of cars per person	0.09	0.14	0.11
Direct elasticity of train mode			
GDP/person elasticity	-0.73	1.00	0.33
Elasticity number of cars per person	-0.33	-0.92	-0.32

The values presented in the tables 5.6-5.8 confirm the qualitative findings outlined in table 5.5. Notably, it is evident that the car mode exhibits almost complete inelasticity concerning the cost and quality of railway services. On the other hand, the train mode demonstrates greater elasticity (often below unit elasticity) regarding the cost and quality of railway services, as well as the costs and travel times associated with car usage. Subsequent studies further support the notion that train passengers are more responsive to changes in transportation offerings (such as reduced travel times and increased frequency) and service quality, rather than fare adjustments. The elasticity values reported in Coppola et al. (2001) align with those in Holmgren (2007)[43] for both short and long distances. Similarly, Arbués (2016)[44] also exhibits comparable magnitude of elasticity values and ratios between the automobile and railway modes. Holmgren (2007) additionally notes that the direct elasticity of public transport modes with respect to the number of vehicle-kilometers provided by the service is slightly higher than unity.

Similar considerations are reflected in the study by Ahanchian et al. (2019)[45], which emphasizes the effectiveness of policies aimed at discouraging car usage in promoting modal shifts towards sustainable transportation options, surpassing the impact of public transport encouragement initiatives and new infrastructure construction. This study also reveals that the efficacy of such measures is significantly higher in densely populated areas compared to rural regions.

Lastly, we acknowledge the research conducted by Wardman et al. (2016)[46], which examines the perceived costs associated with travel times. According to their findings, Italian, Slovenian, and Croatian citizens assign costs ranging from approximately 6 to 20 euros per hour (in 2010 euros) depending on the mode of transport used.

[43] Holmgren j., "Meta-analysis of public transport demand", Transportation research Part A, 41, 1021–1035, 2007

[44] Arbués P., Baños J.F., Mayor M., Suárez P., "Determinants of ground transport modal choice in long-distance trips in Spain", Transportation Research Part A 84, 131–143, 2016

[45] M. Ahanchian, JS Gregg, J. Tattini, KB Karlsson, "Analyzing effects of transport policies on travelers' rational behavior for modal shift in Denmark", Case Studies on Transport Policy 7, 849–861, 2019

[46] M. Wardman, VPK Chintakayala, Gerard de Jong, "Values of travel time in Europe: Review and meta-analysis", Transportation Research Part A 94, 93–111, 2016

5.2 Estimate of potential demand for the Trieste - Rijeka railway section

5.2.1 The forecast model adopted

As briefly mentioned in the introduction of this report, forecasting the demand for a Trieste-Rijeka railway service is complex due to several factors:

a) There is no historical record of direct rail links between these two cities, making specific historical data for the desired traffic unavailable.
b) Despite the evident similarities between the two cities and their respective surrounding areas in terms of their economic and tertiary activities (both being port cities with a strong tertiary sector and hosting prestigious universities), differences in population size, average income, and tourist appeal are expected to result in asymmetries in travel patterns.
c) Croatia recently joined the Schengen area and the Eurozone. While this development offers new opportunities for work and commercial commuting, it renders surveys conducted before 2023 less relevant for analysis and forecasting.

Although this report follows the traditional four-stage forecasting framework (journey generation, distribution, modal choice, and assignment)[47], this framework is only partially applicable to this study. It typically relies on the availability of historical data and econometric estimation of travel demand trends, which is usually conducted for highly integrated regions economically and socially (such as two major cities within the same country or neighboring countries). Due to the unique conditions described above, it was necessary to adopt a specific estimation model tailored for this route, addressing two significant challenges. Firstly, the territorial fragmentation of travel is matched by a scarcity of information on existing travelers. Secondly, as it would be the first direct train connection between the two cities, it is likely that additional travel demand will arise, beyond the simple migration of travelers from other modes of transportation (such as cars or buses).
Therefore, the chosen conceptual model for estimating potential travel demand is a linear additive model with the following characteristics.

Defined:
DP = total potential travel demand between Trieste and Rijeka, equal to the sum of the estimated demand for the entire journey and for the intermediate sections (*i*) , for the various modes of transport available (*m*) , i.e. car, bus and train[48] (the latter indicated with index *t*) .
ΔD = change in total demand, estimated on the basis of tourism demand growth scenarios and the potential new demand generated by the direct rail service,

$$DP = \sum_i \sum_m DT_m^i + \Delta D$$

The potential demand for rail transport DP^t is therefore estimated as follows :

$$DP^t = \sum_i DT_t^i + \Delta D_t + \beta DT_{\neg t}$$

Where:

[47]Directorate-General for Regional and Urban Policy , Ludger Sippel, Julian Nolte, Simon Maarfield, Dan Wolff, Laure Roux, “Comprehensive analysis of the existing cross-border rail transport connections and missing links on the internal EU borders - Final report”, Publications Office of the European Union, 2018. This study highlights, among other things, the only partial applicability of the four-stage forecasting model due to the unavailability of the statistics necessary to calibrate the generation of trips (page 15).
[48]There is also a cycling itinerary between the two cities, indicated by many specialized sites, and practicable in one day (about 5-6 hours). However, it is not possible to estimate the number of travelers currently using this route. For the purpose of calculating the potential railway demand, an estimate can be made based on the availability of the bicycle transport service.

ΔDt represents the change in demand for travel by train resulting from the introduction of the new service.
$\beta\ DT_{\neg t}$ represents the estimated proportion of total travel demand that is currently fulfilled using alternative modes of transportation (such as cars and buses) and has the potential to switch to train travel.
DP^{t} is expressed as an interval between a minimum and maximum value, reflecting the potential range of variation in the forecasts.
The summations must be understood as purged, as far as possible, of the effects of "double counting" ensuring that each traveler is counted only once, even if they use multiple route sections.

During the analysis, extensive data were collected from various sources, including previous studies and surveys conducted by railway service managers. The model presented in the study aimed to integrate data and estimates from diverse origins, obtained through different estimation and survey methods. The following data sources were collected for this analysis:

a) Data on passenger transport demand for both scheduled bus services (Flixbus) and on-demand services (Go-Opti) between Trieste and Rijeka.
b) Data on passenger transport demand recorded in the intermediate railway sections of existing Italian, Slovenian, and Croatian railway services.
c) Data on the presence of Croats in the municipality of Trieste, determined through telephone traces.
d) Declarations obtained from a questionnaire survey conducted among a sample of potential travelers residing in the catchment areas of the destinations served by the new railway line.
e) Socio-demographic data of the municipalities of Trieste, Rijeka, and intermediate locations that are expected to be served by the new railway service.
f) Data and estimates from previous studies, including those specifically referring to the study area, econometric estimation methods of travel demand, and elasticity estimates of travel demand as a function of time and costs.

In some cases, a gravitational model was utilized, incorporating parameters such as estimates of the resident population within the attraction radius of the stations along the route, obtained from the dataset of the Global Human Settlement Layer (GHSL) project by the European Commission. Estimates of the share of Italian and Croatian residents were also considered. Eurostat's modal choice estimates were utilized in other instances.
From the theoretical point of view, the model would require including the estimate of the potential share of new travelers induced by the presence of the service as a function of tourist demand, also considering the potential effect deriving from points of interest (attractors) located near the route served, against suitable interconnection systems between the line in question and these points, as well as the share deriving from new commuting opportunities for work, play and study . The latter values can vary considerably depending on the local policies adopted. Since there was no way to quantify the effect of these policies, we limited ourselves to estimating the potential demand based on the conditions found at the time of the study (and described in chapter 4), leaving out the potential increases in demand linked to the increased tourist accessibility of the main attractors.

5.3 Scenario and sensitivity analysis

Section 4.1 presents the estimates of the demand for transport on the sections of the Trieste – Rijeka railway line for 2024 in the hypotheses that:

- demand grew linearly between 2009 and 2030
- the Divača – Pula line is not activated according to schedule (electrification and upgrading of infrastructure).

It should be noted that even if a constant percentage growth rate of demand were assumed instead of linear growth, the estimates for rail transport demand on the Trieste – Rijeka line would not vary significantly.

The figures in the following subsections illustrate the passenger estimates up to 2024 for each individual route, considering the available estimates and surveys presented in chapter 4.1. Since there was no previous direct service, these estimates and surveys are fragmented, posing a challenge in calculating the number of passengers making the entire journey. In the case of the Villa Opicina – Rijeka section, these estimates, indicated in orange, only represent passengers estimated to travel the entire distance between the two stations without any intermediate stops.

Apart from this data, it is not possible to determine how many passengers exclusively complete the specific route or continue their journey to/from other locations. Hence, the estimate of the number of individual passengers for the Trieste – Rijeka train has a range, with the minimum value being the highest number of passengers among those on the intermediate sections, assuming they all complete the entire journey, and the maximum value being the sum of the passenger counts for each segment, assuming that each passenger begins and ends their journey within that specific segment.

5.3.1 Scenario with change of modal split

Figure 5.1 displays the estimated number of passengers in 2024 for each section of the Trieste – Rijeka line, considering the assumption that the 2009-2030 forecasts of Slovenian railways only accounted for the change in modal split in Slovenia between 2010 and 2019. Consequently, there should be a 20% decrease in the demand estimate compared to the base case for the sections between Sežana and Ilirska Bistrica.

Figure 5.2 illustrates the estimated number of passengers who would utilize the new service based on the aforementioned assumptions and the elasticity assumptions discussed in paragraph 4.1. In this scenario, the potential number of passengers for the Trieste - Rijeka train ranges between 8,000 and 28,400 (equivalent to approximately 22 to 78 passengers per day), with the variation accounting for potential passengers boarding and alighting at intermediate stations.

Figure 5.1. Estimate of passenger rail traffic by 2024 for the main sections of the Trieste – Rijeka route taking into account the change in the modal split in Slovenia between 2010 and 2019

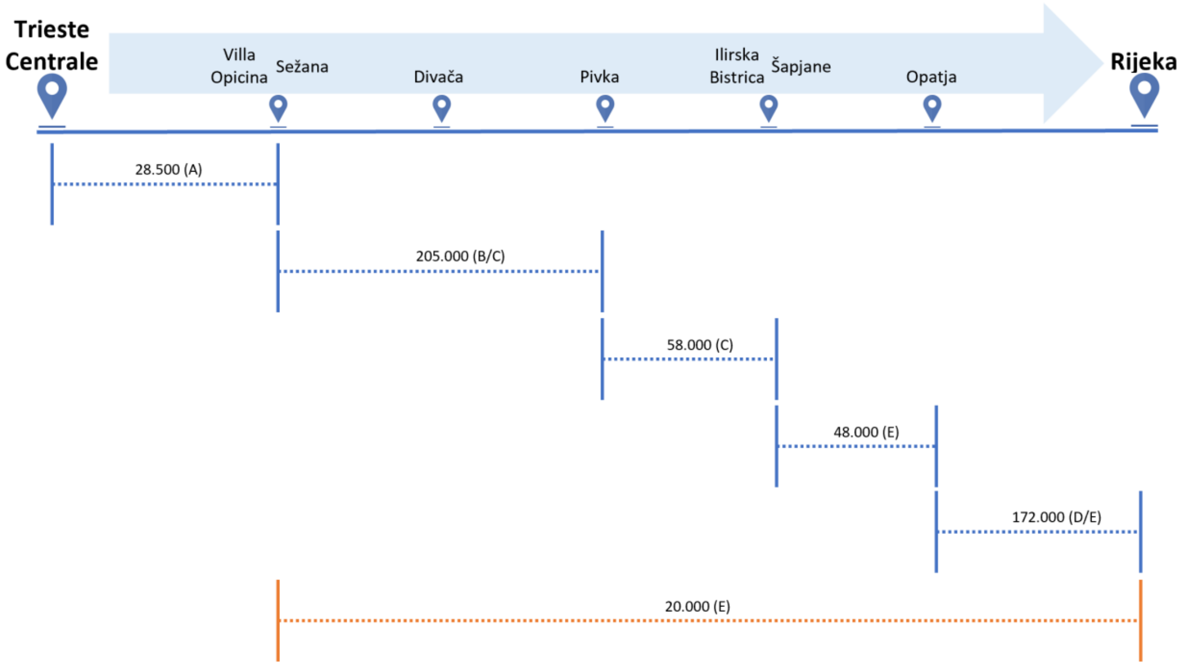
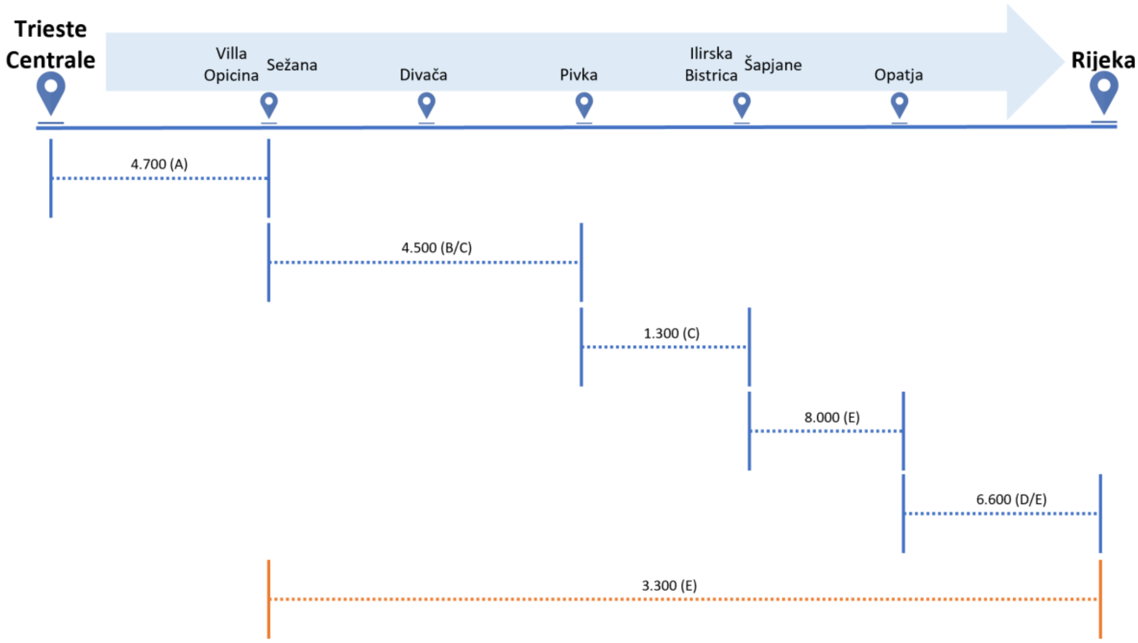


Figure 5.2. Estimate of passengers who would use the new service in the light of the assumptions in figure 5.1.



5.3.2 Worst case scenario

Figure 5.3 depicts the estimated number of passengers in 2024 for each section of the Trieste – Rijeka line, assuming the worst-case scenario. This assumption takes into account the absence of infrastructural interventions in the near future, as well as the unfavorable trend in the modal split observed in Slovenia and Croatia, which negatively impacts railway usage.

Figure 5.4 illustrates the estimated number of passengers who would utilize the new service based on the aforementioned assumptions and the elasticity assumptions discussed in paragraph 4.1. In this pessimistic scenario, the potential number of passengers for the Trieste – Rijeka train ranges between

7,300 and 22,700 (equivalent to approximately 20 to 62 passengers per day), considering the possible presence of passengers boarding and alighting at intermediate stations.

Figure 5.3: estimate of passenger rail traffic by 2024 for the main sections of the Trieste – Rijeka route in the worst case scenario

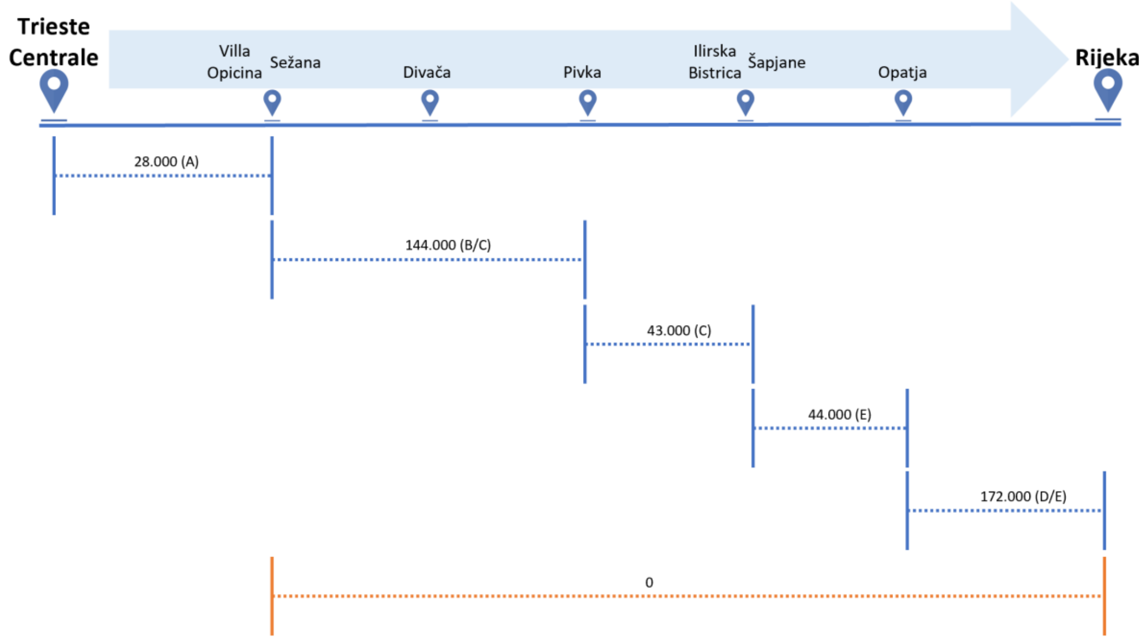
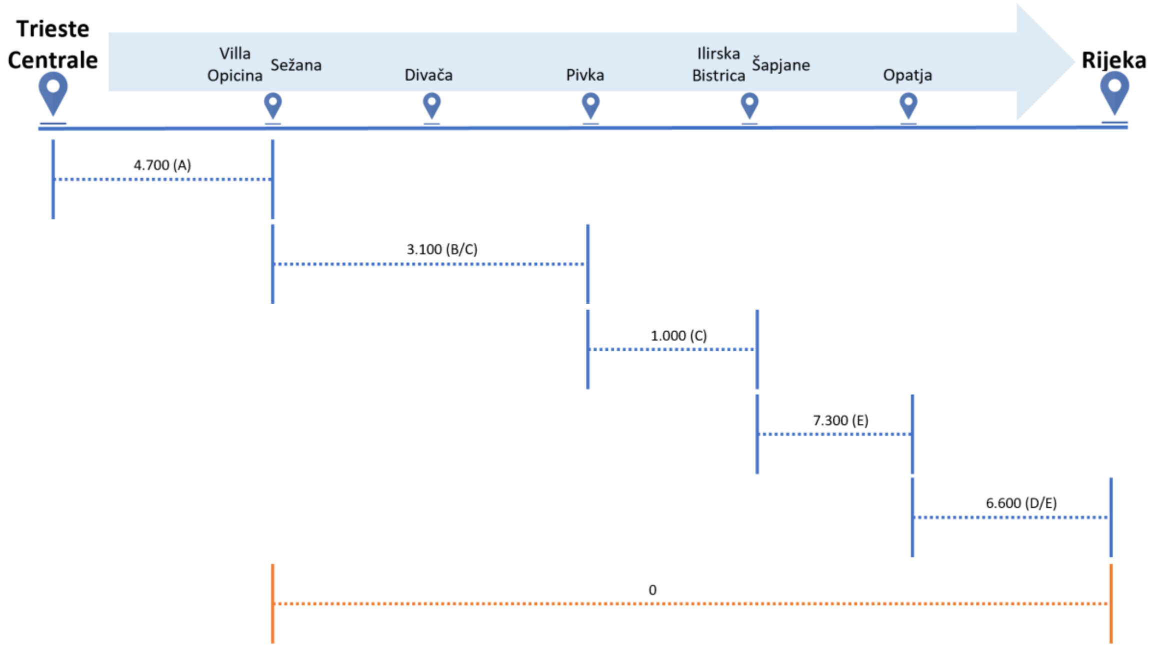


Figure 5.4: estimate of passengers who would use the new service in the light of the assumptions in figure 5.3.



5.3.3 Scenario with integration of lines from Divača to Koper and Pula

Figure 5.5 depicts the estimated number of passengers in 2024 for each section of the Trieste – Rijeka line under the optimistic assumption that the passenger lines from Divača to Koper and Pula have been integrated and upgraded to accommodate a significant volume of passengers traveling between the coastal regions of Istria and the interior of Slovenia (e.g., Ljubljana and Postojna), as well as vice versa.
Figure 5.6 presents the estimate of passengers who would utilize the new service based on the aforementioned assumptions and the elasticity assumptions discussed in paragraph 4.1. In this optimistic scenario, the potential number of passengers for the Trieste – Rijeka train ranges between 36,000 and 66,650 (approximately 98 to 183 passengers per day), considering the possible presence of passengers boarding and alighting at intermediate stations.

Figure 5.5. Estimate of passenger rail traffic by 2024 assuming the integrated and modernized passenger lines from Divača to Koper and Pula

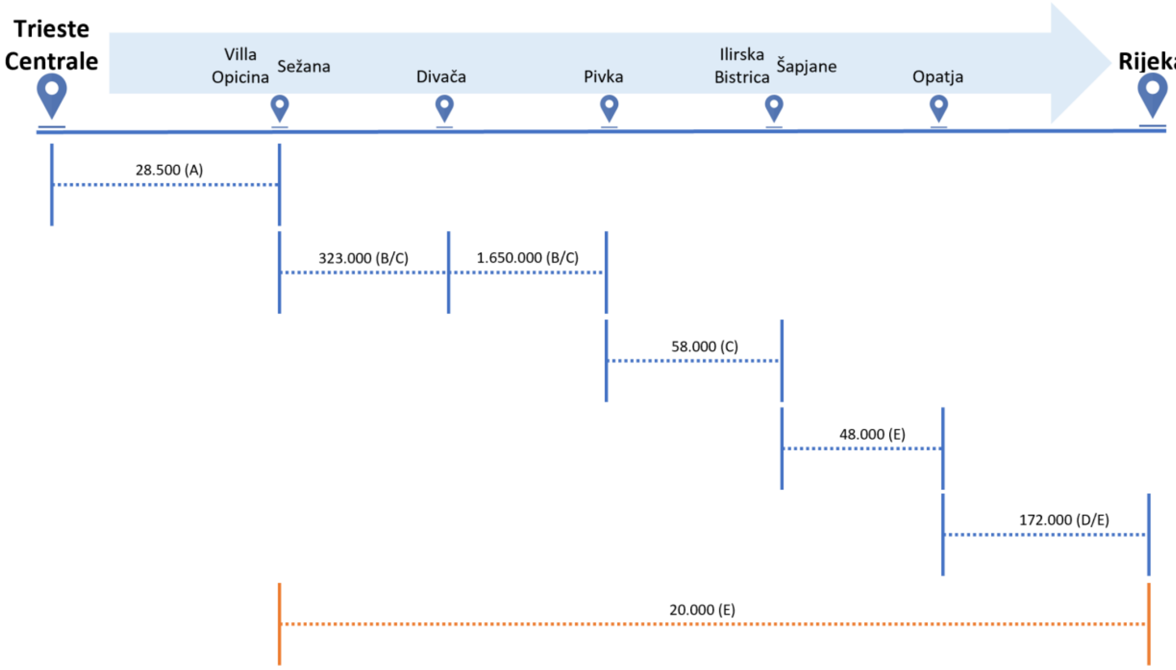
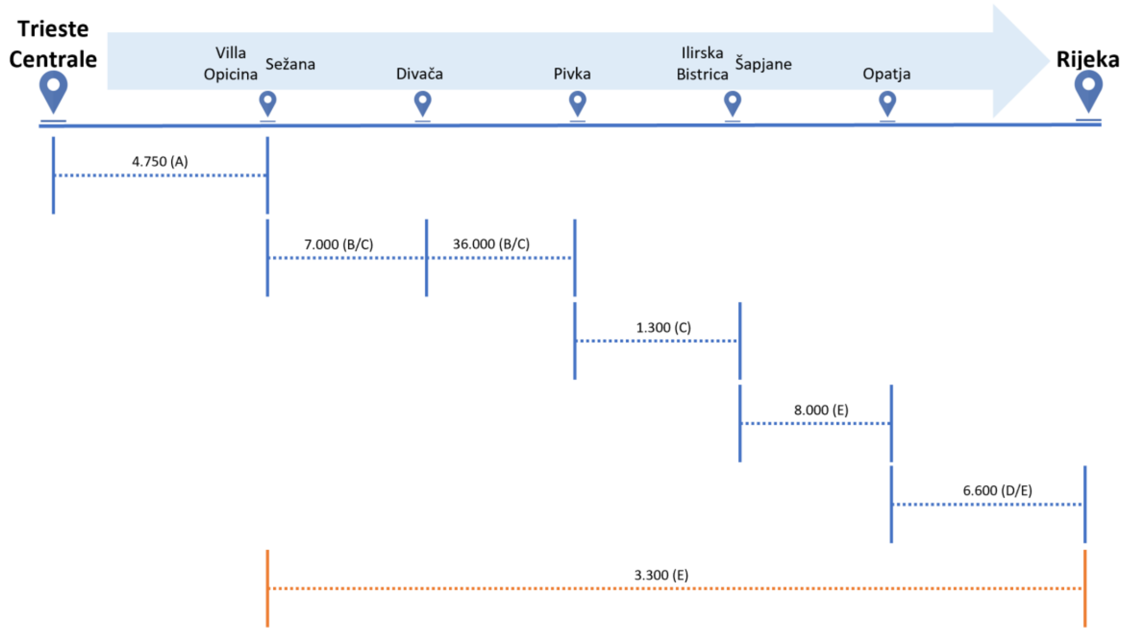


Figure 5.6. Estimate of passengers who would use the new service in the light of the assumptions in figure 5.5



5.3.4 Scenario with travel time reduction

If the direct journey time between Villa Opicina and Rijeka is reduced to 1 hour and 50 minutes, the train mode between these two stations would become comparable to both the bus and car modes, given that there is a smooth connection between Trieste and Villa Opicina. This connection should ideally take no more than 15 minutes and should not require a transfer. Currently, the TI 1825 train takes 25 minutes to travel between Trieste Centrale and Opicina, while other trains take 30 minutes. The same distance can be covered by car in 10-15 minutes and by bus in 20-25 minutes. The Opicina tram takes 15 minutes but does not provide a direct connection between the two stations, requiring an additional 10-15 minutes of walking from the Trenovia depot to Villa Opicina station.
For comparison, the train travel time between Trieste Centrale and Venice Santa Lucia is 2 hours and 15 minutes, and between Monfalcone and Venice Mestre is 1 hour and 30 minutes. These durations are considered acceptable by the many workers who commute between the shipyards of Monfalcone and Marghera. They are also considered acceptable by tourists from Trieste who are interested in visiting the historic center of Venice.
A journey time of slightly over two hours should make the train a competitive option compared to other public transportation modes, considering the estimated 160-200 passengers per day it currently carries. Moreover, it could lead to a shift from car usage or generate new demand, especially if train-pass-based options are available.

5.3.5 Estimate of potential Croatian and Slovenian travelers to and from Trieste

An important reference parameter for the values presented in sections 5.3.1-5.3.4 is derived from the estimation of Croatian and Slovenian travelers who visited the municipality of Trieste in 2022, as calculated in chapter 1 using the methodology outlined in Annex 2 of this report. For convenience, this estimation is reproduced in Table 5.9.

By excluding the results of the unweighted model (which is unrealistic as it disregards the relevance of distance in travel choice) and applying the railway modal split coefficients assigned by Eurostat to Slovenia and Croatia for 2019 (the latest year available unaffected by Covid), we obtain a hypothetical range of approximately 5,000 to 11,000 travelers who would have chosen the train as their mode of transport in 2022 if a Trieste-Rijeka service with the intermediate stops described in this report had been available. It is important to note that it is unrealistic to claim that these travelers actually used the railway. However, given the current circumstances, it is reasonable to believe that in the presence of a railway service such as the one hypothesized in this study, this value represents the lower limit of Slovenian and Croatian travelers that can be expected. Additionally, Italian travelers making the reverse journey are not considered in this study. These numbers indirectly confirm that the scenarios described in the preceding paragraphs are, at the very least, reasonable.

Table 5.9: Estimate of total travelers from Rijeka and Slovenian intermediate stations based on the application of the gravitational distribution criterion to the estimate of Slovenian and Croatian visitors in the year 2022 obtained from telephone traces[49].

	Estimated visitors to Trieste from Rijeka (all modes)	Average daily	Number of total trips per year (round trip)
Unweighted model	35,982	99	71,965
High elasticity weighted model	123,970	340	247,940
Low elasticity weighted model	67,559	185	135.117
High elasticity weighted model	159.131	436	318.262
Low elasticity weighted model and Marchetti threshold	146,671	402	293,343

	Estimated visitors to Trieste from intermediate Slovenian stations (all modes)	Average daily	Number of total trips per year
Unweighted model	29,893	82	59,787
High elasticity weighted model	57,079	156	114.159
Low elasticity weighted model	42,945	118	85,891
High elasticity weighted model	96.124	263	192.249
Low elasticity weighted model and Marchetti threshold	81.103	222	162.206

5.4 Conclusions, sensitivity analysis and indication of the possible configurability of the service on the market

The scenarios considered in this analysis present a range of annual demand for the Trieste-Rijeka railway service, varying from 7,300 travelers in the most pessimistic scenario to 66,650 in the best-case scenario. However, both extremes are highly unlikely, and the most probable range falls between 28,400 and 36,000 travelers per year.

The elasticities shown in the tables in section 5.1 indicate a relative inelasticity of the different modes of transport. They also highlight that demand is more responsive to travel time than to prices. Based on our observations and the modal choice factors discussed in Chapter 5, the following points are worth noting:

a) The current fares for the service with interchange are already relatively low and competitive compared to car usage (cost parity is achieved with around 3 passengers based on actual costs and for 2 passengers based on perceived costs). However, the primary driver of choice is travel time, which has a greater elasticity than the cost of the journey. To be competitive with other modes of transport, the Trieste-Rijeka railway line must minimize travel times. This can be

[49] MIMOSA project, Annex to D.3.1.1. Cross-border movements analysis based on mobile phones.

achieved by evaluating which stations to serve and reducing the distance between Trieste and Villa Opicina, which currently acts as a potential differentiator between car and train usage.

b) Traffic forecasts from various entities (Table 4.1) indicate that integrating and modernizing the Istrian infrastructure with the international network has a higher potential to attract new demand than reducing the already convenient tariffs. Therefore, there are factors at play that go beyond the simple assessment of demand in the current state of affairs.

streSimilarly, the policy elements discussed in Chapter 5 represent significant factors of discontinuity that, while important, are currently difficult to quantify.

Considering the following assumptions:

i) The estimates mentioned in point E of Table 4.1, indicating a potential of around 50 passengers per day (year 2022) for the complete Villa Opicina-Rijeka section or vice versa, are valid.
ii) The direct elasticity, which is -0.66 with respect to the ticket price (Table 2.3), also applies to significant price variations.

If the journey prices between Villa Opicina and Rijeka were reduced to zero while keeping travel times constant, it can be estimated that the number of passengers interested in making the complete Villa Opicina-Rijeka route or vice versa (point E of Table 4.1) would increase from 50 per day (year 2022) to 85 per day (31,000 per year).

Essentially, based on the current fares and the most probable forecasts, the service would initially generate an annual revenue ranging from 386,000 to 489,000 euros. However, due to the inelasticity of demand, even a significant reduction in fares would result in decreased revenues, as the increase in demand is expected to be less than proportional to the tariff reduction.

Therefore, at least in the initial phase of launching the service (which is crucial for demand to become aware of and familiarize with the new transportation option), It is unlikely that the service can achieve the break-even at market prices. Tariff reductions would have less impact than the other conditions mentioned so far, such as the integration and modernization of railway lines (especially the Istrian line), connectivity with points of interest, and comprehensive cross-border communication. However, these conditions take time to fully implement and require actions and coordination that go beyond the direct control of railway managers.

6. Recommendations for the promotion of the railway service

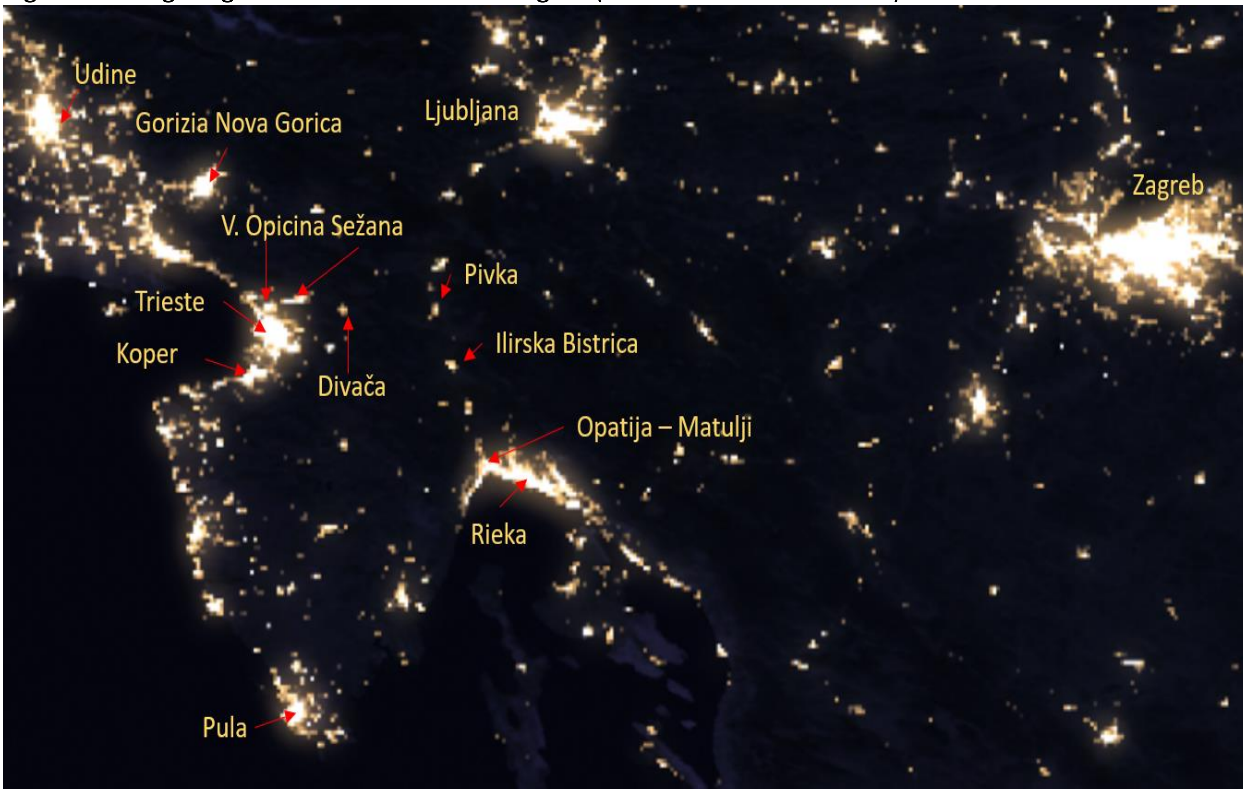
6.1 Preliminary considerations on the viability of the railway service as a commercial/market-oriented service.

This section examines the key features of the proposed railway service and the surrounding environment in which it is expected to operate.

6.1.1 Characteristics of the cross-border region

The Pivka-Rijeka railway line traverses the karst plateaus of the eastern Julian Alps, encompassing the provinces of Trieste, the Slovenian regions of Obalno-kraška and Primorsko-notranjska, as well as the northwestern part of the Croatian county of Primorsko-goranska.
Apart from the cities of Trieste and the Rijeka-Opatija-Matulji conurbation, the cross-border region primarily consists of rural areas with sparse population density (Figure 6.1 and Table 3.1).

Figure 6.1: Night lights in the cross-border region (Source Nasa Worldview)



The province of Trieste is home to a Slovenian-speaking minority, while Rijeka and the coastal cities of Istria have an Italian-speaking minority. Some Croatian individuals migrate to Italy for better wages, and Slovenians frequently commute to the Friuli-Venezia Giulia (FVG) region. Some Slovenian students also attend Italian universities, even if, it's worth noting that, on average, the Slovenian population possesses higher educational qualifications than the Italian population and experiences lower dropout rates.
With the Trieste and the Rijeka-Opatija-Matulji conurbation, the primary economic activities in the cross-border region are agriculture and forestry. Additionally, the region is becoming an increasingly popular tourist destination, particularly for agritourism, cycling, and hiking. Indeed, tourism plays a significant role in the local economy, with substantial growth in the three areas of the region. However, there are variations in terms of target (seaside, mountain, and urban), tourism types (leisure, ecotourism, cultural trips, shopping), and scale. Notably, ecotourism thrives due to the region's abundant natural landscapes

and high forest connectivity compared to other EU regions, except along the Adriatic coast especially on the Italian side of the border.

Only a small percentage of the population (14% of Slovenians and 10% of Italians) in the border area reported crossing the Italian-Slovenian border for work or business purposes. Legal and administrative disparities are considered the main obstacles to cooperation by over 50% of the population, while language (Italian versus Slovenian or Croatian) is viewed as a significant barrier to cooperation, with 68% of respondents perceiving it as such (among the highest percentages in Europe). However, the population does not perceive potential difficulties in physical accessibility at the border as hindrances to cooperation[50]. Conversely, the population does not perceive the possible difficulties of physical accessibility at the border as an obstacle to cooperation.
The region has good road connectivity, thanks to numerous border crossings throughout the entire border length. However, rail connectivity is limited[51].
The recent establishment of a cross-border railway service linking Udine to Ljubljana through the Trieste airport (Interreg Italy-Slovenia project " Crossmoby ") has opened up possibilities for addressing various needs and potential of different sectors and for developing a series of common services , for example for tourism, commuters and businesses.

A study conducted by the European Commission in 2016[52] brings attention to several potential obstacles to Italian-Slovenian cooperation (similar obstacles can be inferred for Italian-Croatian collaboration) that are more intense compared to the average of other European cross-border regions. These obstacles include:

- Socioeconomic disparities
- Physical barriers: difficulties in accessing certain areas due to mountainous terrain
- Cultural barriers: language, culture, and trust
- Regulatory and institutional hurdles

Conversely, the same study suggests that the only obstacle to Slovenian-Croatian cooperation is physical (mountainous terrain).
Cultural barriers between Italy, Slovenia, and Croatia also stem from the region's shared long and intricate history, which influenced the definition of national borders after World War II. The memories of past events are still vivid among the elderly population, but the porous and accessible nature of the area encourages cooperative development.
Furthermore, the Commission's study highlights that Italian-Slovenian-Croatian cross-border cooperation has greater potential than the European average in the following areas:

- Competitiveness and market integration (specifically between Croatia and Italy)
- Human and social capital
- Shared management of NATURA 2000 areas

6.1.2 Possible benefits of the cross-border railway service

The aforementioned Commission study highlights that the Italian-Slovenian-Croatian cross-border rail connections underperformed compared to the European average in several key indicators, including:

- Accessibility of cross-border rail services for the population
- Frequency of cross-border rail connections
- Commercial speed of international trains compared to national trains (specifically at the Italian-Slovenian border)

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[50]European Commission, Directorate-General for Regional and Urban Policy, Fratesi, U., Nilsson, H., Caragliu, A.et al., (2016) Collecting solid evidence to assess the needs to be addressed by Interreg cross-border cooperation programs – Final report, Publications Office, 2016, https://data.europa.eu/doi/10.2776/13983
[51]ibid.
[52]ibid.

According to the study, the lack of attractiveness of cross-border links to potential users can be mainly attributed to the following factors:

- Longer travel times compared to car travel
- Limited number of daily connections
- Insufficient availability of free parking at stations facilitating mode changes
- Inadequate connections to other modes of transport, such as buses

As mentioned earlier, some of these issues have been addressed by the Crossmoby project, which resulted in the establishment of the cross-border railway service connecting Udine to Ljubljana. However, additional potential barriers to a cross-border rail service between Trieste and Rijeka are discussed in section 6.1.3.

Considerations similar to those presented in a 2022 European Commission document[53] can be applied to the cross-border railway service between Trieste and Rijeka. According to the document, the current demand for transportation in the cross-border areas of the mentioned connection suggests that relying solely on ticket sales may not make the service economically viable in the short term, especially during the low tourist season. However, the railway link holds significant symbolic importance as a manifestation of cross-border cooperation, particularly in light of Croatia's recent accession to the Schengen area and the adoption of the euro. Moreover, it has the potential to provide economic support and boost tourism in the regions it traverses (see Figure 6.2), including:

- The province of Trieste
- The Slovenian statistical region of Obalno-kraška
- The northern part of the Primorsko-notranjska statistical region in Slovenia
- The northwestern part of the Croatian county of Primorsko-goranska

Let's consider the example of the Slovenian statistical region of Primorsko-notranjska, which encompasses Pivka, Ilirska Bistrica, and Postojna. This region is one of the weakest Slovenian regions in economic terms, with several indicators reflecting its challenges. For instance, the percentage of people working outside their region of residence is 53%, and there is a significant 10-point difference between the employment rates of males and females, the second highest among Slovenian statistical regions. In 2021, the average monthly net earnings in the region were the lowest in the country. With a GDP per capita of 17,584 euros, it ranks as the third lowest among Slovenian regions. Primorsko-notranjska contributes only 1.8% to Slovenia's GDP and has just over 4,700 businesses, employing an average of 3.4 people each. The region has a car ownership rate of 610 cars per 1,000 inhabitants but with an average vehicle age of 11.7 years[54].

The remaining areas of the cross-border region also exhibit economic vulnerabilities, particularly in rural areas, although not as pronounced due to the presence of key centers strategically positioned within the region. These centers include Trieste, Koper, and Rijeka, which are important port cities, industrial hubs, tourist destinations, and home to universities. Another noteworthy town is Sežana, located on the Slovenian-Italian border, which holds significance in logistics, industry, agriculture, and tourism. Nearby attractions, such as the Lipica Stud Farm, the Vilenica Cave, and the fortified village of Štanjel, contribute to the area's appeal. Additionally, the rural areas along the Italian-Slovenian border attract significant food and wine tourism.

Lastly, it is essential to acknowledge that chapters 4 and 5 of this study identify a pool of potential railway service users within the cross-border region, categorized into four distinct groups with varying needs:

- Commuters
- University students
- Hikers

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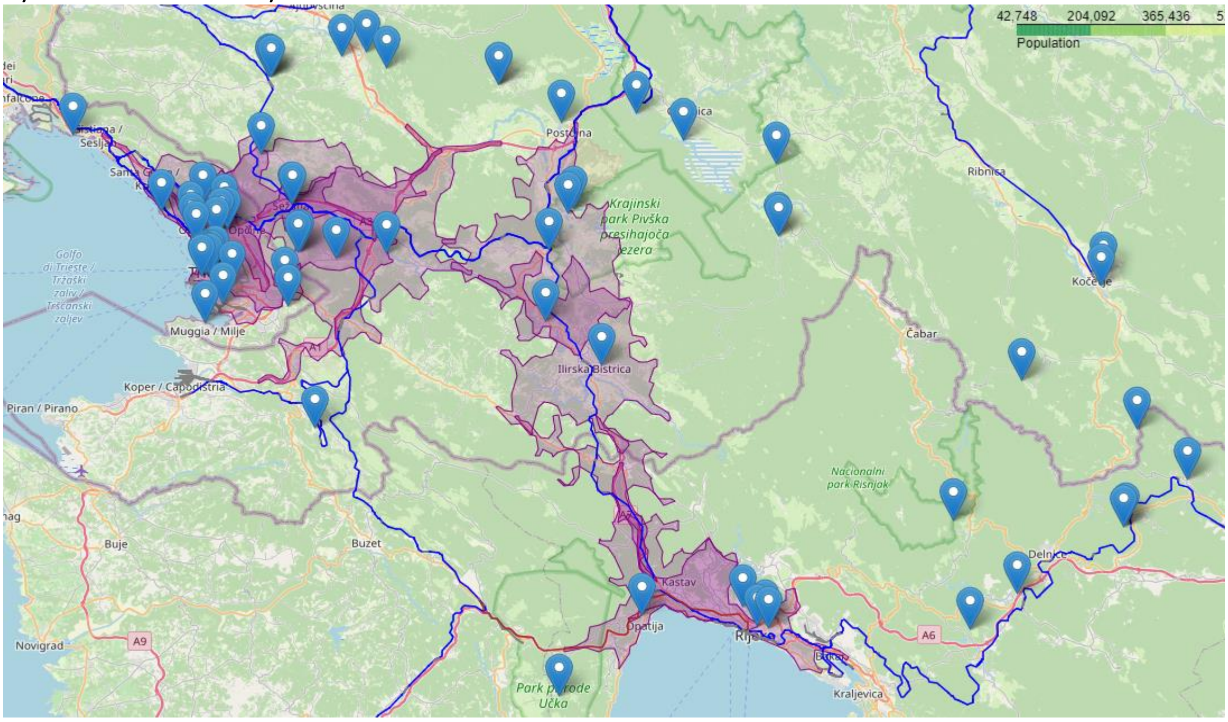
[53]European Commission, Directorate-General for Regional and Urban Policy, (2022) Study on providing public transport in cross-border regions – Mapping of existing services and legal obstacles : bus line Gorizia (Italy) – Nova Gorica (Slovenia), Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2776/746269

[54]https://stat.si/obcine/en/Region/Index/10

- Shoppers

These users would opt for the railway service if it could provide a competitive travel time. Moreover, the number of users could significantly increase if supportive measures were implemented to enhance and stimulate the railway service, including ancillary services such as last mile connections.

Figure 6.2: Points of interest indicated by national tourism agencies and their reachability in 15 minutes by car from the railway line stations



6.1.3 Possible barriers to a cross-border rail service

The barriers to cross-border rail transport, as identified in the Final Technical Report of the COMPASS project [55] and subsequently adopted by various EU projects and studies on public transport provision in cross-border regions[56], can be categorized into four significant categories:

A1: Availability of information

A2: Service levels

A3: Organizational, legal, and institutional frameworks

A4: Pricing

Table 6.1 presents an overview of specific challenges observed in the Trieste-Rijeka section. These critical issues were identified through on-site inspections along the railway line, analysis of official documents from railway companies and entities responsible for spatial and transport planning, and the utilization of information obtained from public datasets provided by national and European statistical bodies.

[55] EU COMPASS, "Better Connections in European Passenger Transport – Final Technical Report", Publications Office of the European Union, 2002.

[56] For example: European Commission, Directorate-General for Regional and Urban Policy, (2022) Study on providing public transport in cross-border regions – Mapping of existing services and legal obstacles: inventory of administrative and legal obstacles to cross-border public transport, Publications Office of the European Union, https://data.europa.eu/doi/10.2776/739282 ;

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Table: 6.1: Barriers to cross-border public transport according to the analysis of the Trieste-Rijeka section

Barrier type	Critical issues	Current situation
A1 Availability of information	**A1.1 Language problems.** Information cannot be obtained in both languages.	The Italian and Croatian ticket machines provide information also in English, the Slovenian ones only in Slovenian. The timetables displayed in the station are only in the national languages. The websites are also in English.
	A1.2 Lack of information availability. Information is not available, poorly disseminated or not easily accessible (e.g., timetables, fares, types of tickets, where to find them and how to use them).	Only the main stations have manned ticket offices (Trieste, Sežana , Divača , Pivka , Rijeka) Online ticket purchase: The Italian site also sells tickets for stations on foreign lines served by trains departing from or arriving in Italy. The Slovenian site only sells tickets up to the border stations, for international tickets you are sent to a DB site which does not always allow you to buy the ticket. The Croatian site only sells tickets for domestic travel. Stations of destination of the trains on the timetables displayed in the station: Italian and Slovenian timetables up to the final foreign destination. Inconsistencies have been found between the timetables published on the Italian and Slovenian scoreboards (e.g., for the TI 1825 and TI 1897 trains departing from Trieste at 19:45 the Trieste station scoreboard indicates different times from that of the Sežana station)
	A1.3 Unintelligible information content. Information is complex or poorly presented (e.g., numerous footnotes).	The boards of the three countries adopt different graphics and ways of indicating the routes. In some cases, the complete routes of the trains are not clearly highlighted. In some boards there are numerous explanatory notes placed at the side or at the bottom and in the national language only.
	A1.4 Insufficient coordination. There is a lack of an integrated approach to information provision (e.g., different printed formats instead of standardized layouts, missing links between internet sites, no reference in timetables to connecting cross-border lines).	Times displayed and websites are different from country to country. Furthermore, some "route planner" websites consulted only have some connections and/or are not updated on timetables

	A1.5 Little or no availability of maps. The maps provided do not cover cross-border lines.	There are no maps in the stations. The websites feature national maps only.
	A2.1 Few lines. Very often there is only one line passing across the border, while several lines terminate close to or close to the border.	Double-track line between Villa Opicina and Sežana , single-track between Ilirska Bistrica , Šapjane and Rijeka
	A2.2 Low frequency of services.	The frequency on the whole route is very low, effectively reduced to only one complete combination in each direction, with the need to change and a long wait in Pivka. See chapter 2: figures 2.2 and 2.3 for a complete mapping of the railway services existing on the line, including local services between intermediate stations only; figure 2.4. for services useful for the entire Trieste – Rijeka section.
	A2.3 Long connecting times with other train or bus services.	There is no harmonization of timetables regarding connections at Pivka (see figure 2.1)
	A2.4 Changing vehicles at the border.	Unnecessary
	A2.5 Mandatory interchange. Line ends at the border station, for any destination you have to change	Unnecessary
A2 Levels of service	**A2.6 Loss of time caused by the cross-border procedure.**	No (entirely traveled in the Schengen Area from 01.01.2023)
	A2.7 Missing links.	The railway connection with Istria (Pula) from Divača was undergoing upgrading works at the time of the site inspection (May 2023) The Istrian line and Rijeka are connected only at the Divača junction.
	A2.8 Poor harmonization of the timetables of the two countries.	There seems to be no harmonization of timetables
	A2.9 Unreliable public transport services.	Data not available
	A2.10 Different minimum standards between countries.	No
	A2.11 Loss of time due to technical aspects. Time losses can be caused by technical aspects such as switching locomotives at the border station (different voltage systems).	11 minutes on the IT-SI border, 15 on the SI-HR border
	A2.12 Low commercial speed.	Minimum railway times: 0:28 Trieste-Villa Opicina 0:42 Villa Opicina-Pivka 1:37 Pivka -Rijeka Without considering the stops at the borders

		Bus times 1:50 Car times 1:20
	A2.13 Insufficient quality standard of vehicles / stations. The quality of vehicles used on cross-border services is sometimes worse than the quality of vehicles usually used on domestic services (e.g., grants are made for investment in new vehicles only for domestic services, old vehicles are transferred to cross-border connections as fewer passengers are affected by older vehicles due to less demand).	There are no quality standard issues for the vehicles. The minor stations are accessible to people with disabilities, but do not appear to be equipped with an escort service. Platform-to-train accessibility is not guaranteed for all trains
	A2.14 Lack of demand. Lack of demand due to low population density within the cross-border region.	The current demand of the railway service is not representative for the entire journey but shows sections with high traffic intensity. The entire route has high growth potential, although conditioned by the implementation of infrastructure upgrading plans and the implementation of policies to ensure interconnection with the Istrian and international networks, first/last mile connectivity with points of interest, and the communication of timetables and fares in an easily accessible and understandable way in every country.
A3 Organizational, legal and institutional frameworks	**A3.1 Different responsibilities of administrations.** The administrative levels responsible for public transport differ between countries due to a different administrative system.	Italy (FVG region) and Slovenia have previous experiences of European Cross- Border Mobility , for example: ● The Udine / Trieste / Ljubljana cross-border passenger rail connection ● The international urban line Gorizia / Nova Gorica These previous experiences provide indications on how to overcome the A3-type critical issues that could emerge
	A3.2 Lack of subsidies.	See A3.1
	A3.3 Different legal frameworks.	See A3.1
	A3.4 Licensing/grant issues.	See A3.1
	A3.5 Different labor laws.	See A3.1
	A3.6 Length of the decision-making procedure. As a rule, two procedures are required (in both countries) for a single issue involving a lengthy decision-making process.	See A3.1
	A3.6 Different security standards.	The current situation of the lines allows very low maximum speeds of the trains: 75-80km/h in the Italian and Slovenian

		sections, 40-50 km/h in some Croatian sections. Safety standards for track and signaling systems may need to be upgraded to allow trains to achieve higher commercial speeds. It may be necessary to build underpasses between platforms giving access to the platforms at different stations. The interactive map for monitoring the progress of the TEN-T network[57], in relation to the standard levels of rail traffic management (ERTMS) indicates "no data" for the section between Pivka and Rijeka, both for ETCS and for GSM-R[58]
	A3.8 High investment costs. Improvements involving infrastructure investments are often unprofitable due to high costs in relation to low demand. Financing a cross-border measure could be burdensome due to the need for cross-border agreements.	For the same reasons mentioned in point A.3.6, significant infrastructural investments may be needed to allow convoys to reach higher commercial speeds. The line does not meet different characteristics required (see, eg, TENtec Interactive Map Viewer) of both core and comprehensive TEN-T lines. For example, the whole line does not satisfy the maximum permissible speed values and the Pivka-Šapjane section does not satisfy the "max axle load" value
	A3.9 Lack of cross-border cooperation structures.	See A3.1
	A3.10 Different and stringent local planning regulations.	See A3.1
	A3.11 Insufficient regulatory information.	See A3.1
	A3.12 Little or no willingness to cooperate. One reason for the lack of cooperation could be the lack of knowledge of the competent partners (decision makers) on the other side of the border.	No - Various ECBM type collaborations are already active
	A3.13 Lack of cooperation between operators.	See A3.1
	A3.14 No authority with arbitration functions.	See A3.1

[57]https://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/map/maps.html

[58]ECTS (European Train Control System) and GSM-R (Global System for Mobile communications for Railways) are the two basic building blocks of the single European signaling and speed control system (European Railway Traffic Management System – ERTMS), a standard aimed at ensure the interoperability of national rail systems while allowing greater speed and safety of transport.

	A3.15 Difficulty agreeing on the distribution of costs and profits / revenue sharing.	The different length and the different demand along the different national routes suggests the development of a revenue distribution model before the introduction of the cross-border lines
	A3.16 Customs or border police controls.	No – Schengen Area
	A3.17 Currency variations between countries.	No – Euro area
	A3.18 No possibility to deduct travel expenses from taxes.	No – It is not possible to make IT-SI international subscriptions
A4 Pricing	**A4.1 High level of fares for cross-border travel.** Fares for cross-border travel may be higher than for travel from comparable countries, e.g. i) the fare is calculated by adding the two national fares up to the border of each country, typical fare reduction formulas are not accepted for cross-border travel, ii) cross-border passengers on a regional connection are forced to use Intercity or HS trains (as there is no alternative rail with regional trains), iii) the fare is calculated at a higher fare level	No, in fact, see the following rates. International train fares: Trieste/Villa Opicina-Pivka €3.60 Pivka /Rijeka 6.00-11.00€ Domestic train fares (2-class, adult one way) Trieste-Villa Opicina €2.90 Sežana-Ilirska Bistrica €5.80 Rijeka- Šapjane €2.93 Bus fares: 9:99€
	A4.2 Lack of availability of a full range of tickets. Only certain types of tickets are available for the cross-border journey, e.g. no multiple-journey tickets, no weekly or monthly passes. As a result, fare reductions for cross-border public transport as usually exist for season tickets are missing.	IT-SI international rail pass are not possible
	A4.3 Different levels of tariffs between countries. When the level of tariffs is high compared to the average income level of people from the other country, it may be more convenient to use a private car than to use public transport to cross the border.	Our checks do not show a significant difference, in absolute terms, between the different national railways. In relative terms, the OBB tariff is higher than the Italian, Slovenian and Croatian ones
	A4.4 Problems with distribution channels. Difficulty buying tickets that cover all segments of a passenger's journey, for example, in regional rail transport, passengers often have to use the bus or tram to travel from the train station to the city center	Currently it is not possible to buy a direct ticket Trieste-Rijeka

	A4.5 No preferential tariff. For the cross-border section there are no usual fare reductions (e.g. the elderly, disabled, students) as they are normally provided for domestic tickets. One reason may be that the respective authority only provides subsidies for national services, but not for cross-border lines.	There is no discounted fare for children on the IT-SI cross-border route, but all the railway companies involved have discounted fares for children under 12 (other categories) on domestic routes
	A4.6 Restrictions on accepting currency on board.	No, the entire route takes place in the Euro area from 01.01.2023
	A4.7 Complexity of the tariff system. There may be conflicting regulations regarding cross-border routes (e.g. tickets must be dated before boarding on one side of the border, on the vehicle on the other).	In Italy tickets must be stamped before boarding.
	A4.8 No integration of tariff systems. Fare systems do not cover all public transport lines. Ticket fares must be paid separately by passengers for each operator. Because of this, one ticket is not available for all segments of a journey and consequently the fare may also be much higher.	We have not found evidence of an integrated tariff system for the entire route. There are integrated tickets for cross- border journeys included within the route.

To address the barriers presented in Table 6.1, it is necessary to evolve the definition of the ECBM system through a series of actions.

The following checklists, proposed in a document of the European Commission[59] for the development of cross-border public services, outline the necessary steps. It is important to note that this checklist should not be considered static, and the proposed points should be periodically reviewed to ensure the best quality and sustainability of the service.

Checklist:

1. Define the service
    - 1.1. Specify the type of service
    - 1.2. Define the service area
    - 1.3. Evaluate the frequency of the service
    - 1.4. Determine the funding mechanism for the service
    - 1.5. Define indicators, targets, and criteria for monitoring the service's performance
2. Agree on the use of infrastructure (including rolling stock)
    - 2.1. For existing infrastructure, define:
        - 2.1.1. Ownership of the infrastructure
        - 2.1.2. Responsibility for maintaining the infrastructure
        - 2.1.3. Actions required to adapt, renovate, or make the infrastructure compliant
        - 2.1.4. Sources of funding for infrastructure maintenance and improvements
            - 2.1.4.1. Joint resources
            - 2.1.4.2. Separate contributions from each stakeholder
    - 2.2. For new infrastructure, define:
        - 2.2.1. Infrastructure to be built
        - 2.2.2. Refer to points 2.1.1-2.1.4 for the management of new infrastructure
    - 2.3. Harmonize existing standards to ensure compatibility
3. Agree on human resource management
    - 3.1. Evaluate the need to enhance human resources
    - 3.2. Establish rules for service delivery
    - 3.3. Define training, information, and communication criteria
    - 3.4. Define rules and practices that facilitate collaboration among personnel from different nationalities
4. Evaluate legal frameworks, particularly regarding:
    - 4.1. Compatibility of national legal frameworks
    - 4.2. Existence of legal frameworks or cross-border agreements
    - 4.3. Existence of EU legal frameworks
    - 4.4. Existence of sector-specific legal frameworks
5. Define management modalities, considering rolling stock and fixed infrastructure separately
    - 5.1. Choose the manager: public vs. private, existing or specially created
    - 5.2. Determine the management mode:
        - 5.2.1. Single centralized management by one service provider
        - 5.2.2. Centralized management by one provider who coordinates the actions of other service providers
        - 5.2.3. Distributed management

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[59] European Commission, Directorate-General for Regional and Urban Policy, Roux, L., Wolff, D., Nolte, J.et al., *Comprehensive analysis of the existing cross-border rail transport connections and missing links on the internal EU borders – Final report* , Publications Office, 2018, **https://data.europa.eu/doi/10.2776/69337**

6.1.4 *Preliminary indications*

This section presents several potential actions that can be taken to enhance the attractiveness of the railway service, particularly within the cross-border region. The initial assumption is that the service will include intermediate stops between Trieste Centrale and Rijeka. These actions aim to justify the use of the railway for transportation within the cross-border region.
By combining available information with the recommendations from Wardman's study (2016), the following indications arise:

- If the journey from Trieste to Rijeka by rail takes 2:30, i.e., twice as long as the same journey by car, the rail ticket should cost almost nothing in order for the train to be competitive in the modal choice of potential users, if we neglect every other aspect of the trip other than the price. However, it's important to note that other factors such as bike transport options, travel comfort, the possibility of working during the journey, etc., can mitigate this consideration. Additionally, an information campaign could be conducted to highlight that, at current railway tariffs, the cost of the car journey is equivalent to approximately three travelers (taking into account all costs, including those not typically incurred by users, as mentioned in paragraph 5.1).
- The train mode is particularly appealing for commuters who have season tickets, as it makes train travel significantly more cost-effective compared to using a car. This applies to other ticket options such as family or group passes, which can make the train a competitive alternative to car travel, even when considering carpooling.
- For tourist demand, pricing considerations can also be mitigated by providing additional services that incorporate the railway sections into a broader tourist route.

Regarding the last point, ensuring "last mile" connectivity by road between the railway stations and the main points of interest is crucial. While the terminal cities have well-established connectivity, the intermediate stations are located in areas with dispersed housing patterns, making a traditional Local Public Transport (LPT) service economically unsustainable. Therefore, it is vital to identify business models that rely on sharing and collaboration with local stakeholders. These models should offer high operational flexibility and low fixed costs. Typically, such transport services involve partnerships or public-private agreements and should be viewed as an opportunity to activate local entrepreneurial resources, rather than expanding LPT services. Examples of these models include on-demand services like Uber and shared vehicle services (such as bikes, e-bikes, e-scooters, and microcars) with initial investments covered by the public and management handled by private individuals.
In a broader context, this flexible integration between rail and road can be extended to encompass other tourist services managed by local communities, such as hospitality, catering, and accommodation. This approach creates an "all-inclusive" experience where choosing the railway allows access to a hub of non-railway services. Similar integration already exists in the airline industry, where car rental, accommodation, and other services are offered through their commercial channels.

Here are some further possible actions to consider:

- Create a knowledge base on joint ECBM actions, documenting their outcomes and user feedback.
- Implement coordinated marketing activities, such as:
    - Introduce a pilot project offering free public transport on Saturdays.
    - Provide discounted services within the area.
    - Establish coordinated communication channels with multilingual support and immediate access to ticket purchasing tools.
    - Offer integrated train-attraction tickets for major points of interest (refer to chapter 3 on points of interest).
- Explore opportunities to extend, coordinate, or share trains with the Crossmoby railway service, making the line a connection between the three airports of Trieste/Ljubljana/Rijeka.

- Consider introducing a stop at Bivio di Aurisina and coordinating timetables with trains on the Trieste-Venice and Trieste-Udine lines.
- Coordinate services between Sežana-Nova Gorica and Divača-Koper, and potentially in the future, the Divača-Pula lines.
- Align the line's timetables with those of trains heading south of Rijeka or consider extending the line to certain stations south of Rijeka.
- Coordinate the line's timetables with other services serving coastal towns or locations in Istria.
- Establish a connection on Italian territory with a train to Austria, complementing existing connections on the Rijeka-Ljubljana line.
- Provide additional services at minor railway stations, such as:
  - Increase car and bicycle parking capacity to accommodate commuters.
  - Introduce bus links to facilitate seamless transitions to public transport.
  - Offer bicycle and car rental services, potentially partnering with local shops to attract new customers.
  - Provide on-call transport services to assist passengers in reaching their final destinations. In some cases, the cost may be shared with the destination (e.g., shopping malls, workplaces for commuters).
  - Enable the transportation of small quantities of accompanied and/or unaccompanied goods.
- Enhance the travel experience on the train to compensate for the additional travel duration, including:
  - Providing amenities such as tables, power outlets (now standard), and Wi-Fi (potentially with entertainment or training services).
  - Offering food vending machines and beverage services.
  - Allowing the transport of bicycles with battery recharging facilities and electric scooters.

Now, let's consider a rail service focused on establishing a direct connection between Trieste and Rijeka. To ensure its attractiveness, as previously emphasized, this service should offer a travel time that is at least comparable to road transportation. Consequently, not all potential intermediate stations may be feasible as stops. Additionally, the infrastructure should ultimately support higher train speeds than currently possible. However, it is important to maintain the Pivka stop to facilitate connections with Ljubljana and Slovenian railway services. Similarly, it is advisable to retain the Divača stop to enable connections with the Istrian peninsula and Pula.

6.1.5 Summary of barriers, critical issues and opportunities in "SWOT" form

In conclusion, it is valuable to provide a synthesis of the findings from the analysis using the well-known "SWOT" framework. While this approach simplifies the presentation of problems, it offers a useful representation tool to understand the complex landscape of the analyzed situation.

Strengths:

- The area is experiencing increased logistic and economic interconnection due to TEN-T planning and the Croatia's recent entry into the Schengen and Euro areas.
- The two terminal cities possess socio-economic and cultural attractions such as important port sites, university campuses, and interconnection hubs with ferries to Croatian islands and the coast.
- There is growing recognition of the demand for travel between the two cities, with the railway identified as a priority element for reducing road traffic and carbon emissions.

Weaknesses:

- The current demand for rail transport is relatively low compared to the available transportation options, particularly car travel.

- The population of Rijeka and the Primorje-Gorski region Kotar has experienced a decline in recent years, with significant migratory movements both incoming and outgoing, resulting in a nearly balanced migratory flow.

Opportunities:

- Survey results indicate a strong inclination to travel from Trieste to Rijeka, with a higher-than-expected percentage of respondents expressing definite or high likelihood of using the train.
- The served destinations are either of existing or potential tourist interest, especially for cycling, hiking, and trekking. In particular, online evidence suggests that the Rijeka-Trieste route attracts interest and is utilized by cycle tourists.
- There is significant potential for fostering cross-border cooperation to support the rural economies along the railway line and to bridge cultural barriers between Italian-speaking, Slovenian-speaking, and Croatian-speaking populations.
- Exploring "last mile" services between stations and nearby attractions, including agreements and collaboration with local stakeholders, could alleviate the burden on local public transportation (especially at intermediate locations) where projected flows might not be economically viable.

Threats:

- Flixbus operates on the Trieste-Opatija-Rijeka route, offering highly competitive prices and journey times. Flixbus is known for its flexibility in adjusting offers, with the ability to add or remove trips with short notice.
- Nomago and Arriva are bus service operators that already provide connections between Croatian towns, including routes between Trieste and Poreč, Rovinj, and Pula for Nomago. While they currently do not offer direct connections between Trieste and Rijeka, they could potentially do so in response to growing demand, as there are minimal barriers for entering the road transportation market.

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List of web- gis platforms used for geographic data processing

Geojson
Google Maps
Koomot
Openrouteservice
Openstreetmap
Openrailservice
Ridewithgps
TENtec Interactive Map Viewer

Annex 1: Estimation of regional, urban and suburban transport demand on the Škrljevo - Šapjane section

Based on the passenger transport demand forecast carried out by HŽ Infrastruktura and IGH Institute for the area between Šapjane and Škrljevo [60], we estimated the part of demand concerning the intermediate routes, starting from the population density incident in the destinations. The purpose of the estimate is to calculate how much of the urban and regional transport demand (therefore, mainly commuter demand) potentially affects the section between Šapjane and Rijeka.
This is the procedure:
- Table 1.5 considered the regional, urban and suburban demand forecast for 2024-2025 by the aforementioned study by HŽ Infrastruktura and IGH Institute, which forecasts 12,453,000 passengers on the Škrljevo - Rijeka - Opatija/ Matulji - Jurdani – Šapjane route .
- We estimated the density of the incident population on each destination using the data from the GHSL dataset [61], parameterizing it to the incident value within a radius of 20 minutes on foot from the respective stations, more or less corresponding to a circle with a radius of 1 km from the stations (therefore an area of 3.14 sq km).
- We hypothesized that the more a center has a high density of incident population, the more it will be the origin and destination of travel. Consequently, we have parameterized the number of travelers for each route:

a) the percentage of population incident in the considered neighborhood of each station [62],

b) the percentage of the population residing in each locality [63].

The results are shown in the tables below. The first refers to the incident population, the second to the resident population:

	Skrljevo	Rijeka	Opatija/ Matulji	Jurdani	Sapjane
Estimated accident population within a radius of 1 km from the station	1,856	25,716	8,624	1,655	283
Quote	0.05	0.67	0.23	0.04	0.01
Estimated passengers per route (with Rijeka center)					
Rijeka - Opatija/ Matulj			11.214.035		
Škrljevo -Rijeka	606.093				
Rijeka- Jurdani				540.455	
Rijeka- Šapjane					92,416
Average daily:					
Rijeka - Opatija/ Matulj			30,723		
Škrljevo -Rijeka	1,661				
Rijeka- Jurdani				1,481	
Rijeka- Šapjane					253

[60] Projekt izgradnje drugog kolosijeka, obnove i modernizacije pružne dionice Škrljevo – Rijeka Jurdani (Šapjane), Hž Infrastruktura, Institut Igh, Granova, public presentation, Rijeka 23 January 2020. https://www.hzinfra.hr/wp-content/uploads /2020/01/2020.01.23-Prezentacija-RI-23.01.20.-V2-final.pdf.

[61] In this regard, see the methodological note on the estimation of the accident population, at the end of this chapter.

[62] The estimate of the accident population on the territory is obtained from data from the Global Human Settlement Layer (GHSL) system of the European Commission, updated to dates between 2015 and 2018 (https://data.jrc.ec.europa.eu/collection/ghsl), calculated using the isochrones generated by the Openrouteservice service

[63] Population data is taken from Croatian National Statistical Office DZS - Državni Zavod za Statistiku.

	Skrljevo	Rijeka	Opatija/ Matulji	Jurdani	Sapjane
Estimated resident population in the localities	1,300	107,338	10,589	848	10,771
Quote	0.01	0.82	0.08	0.01	0.08
Estimated passengers per route (with Rijeka center)					
Rijeka - Opatija/ Matulj		11,223,461			
Škrljevo -Rijeka	123,725				
Rijeka- Jurdani				80.707	
Rijeka- Šapjane					1,025,108
Average daily:					
Rijeka - Opatija/ Matulj		30,749			
Škrljevo -Rijeka	339				
Rijeka- Jurdani				221	
Rijeka- Šapjane					2,809

The two tables show different values since the data on residents differs significantly from that of the affected population, which is also linked to the greater or lesser presence of commercial, work, etc. activities. For the purposes of our estimation, the different values can be considered as the extremes of a reference interval. Starting from these data, it is possible to estimate the share of demand that affects the different travel modes starting from the modal split of land passenger transport recorded by Eurostat [64]. The latest data available (2020) assigns Croatia a share of 2.8% to trains, 13% to buses and 84.2% to buses.

In conclusion, the table below shows the estimated range of daily rail passengers for the routes considered.

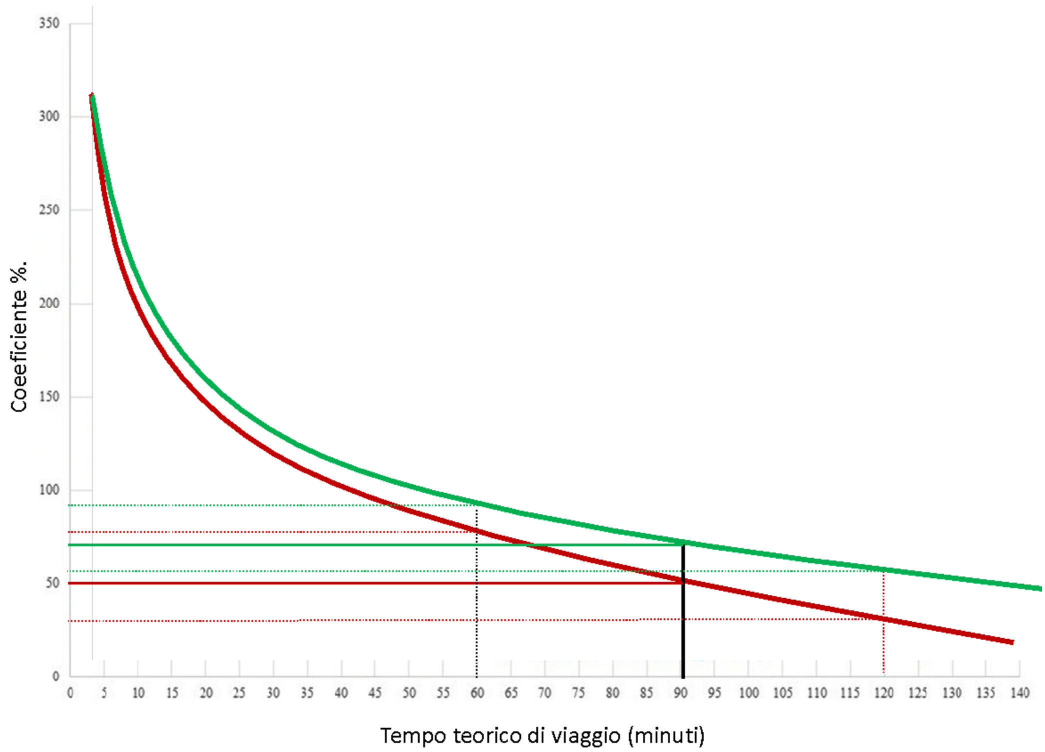
Estimate of the average daily number of local commuting rail passengers for stations in the urban and suburban area of Rijeka	
Rijeka - Opatjia / Matulji	850 - 860
Rijeka - Sapjane	7 - 79

[64] https://ec.europa.eu/eurostat/databrowser/view/TRAN_HV_PSMOD__custom_3400053/bookmark/table?lang=en&bookmarkId=0627a685-8004-4af8-b0ea-e4ba1363f92d

Annex 2: Estimation of the number of Croatian visitors coming from the Rijeka area based on the analysis of telephone traces.

Based on the survey conducted in 2022 within the MIMOSA project[65] to determine the number of Croatian visitors in the Municipality of Trieste, we estimated the proportion likely originating from the urban area of Rijeka using a gravity-based approach. This approach used the population share of areas near the Italian border as a weighting parameter, adjusted by a coefficient reflecting the distance from Trieste. The coefficient was calculated based on studies that aimed to determine time thresholds related to travel choices under various conditions. Specifically, Marchetti (1994) identified a threshold ranging from 1 to 1:30 for daily commuting, which was largely confirmed for European countries in a recent study by Giménez-Nadal et al. (2022). The probability of choosing a destination beyond these thresholds decreases rapidly.

Although these thresholds are related to commuting for work and study purposes and are not directly applicable to cross-border travel for reasons other than functional commuting, they provide an indication of the daily travel range or short-term stay. Another study (Zhu et al., 2020), based on ticket analysis, estimated the additional travel time threshold between two destinations based on the travel time itself. According to this study, as the travel duration increases, this threshold decreases non-linearly. We considered this threshold as a proxy for the probability of choosing a particular trip based on its duration. By graphically interpolating the diagram from Zhu et al. and approximating the interval with two curves representing different travel choice elasticities with respect to time, we established the relationship between distance and weighting coefficient, as shown in the following graph.

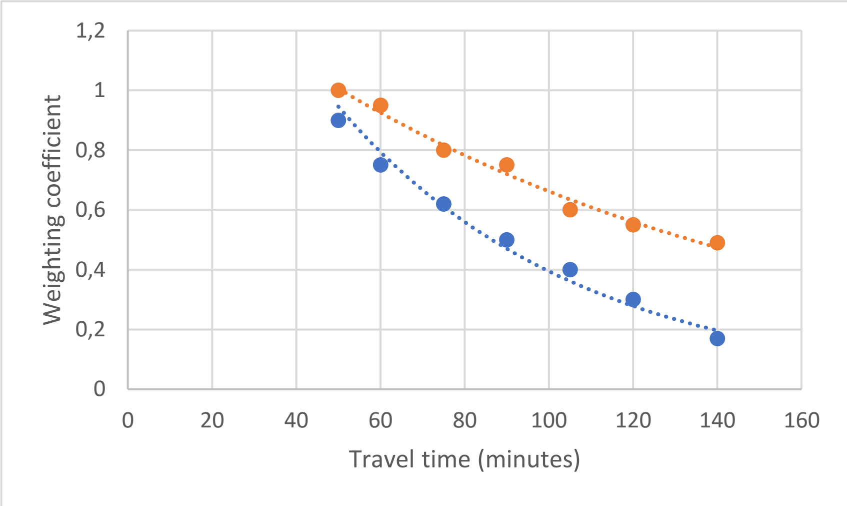


Source: our elaboration on the analysis carried out in Zhu et al, 2020 (assumption of proxies and graphical interpolation of the data graphically represented in the article).

[65] MIMOSA project, Annex to D.3.1.1. Cross-border movements analysis based on mobile phones.

The relationship between the distance expressed in minutes and the relative weight of the population is therefore the following:

	Coefficients	
Time in minutes	Greater elasticity	Less elasticity
50	0.9	1
60	0.75	0.95
75	0.62	0.8
90	0.5	0.75
105	0.4	0.6
120	0.3	0.55
140	0.17	0.49



The model from which we extracted the travel choice elasticity based on distance (Zhu et al., 2020) actually proposed a wide range of values, which we synthesized into two curves: a "high" curve and a "low" curve. These curves indicate how "elastic" the traveler is in considering distance when making their choice. The more "elastic" the traveler is (higher elasticity), the less they care about distance, and therefore, distant origins have a greater weight compared to a less elastic traveler who is less inclined to travel long distances (thus assigning a lower weight to the population of the place of origin).

We estimated the number of potential trips made from the metropolitan area of Rijeka based on the population of neighboring areas weighted by these coefficients. We also considered the possibility that beyond a certain distance, the number of travelers would decrease to zero, due to a threshold known as the "Marchetti constant" or "Marchetti threshold." For our estimates, we set this threshold at 90 minutes based on several studies[66] that have indicated a decrease in travel beyond 90 minutes. It is worth noting that this threshold applies to daily commuting or day trips. The data collected in the MIMOSA project study does not specify whether the visitors recorded are day visitors or overnight visitors. Therefore, we assume that the estimated travel demand from Rijeka represents all "day-trippers." The estimated range thus obtained is approximately 68,000 to 160,000 annual Croatian visitors to the Municipality of Trieste from Rijeka, resulting in a daily average over the year ranging from approximately 185 to 440 visitors.

The main limitation of this estimation lies in considering the elasticity of travel demand based on travel time as a continuous variable. In reality, as mentioned earlier, the table below presents the results obtained by adopting this criterion.

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[66]For example: Marchetti, C. (1994). Anthropological invariants in travel behavior. *Technological forecasting and social change* , *47* (1), 75-88.

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Croatian travelers in the municipality of Trieste 2022 — 553,000 (from MIMOSA D.3.1.1. annex)

	pop.ne	Distance (car)	Distance in minutes	Coeff . 1 greater elasticity	Weighted population coeff . 1	Coeff . 2 less elasticity	Weighted population coeff . 2	Weighted population coeff . 1 and threshold (90')	Weighted population coeff . 2 and threshold (90')
Stadt Zagreb	767131	02:30	150	0.1	76713	0.4	306852		
Zagreb	299985	02:50	170	0.1	29999	0.3	89996		
Karlovac	112357	02:30	150	0.1	11236	0.4	44943		
Primorje Gorski Kotar (excluding Rijeka and Opatija)	158845	01:30	90	0.5	79423	0.75	119134	79423	119134
Pula	52011	01:45	105	0.4	20804	0.6	31207		
Porec	16583	01:15	75	0.62	10281	0.8	13266	10281	13266
Rovinj	12932	01:30	90	0.5	6466	0.75	9699	6466	9699
Umag	12661	00:50	50	0.9	11395	1	12661	11395	12661
Novigrad	3900	1 o'clock	60	0.75	2925	0.95	3705	2925	3705
Rest of Istria (average time)	95239	01:30	90	0.5	47620	0.75	71429	47620	71429
Opatija	10660	01:15	75	0.62	6609	0.75	7995	6609	7995
Rijeka	107338	01:15	75	0.62	66550	0.8	85870	66550	85870
Total	1649642				296861		702892	158109	229894
Rijeka weight	6.5%				22.4%		12.2%	42.1%	37.4%
Weight Rijeka + Opatija	7.2%				24.6%		13.4%	46.3%	40.8%

It should be noted that the "Marchetti threshold" adopted in this evaluation (90') is an "extreme" value, which cannot be considered as a real parameter for excluding the destination from travel choices. Therefore, the maximum value of about 175,000 visitors from Rijeka and Opatija to Trieste should be considered as an upper extreme calculated in a condition in which the duration of the journey affects the travel choice discontinuously and restrictively. Similarly, the unweighted estimate (39.556) is unrealistic, as it assumes that distance has no impact on travel choice.
In conclusion, considering that each visitor makes a round trip and a return trip, the set of estimates can be summarized as follows:

	Esteemed visitors to Trieste* from Rijeka	Average daily	Number of total trips per year
Unweighted model	35982	99	71965
High elasticity weighted model	123970	340	247940
Low elasticity weighted model	67559	185	135117
High elasticity weighted model	159131	436	318262
Low elasticity weighted model and Marchetti threshold	146671	402	293343

	Esteemed visitors to Trieste* from Rijeka and Opatija	Average daily	Number of total trips per year
Unweighted model	39556	108	79112
High elasticity weighted model	136282	373	272564
Low elasticity weighted model	73849	202	147697
High elasticity weighted model	174935	479	349869
Low elasticity weighted model and Marchetti threshold	160327	439	320655

* Base: 522,000 Croatian visitors in 2022 (From MIMOSA D.3.1.1. Annex).

The same criterion was applied to the survey, carried out by the same study, on the number of Slovenian visitors to Trieste. The results are presented in the following tables.

Slovenian travelers in the municipality of Trieste 2022 2,242,995 (from MIMOSA D.3.1.1. annex)

	Population	Distance (car)	Distance in minutes	Coeff . 1 greater elasticity	Weighted population coeff . 1	Coeff . 2 less elasticity	Weighted population coeff . 2	Weighted population coeff . 1 and threshold (90')	Weighted population coeff . 2 and threshold (90')
Ljubljana	284340	01:15	75	0.62	176291	0.8	227472	176291	227472
Domzale	36790	01:30	90	0.5	18395	0.75	27593	18395	27593
Ivanchna Gorica	17590	01:30	90	0.5	8795	0.75	13193	8795	13193
Medvode	16790	01:20	80	0.58	9738	0.77	12928	9738	12928
Grosuplje	21280	01:20	80	0.58	12342	0.77	16386	12342	16386
Vrhnika	17650	1 o'clock	60	0.75	13238	0.95	16768	13238	16768
Logatec	14690	1 o'clock	60	0.75	11018	0.95	13956	11018	13956
Rest of the Osrednjeslovenska regija (Central Slovenia)	146311	01:15	75	0.62	90713	0.8	117049	90713	117049
Koper	53440	00:30	30	1.1	58784	1.1	58784	58784	58784
Piran/Piran	18440	00:45	45	1	18440	1.15	21206	18440	21206
Sežana	13423	00:25	25	1.2	16108	1.2	16108	16108	16108
Izola / Island	16720	00:40	40	1	16720	1.1	18392	16720	18392
Divacha	4157	00:30	30	1.1	4573	1.1	4573	4573	4573
Rest of Obalno-kraška (Littoral-Karst)	48334	00:40	40	1	48334	1.1	53167	48334	53167
Ajdovshchina	19741	00:50	50	0.9	17767	1	19741	17767	19741
Idrija	11723	01:30	90	0.5	5862	0.75	8792	5862	8792
Nova Gorica	31835	1 o'clock	60	0.75	23876	0.95	30243	23876	30243
Tolmin	10969	01:40	100	0.45	4936	0.58	6362		
Rest of Goriška (Goriziano)	44088	01:15	75	0.62	27335	0.8	35270	27335	35270
Maribor	96780	1 o'clock	60	0.75	72585	0.95	91941	72585	91941
Slovenian Bistrica	37339	02:15	135	0.25	9335	0.48	17923		
Ptuj	23531	02:30	150	0.1	2353	0.4	9412		
Rest of Podravska	169907	02:20	140	0.17	28884	0.49	83254		
celje	28557	02:05	125	0.28	7996	0.52	14850		
Kranj	56784	01:30	90	0.5	28392	0.75	42588	28392	42588
Velenje	33558	2:00 am	120	0.3	10067	0.55	18457		
Novo Mesto	37339	01:45	105	0.4	14936	0.6	22403		
Ilirska Bistrica	4279	1 o'clock	60	0.75	3209	0.95	4065	3209	4065
Pivka	6222	00:50	50	0.9	5600	1	6222	5600	6222
Reto of Slovenia	784393	01:30	90	0.5	392197	0.75	588295		
Total	2107000				1158816		1617392	688113	856435
Weight Intermediate stations	1.3%				2.5%		1.9%	4.3%	3.6%

	Esteemed visitors to Trieste from Rijeka	Average daily	Number of total trips per year
Unweighted model	29893	82	59787
High elasticity weighted model	57079	156	114159
Low elasticity weighted model	42945	118	85891
High elasticity weighted model	96124	263	192249
Low elasticity and threshold weighted model	81103	222	162206

Overall, the estimate resulting from the use of data from telephone traces collected for the MIMOSA project leads to an estimate of potential travelers from the locations served by the intermediate stations of the railway line between Trieste and Rijeka which is shown in the following table

Estimated total travelers from Rijeka, Opatija and Slovenian intermediate stations	Number of total trips per year	Average daily	Number of total trips per year
Unweighted model	65876	180	131752
High elasticity weighted model	181049	496	362099
Low elasticity weighted model	110504	303	221008
High elasticity weighted model	255255	699	510511
Low elasticity and threshold weighted model	227775	624	455549

Methodological note on the estimation of the accident population:

The "accident" population is a parameter estimated by the European Commission and made available in a georeferenced way by the Operauteservice platform . In this report it was used to apply gravity estimates to the origin/destination of passenger flows. Below is the disclaimer of the European Commission regarding the reference project that makes this data available.

"*The Global Human Settlement Layer (GHSL) project is supported by European Commission, Joint Research Centre and Directorate-General for Regional and Urban Policy. The GHSL produces new global spatial information, evidence-based analytics, and knowledge describing the human presence in the planet. The GHSL relies on the design and implementation of new spatial data mining technologies allowing to process automatically and extract analytics and knowledge from large amount of heterogeneous data including: global, fine-scale satellite image data streams, census data, and crowd sources or volunteering geographic information sources. Spatial data reporting objectively and systematically about the presence of population and built-up infrastructures are necessary for any evidence-based modelling or assessing of i) human and physical exposure to threats as environmental contamination and degradation, natural disasters and conflicts, ii) impact of human activities on ecosystems, and iii) access to resources.*"

Source: European Commission Joint Research Center Data Catalog - Global Human Settlement Layer

https://data.jrc.ec.europa.eu/collection/ghsl , https://ghsl.jrc.ec.europa.eu/about.php

(last visited : May 3rd , 2023) .

Methodological note relating to the daily and annual passenger count.

The transition from daily estimates to annual estimates can take place in different ways depending on the prevailing type of traffic. For example, studies in which the largest share of passengers is due to commuting (for work or study) usually considers a value between 200 and 250 working days for the purpose of calculating the daily average starting from the total, i.e. the total annually starting from the daily surveys. For example, this is what we found in the studies carried out by HŽPP concerning the Istrian railway and the routes to and from Rijeka. In the event that there is a significant presence of travelers for tourist reasons or in any case not linked to work commuting, it is instead necessary to relate the total to 365 days (as in the case, for example, of the study carried out on the basis of telephone traces).

This study uses the reference parameter in terms of days/year which was used by the reference studies and, where this information is not made available or cannot be reconstructed from the data, the value of 365 days/year.