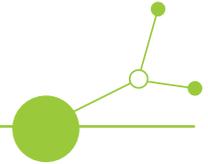


Study of cross-border commuting in the Trieste FUA

GreenPATH

D1.1.2



Final Version

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Executive summary

Within the general framework of the GreenPATH project, the present deliverable addressed the analysis of commuting in the Trieste FUA with a focus on cross-border trips from Slovenia to Italy. The key rationale of the analysis is providing some quantitative facts and technical elements which could pave the way to further analyses, in case, leading to the possible design and implementation of extensions of public transport services providing a sustainable solution to this demand and needs.

For this purpose, the analysis of cross-border transport demand for commuting purposes has been accompanied by a comprehensive analysis of the territorial context in which the specific phenomenon of cross-border commuting is framed. Typically, this involves exploring the relationship between an urban core and its suburban or rural hinterland. However, in the case of Trieste, these dynamics are deeply intertwined with its peculiar position and characterisation as both a regional capital and a border city at the southeastern tip of Friuli Venezia Giulia, shaped by its historical evolution from a major port of the Austro-Hungarian Empire to a regional center with a limited hinterland, and now as a bridge in European integration. More specifically, the present analysis, dealing with the cross-border dimensions, extends beyond the Trieste FUA, made up of the six municipalities of its own NUTS 3, to include the neighbouring Slovenian Obalno-kraška region. Furthermore, in order to provide a complete picture, geomorphological conditions should be taken into account as well. For this purpose, it is to recall orographic conditions related to its location between the Karst plateau, steeply descending towards the Adriatic Sea, thus providing challenging conditions for urban and infrastructure development. In fact, also because of the geomorphological context, a quite sharp gradient between highly urbanised and rural/peripheral areas can be ascertained.

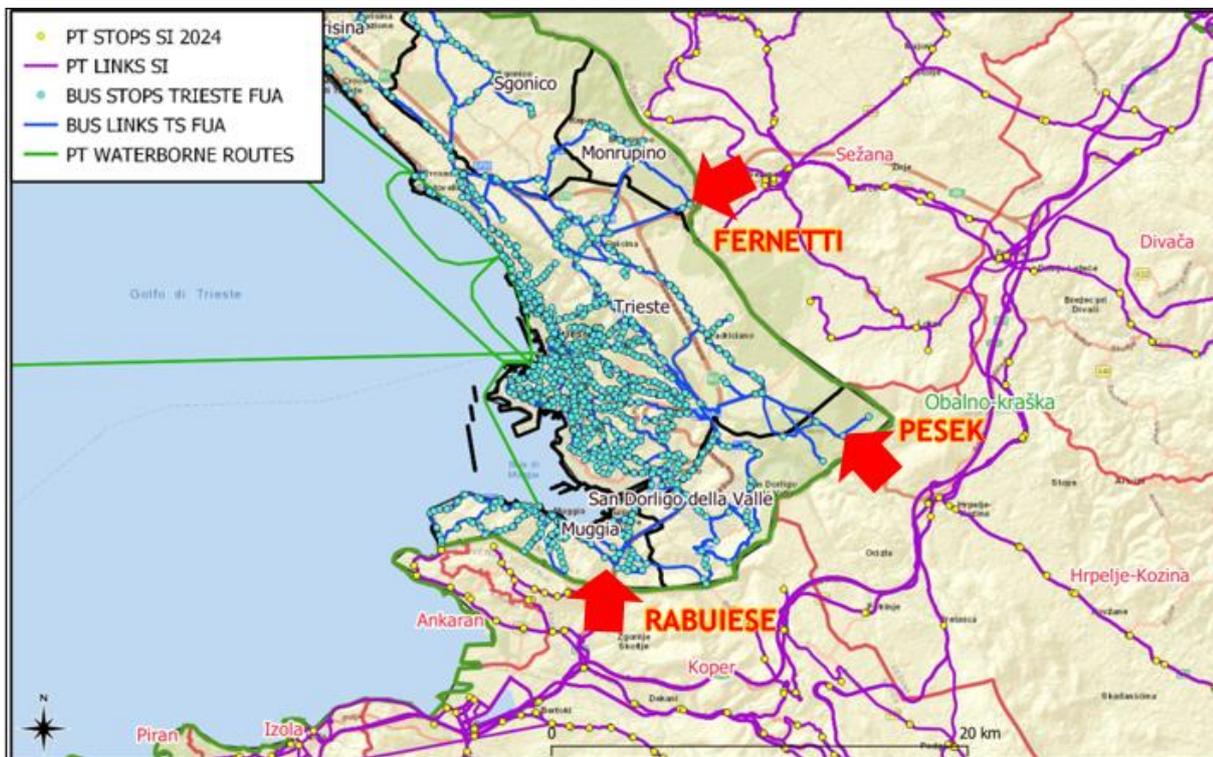


Figure 1 - The analysed border crossing and the Local Public Transport network on both sides of the border



The geographical and geomorphological characteristics described previously, over the years, have significantly contributed to shaping the Trieste FUA transport network, featuring a deep-sea port and three major TEN-T corridors, but also faces limitations being a terminus rail station.

Concerning the road network, the main links run along/parallel to the coastline. In particular, a motorway axis linking to the rest of Italy continues through a partial ring around Trieste city, which branches off towards Slovenia in two distinct directions, respectively heading to Ljubljana and Koper. The connections going through the two related cross-border crossings (Ferneti and Rabuiese), together with another one (Pesek) along a secondary road, are the key focus of the present analysis.

Furthermore, a relevant deal has been paid to transport demand, representing a key aspect of the transport system and expressing the mobility needs that must be met. Unfortunately, obtaining reliable and complete data for this purpose proves particularly challenging. Available statistics often lack comprehensive coverage and are limited to specific areas, time periods, or components of overall mobility.

Nonetheless, through the present analysis, it has been ascertained that the presence of various data sources, on both sides of the border, can effectively contribute to a first overall assessment of cross-border commuting mobility needs. Among others, it is important to mention the innovative approach now being provided by the use of mobile phone users' location data, which has been applied (starting from 2017) by the Friuli Venezia Giulia Region offices to the analysis of transport flows. More in general, the identified sources provide sources related to the following themes:

- transport demand (either from comprehensive transport modelling or specific datasets on cross-border commuters)
- traffic counts in sections of the road network
- network and timetables of the local public transport services.

The different data sources typically are related or focus mainly on one side of the border; however, by integrating sources from both sides, a good overview can be effectively achieved.

In particular, this resulting picture from cross-checking different and heterogeneous data sources, though with some differences, is also coherent with the presence of relevant flows, especially at the 3 border crossing points, as also testified by the following table.

Section Name SI/IT	Average Traffic Vehicles	Daily - All	Average Traffic Passenger	Daily - Cars
MT Ferneti / Fernetiči	17487		12549	
MT Lipica/Basovizza	4372		3938	
MT Kozina / Pesek	5725		4912	
MT Škofije / Rabuiese	15537		13188	
MT Lazaret / Lazzaretto	1400		1142	

Table 1 - Annual Average Daily Traffic at border crossings of the Trieste FUA. Source: Slovenian Infrastructure Agency, Ministry of Infrastructure of the Republic of Slovenia



In order to address the needs of cross-border commuting, a preliminary assessment of the missing PT connections limiting multimodal accessibility has been carried out with particular reference to the Ferneti and Rabuiese border crossing.

These first assessments set the basis for further deepening, leading to new/extended services at the cross-border level. Nonetheless, it is important to highlight the relevant aspects to be further detailed in case of potential follow-ups. They include different relevant aspects, in terms of technical issues and approaches to be considered, addressing the terms related to long-term economic sustainability (either ensuring a core level of demand or exploiting possible funding opportunities) as well as taking into account legal constraints and provisions of the legislative framework allowing the FVG region to introduce cross-border services.



1. Introduction

In this chapter, the key goals, objectives and background of the study are presented, starting from a brief presentation of the GreenPATH project. Then, the second paragraph focuses on the analysis of cross-border commuting towards the Trieste Functional Urban Area (FUA in the following), which is the key objective of the present deliverable. In this regard, a brief overview of the analyses described in the following chapters is presented, together with a synopsis of relevant synergic (ongoing and past) projects and initiatives.

1.1. The GreenPATH project

GreenPATH will develop an innovative approach to commuting in Central European Functional Urban Areas (FUAs). It aims to co-design smart and green mobility solutions with public and private stakeholders, benefiting students and employees by promoting sustainable transport. The project addresses the challenge of decarbonising urban mobility through tested solutions, strategies, and action plans. It involves 11 partners, including local administrations, mobility agencies, operators, universities, and research bodies from EU Regions where transport is a major contributor to greenhouse gas emissions.

GreenPATH focuses on sustainable mobility within FUAs and tackles commuting challenges through integrated governance of commuter flows and innovative mobility management solutions. The project will utilise new technologies and data-sharing platforms to enhance transport efficiency and improve the commuting experience with real-time information and personalised travel options. Transnational cooperation is key, bringing together expertise from Italy, Germany, Austria, Slovenia, Hungary, and Croatia. This cooperation contributes to overcoming national legislative barriers and creating applicable mobility management tools across the region. GreenPATH aims to deliver formal cooperation agreements, collaborative solutions for sustainable mobility, a comprehensive strategy, and action plans for each FUA. Decision-makers will adopt these outputs to ensure long-term implementation and cooperation beyond the project's completion, benefiting a wide range of users, including local authorities, service providers, and educational institutions.

1.2. The specific focus and goals of this analysis

Within the general framework of the GreenPATH project, the present deliverable addressed the analysis of commuting in the Trieste FUA with a focus on cross-border trips from Slovenia to Italy. The key rationale of the analysis is providing some quantitative facts and technical elements which could pave the way to further analysis, in case, leading to the possible design and implementation of extensions of public transport services providing a sustainable solution to this demand and needs.

Hence, this analysis aims to provide elements for improving multimodal accessibility in a cross-border area, also addressing a peculiar case of the relationship between an urban core and its suburban/rural hinterland. Obviously, while addressing cross-border integration in such a relevant context, it is important to highlight and exploit synergies with different past and ongoing projects and initiatives.

In this regard, it is worth mentioning the different Interreg projects as those listed in the following table.



PROJECT	PROGRAMME	DURATION	WEBSITE
CONNECT2CE	Interreg CENTRAL EUROPE	06/2017 - 05/2020	https://www.interreg-central.eu/Content.Node/CONNECT2CE.html
PERIPHERAL ACCESS	Interreg CENTRAL EUROPE	06/2017-06/2020	https://www.interreg-central.eu/Content.Node/Peripheral-Access.html
SUSTANCE	Interreg CENTRAL EUROPE	04/2023 - 03/2026	https://www.interreg-central.eu/projects/sustance/
INTER-CONNECT	Interreg ADRION	01/2018 - 12/2020	https://interconnect.adrioninterreg.eu/
TRADOMO	Interreg IV-A Italy -Slovenia	09/2012 - 12/2021	https://2007-2013.ita-slo.eu/projects/projects_2007_2013/2013032111235625.html
CROSSMOBY	Interreg V-A Italy -Slovenia	09/2018 - 12/2021	https://2014-2020.ita-slo.eu/en/crossmoby
FORTIS	Interreg V-A Italy -Slovenia	03/2020 - 02/2022	https://2014-2020.ita-slo.eu/fortis
MIMOSA	Interreg V-A Italy -Croatia	01/2020 – 06/2023	https://programming14-20.italy-croatia.eu/web/mimosa
CIVITAS PORTIS	Horizon 2020	09/2016 -08/2020	https://civitas.eu/portis/

Table 1 - Synergic ongoing and past projects

From a methodological perspective, this study contributes to the objectives outlined in the S2 Strategy of the Action Plan for Streamlining Public Transport Connections in Cross-Border Areas, developed under the FORTIS project (Interreg V-A Italy-Slovenia Programme). Specifically, the S2 Strategy focuses on 'Supporting the decision process with data and technical analyses. In fact, effective decision-making requires a thorough assessment grounded in quantitative data about both current conditions and future scenarios. However, data availability is typically lacking and fragmented, especially at the cross-border level.

In order to address these challenges, three Actions, representing a concrete set of measures to be implemented, have been proposed in relation to the S2 strategy (see Table 2).

S2 - Supporting the decision process with data and technical analyses	1	Setting-up integrated information systems and data sharing and integration at CB level with reference to the international lines as well as the whole mobility of the CB area (possibly adopting the Open Data approach)
	2	Collecting mobility statistics and demand data through traditional (survey on the fields including traffic counts and questionnaires) as well as innovative surveys (e.g. Big Data from cell phones)
	3	Developing what-if scenarios and evaluations supporting the joint decision-making process and integrated planning at CB level

Table 2 - FORTIS project S2 Strategy and the corresponding three proposed Actions



Looking at the descriptions of these actions, it is evident how they are relevant correspondences with the present study.

In fact, this study addresses the significant knowledge gap regarding data and quantitative assessment of cross-border transport demand for commuting purposes, thus contributing directly to the objective of the first action. Moreover, by gathering and integrating all available data sources, including both traditional methods (e.g., traffic counts and surveys) and innovative approaches (e.g., cell phone data), it also aligns with the second action. Regarding the third action, the evaluation of future scenarios represents a potential and desirable follow-up to the current work.

1.3. The themes addressed and the deliverable structure

In this deliverable, the analysis of cross-border transport demand for commuting purposes is accompanied by a comprehensive analysis of the territorial context in which the specific phenomenon is framed.

In this regard, the present document can be divided into two main parts. The first part (chapters 1-4) provides a comprehensive overview of the Trieste Functional Urban Area (FUA) and its related transport system and passenger mobility demand, also considering the cross-border dimension. The second part (chapters 5-8), instead, focuses more specifically on cross-border commuting.

More specifically, Chapter 2 examines the demographic, socio-economic, and geographical characteristics of the Trieste Functional Urban Area (FUA), including its cross-border context. It also highlights specific polarities that act as attractors for commuter flows, such as the port, industrial zones, hospitals, the university and research centres. Chapter 3 focuses on the multimodal transport system within the FUA, offering a general overview of the public transport network and its cross-border dimension, concluding with a summary of relevant transport planning documents.

Then, Chapter 4 introduces the innovative approach of making use of mobile phone data for analysing passengers mobility applied in the Friuli Venezia Giulia Region. Along with a brief general overview, the usage of these data is applied to cross-border commuting, which becomes the key focus of the analyses in the remaining part of the document.

In this regard, a summary of all the other data sources used in the study is provided in Chapter 5. The resulting data are integrated and cross-checked in Chapter 6 to analyse flows at border crossings and estimate cross-border commuter volumes along key routes.

Chapter 7 examines the cross-border public transport supply in relation to its (potential) capacity to meet cross-border commuter demand, especially once the gaps in multimodal accessibility at the cross-border level are filled.

Finally, Chapter 8 outlines potential improvements to cross-border public transport services, discussing ideas, constraints, and areas for further development in case of future implementation.



2. The Trieste Functional Urban Area and its cross-border dimension

As outlined in the introduction chapter, a crucial and indispensable step in the present analysis is to provide a comprehensive understanding and assessment of the territorial context represented by the Trieste Functional Urban Area (FUA). Furthermore, given the specific focus on cross-border trips between Italy and Slovenia, it is essential to expand the territorial scope of the analysis and consider neighbouring areas beyond the national border. To this end, the following paragraphs will describe key characteristics, ranging from geomorphological to socio-economic aspects, first for the Trieste FUA and then for the neighbouring Obalno-kraška region in Slovenia. Finally, some observations on the concept of a cross-border FUA and potential drivers for its future development will be presented.

2.1. The Trieste Functional Urban Area (FUA)

In general, a Functional Urban Area can be defined as the combination of two key elements:

- A city where a majority of the population lives in an urban centre of at least 50,000 inhabitants
- A commuting zone contains the surrounding travel-to-work areas of a city where at least 15 % of employed residents are working in the city.

The resulting FUA is typically characterised by a high degree of complementarity and interconnectedness in terms of daily commuting patterns, but also economic activities and services¹.

This definition corresponds to a classification at the EU level (and beyond) developed over recent years by the OECD² and Eurostat. It is meant to harmonise urban-rural areas classifications across Member States, aiming to reflect real-world functional integration rather than administrative boundaries. By doing so, it enables policymakers to address challenges such as transportation, housing, and labour markets comprehensively, taking into account the actual scope of key relationships occurring within these areas.

An overview of FUAs is provided through the EUROSTAT atlas, from which is excerpted the representation in the following Figure 1, providing a zoomed view including the Trieste FUA. It is easy to verify that it corresponds exactly with the NUTS3 area representing the former province of Trieste.

In this regard, it should be noted that, starting from 2017 (on the basis of the Regional Law 26/2014), the former 4 provinces in Friuli Venezia Giulia Autonomous Region (Udine, Pordenone, Gorizia and Trieste) were formally suppressed and initially replaced by 18 “Unioni Territoriali Intercomunali” (UTI). More recently (on the basis of the regional law 21/2019), the UTI, in turn, have been substituted by the “Enti di Decentramento Regionale” (EDR), which covers the same territorial areas of the 4 former provinces, albeit with reduced competences and no political decision-making body³.

¹ L. Dijkstra, A. J. Florczyk, S. Freire, T. Kemper, M. Melchiorri, M. Pesaresi, M. Schiavina (2021) “Applying the Degree of Urbanisation to the globe: A new harmonised definition reveals a different picture of global urbanisation”, *Journal of Urban Economics*, Volume 125.

² Organisation for Economic Co-operation and Development (OECD)

³ At the time of writing this report, a further change is taking place with a regional law envisaging the re-introduction of provinces, which has already been approved by the Regional Council and is awaiting nulla osta by the national Parliament.



It is worth highlighting how this coincidence is quite unique, as the FUA concept, as described above, is not intended to replicate administrative subdivisions. For example, this does not occur in the other two FUAs of the Friuli Venezia Giulia Autonomous Region.

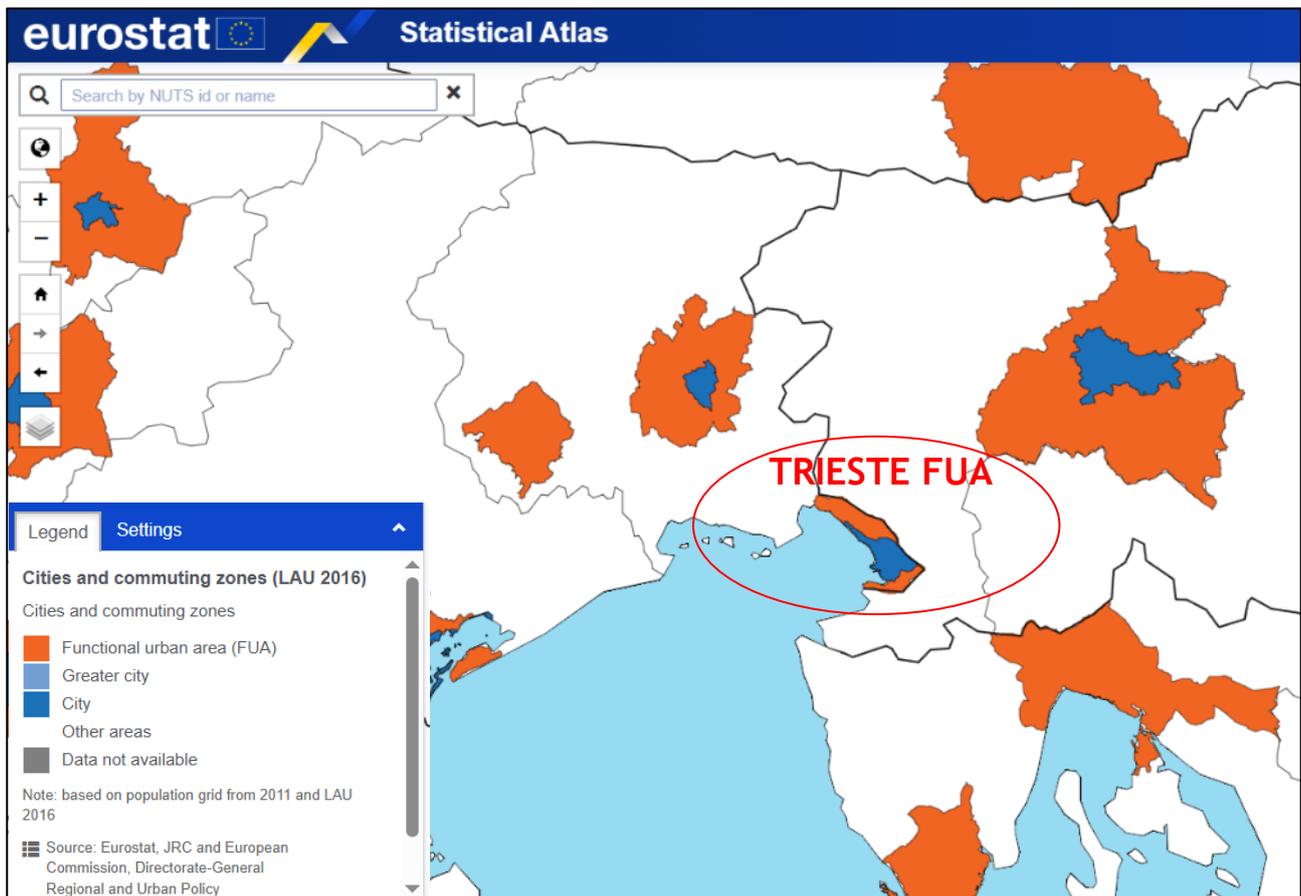


Figure 1 - FUAs, cities and commuting zones - zoomed view including the Trieste FUA. Source: Eurostat, JRC and EU Commission - Directorate-General Regional and Urban Policy

2.1.1. The geomorphological and socio-economic context of the Trieste FUA

More specifically, the Trieste FUA corresponds to the smaller NUTS3 area in Italy in terms of surface, being made up of only the 6 municipalities reported in Table 3 and represented in Figure 2.

Municipality	Population	Surface area (km ²)	Population Density (Inhabitants/km ²)	Elevation (m a.s.l.)
Duino-Aurisina	8196	45.17	184.57	2 - 330
Monrupino	840	12.68	68.44	418
Muggia	12771	13.66	937.18	2
San Dorligo della Valle	5665	24.51	235.09	106
Sgonico	1975	31.31	64.24	278
Trieste	199338	84.49	2380.03	2 - 674



OVERALL FUA	TRIESTE	228785	211.82	1089.19	2-674
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Table 3 - The municipalities making up the Trieste FUA

From these key data, it is clear that the Municipality of Trieste plays a major role, accounting for approximately 87% of the overall FUA, while the second-ranked municipality, Muggia, accounts for about 5.5%. Concerning the remaining municipalities, two out of three have populations well below 1%.

In terms of surface area, although the situation is more balanced, Trieste remains the largest, covering almost 40%, with Duino-Aurisina in second place at 21%, and each municipality having a value above 5%.

Regarding population density, the remarkably high value at the NUTS 3 level of 1089 inhabitants/km² is largely due to the high density of the Trieste Municipality, which is approximately 2380 inhabitants/km². In contrast, the other municipalities have significantly lower densities, with a minimum of 64.24 inhabitants/km² in the case of Sgonico.



Figure 2 - The municipalities making up the Trieste FUA

These differences are quite representative of the peculiar character of Trieste city and its FUA. In this regard, it is to underline that, in spite of being the capital city of Friuli Venezia Giulia, Trieste is a “border city” located towards the end of a narrow strip of Italian territory (lying between the Adriatic Sea and Slovenia), in correspondence of the south-eastern corner of the region. These somehow contradictory conditions are also emphasised when considering the historical background. In this purpose, it is to recall the vicissitudes of the last century that led Trieste, a city characterised by a strong international character, from being a key maritime gateway of a transnational empire - the former Austrian Empire - to a regional centre with a limited hinterland, in such a peculiar bordering condition as the former “Iron Curtain” and, eventually, to the renewed perspective related to its positioning in a key area for European unification process, bridging between Western and Eastern countries.



Furthermore, in order to provide a complete picture, geomorphological conditions should be taken into account as well. For this purpose, it is to recall orographic conditions related to its location between the Karst plateau, steeply descending towards the Adriatic Sea, thus providing challenging conditions for urban and infrastructure development.

This situation is effectively mirrored in the following representation of the density of inhabitants according to the 1 km² population grid by EUROSTAT. Overall, also because of the geomorphological context, a quite sharp gradient between highly urbanised and rural/peripheral areas can be ascertained (see Figure 3).

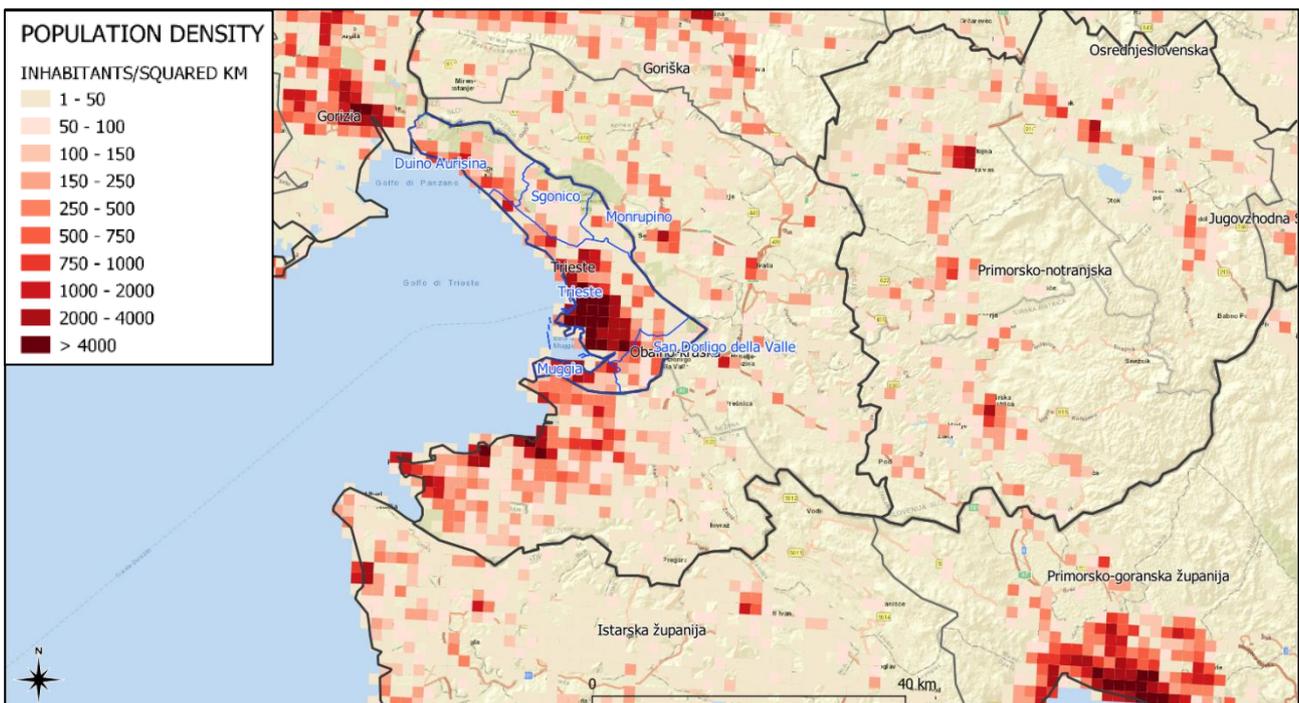


Figure 3 - Distribution of population density in the Trieste FUA and neighbouring areas. Source: own elaborations on ISTAT, SURS, and EUROSTAT data.

According to a classification provided by EUROSTAT, based on analysis of contiguous cells⁴, the different values of each cell of the grid can be referred to following typologies of urbanisation level:

- Urban centres (High-density clusters): clusters of contiguous grid cells of 1 km² with a density of at least 1,500 inhabitants per km² and a minimum population of 50,000 after gap-filling.
- Urban clusters: clusters of contiguous grid cells of 1 km² with a density of at least 300 inhabitants per km² and a minimum population of 5,000.
- Rural grid cells: grid cells outside high-density clusters and urban clusters.

⁴ Source: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Territorial_typologies&oldid=91416

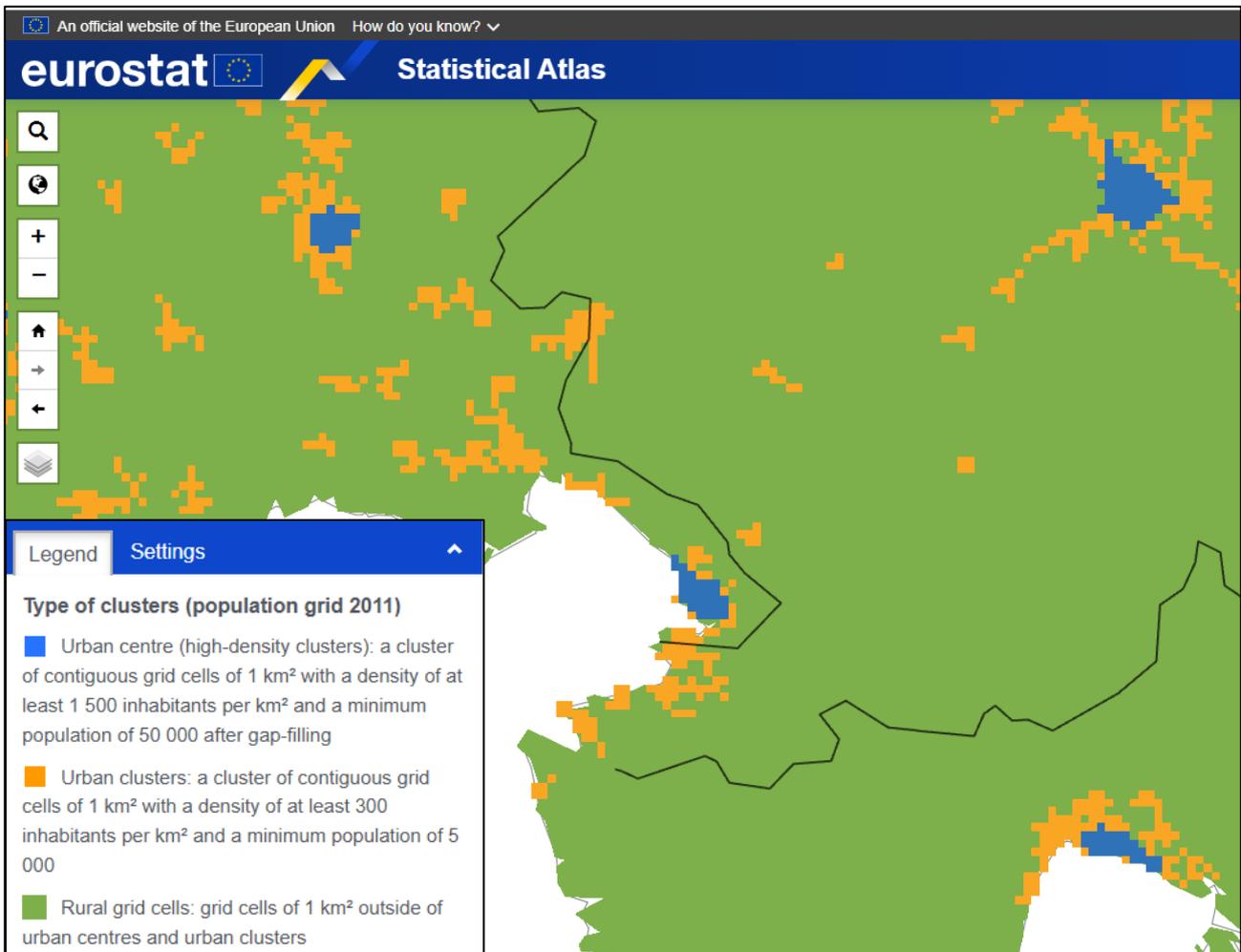


Figure 4 - Type of clusters of urbanisation level in the Trieste FUA and neighbouring areas based on 1 km² grids. Source: Eurostat

Bringing this classification to the municipality level, the following typologies can be ascertained:

- Cities - Densely populated areas: at least 50% of the population lives in urban centres;
- Towns and suburbs - Intermediate density areas: less than 50% of the population lives in rural grid cells and less than 50% of the population lives in urban centres;
- Rural areas - Thinly populated areas: more than 50% of the population lives in rural grid cells.

Looking at the resulting picture in Figure 5, considering the Trieste FUA and the neighbouring areas both in the Italian NUTS3 of Gorizia and in the Obalno-Kraska region in Slovenia, only the municipality of Trieste is considered a city. Nonetheless, all the remaining municipalities along the Adriatic Sea coast belong to the category “Towns and suburbs”. Concerning the hinterland, instead, the Rural areas are the predominant typology, with particular reference to Karst (in Italian municipalities close to the national border as well as in Slovenia).



Figure 5 - Degree of urbanisation of municipalities in the Trieste FUA and neighbouring areas. Source: EUROSTAT.

As far as economic activities are concerned, they are mainly concentrated in the Municipality of Trieste; nonetheless, as reported in the following

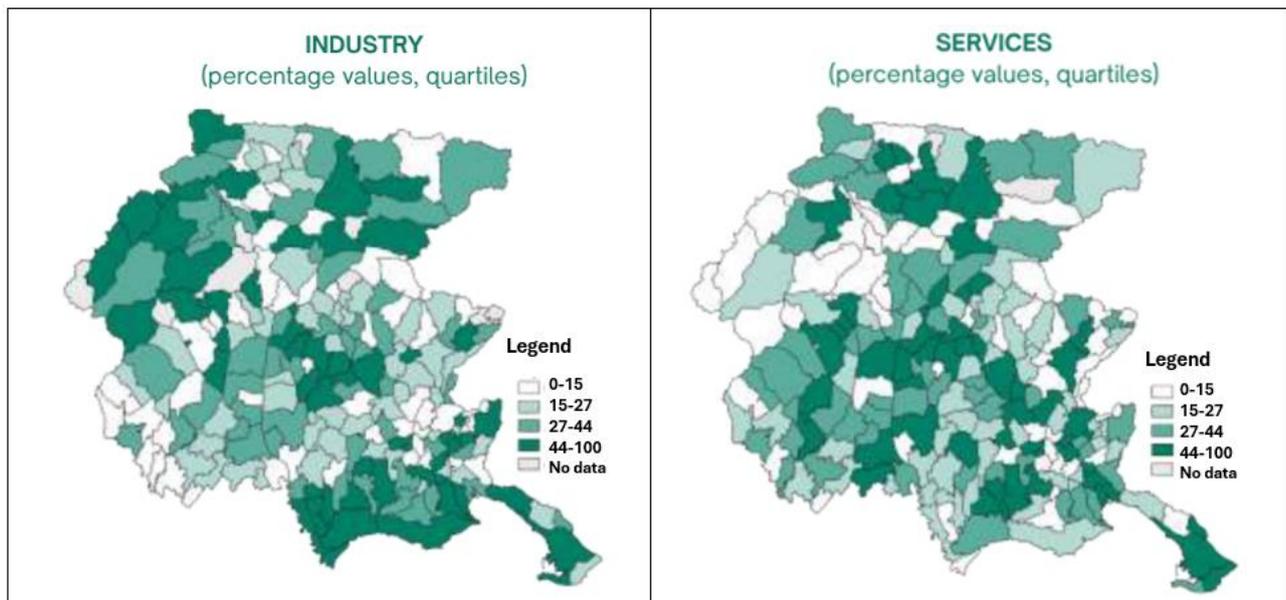


Figure 6, other municipalities also hold relevant numbers of employed in the industry or services sectors.

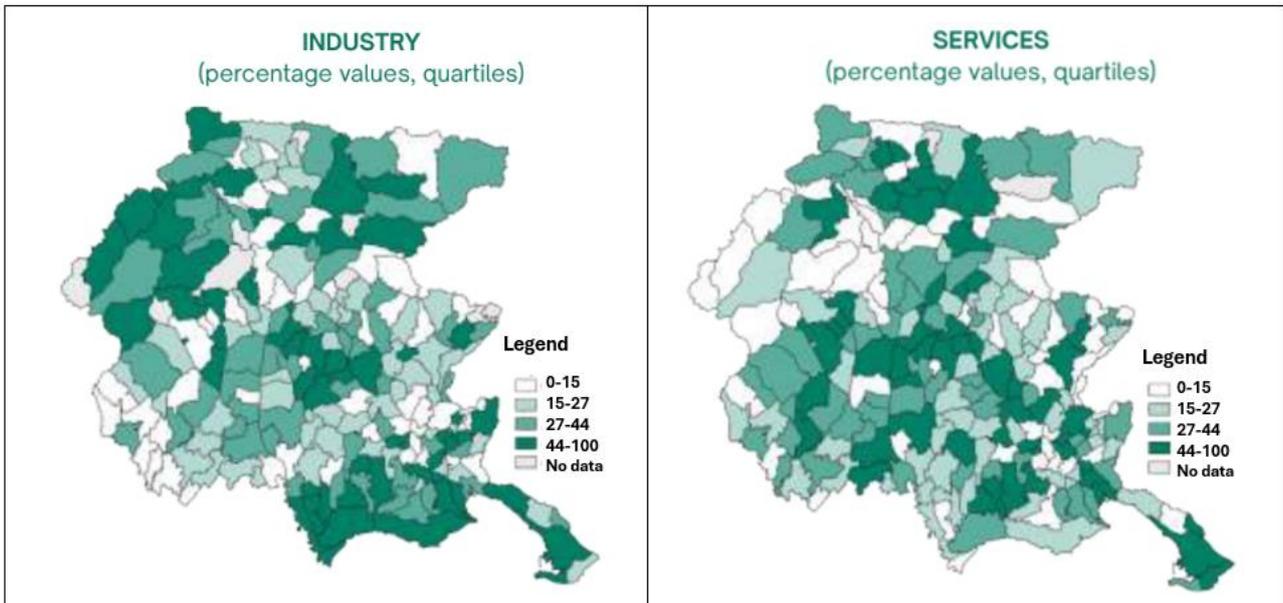


Figure 6 - Percentage of employed in the Industry and Services sectors in the FVG municipalities (ref. year 2017). Source: ISTAT

2.1.2. The key attractors/polarities

Going more into detail into the localisation of key attractors and polarities, they are primarily concentrated in the Trieste city centre, as illustrated in Figure 7 and Figure 8, excerpted from the Trieste Sustainable Urban Mobility Plan (SUMP). Looking at the attractor poles for commuters, the category encompassing main Companies and Public Administration (PA), represented by brown dots in Figure 7 and Figure 8, is particularly relevant. They are mainly positioned in the proximity of the coastline, especially in the central areas at a close distance to the historical centre and the main railway station, but also in the southern part of the Gulf of Trieste, facing Muggia, where the main terminals of the new port and the industrial area are located.

In particular, the port area and industrial zone correspond to the area in violet and light blue colour in the following Figure 9 excerpted from the online visualizer of the City Master Plan (“Piano Regolatore Generale”).

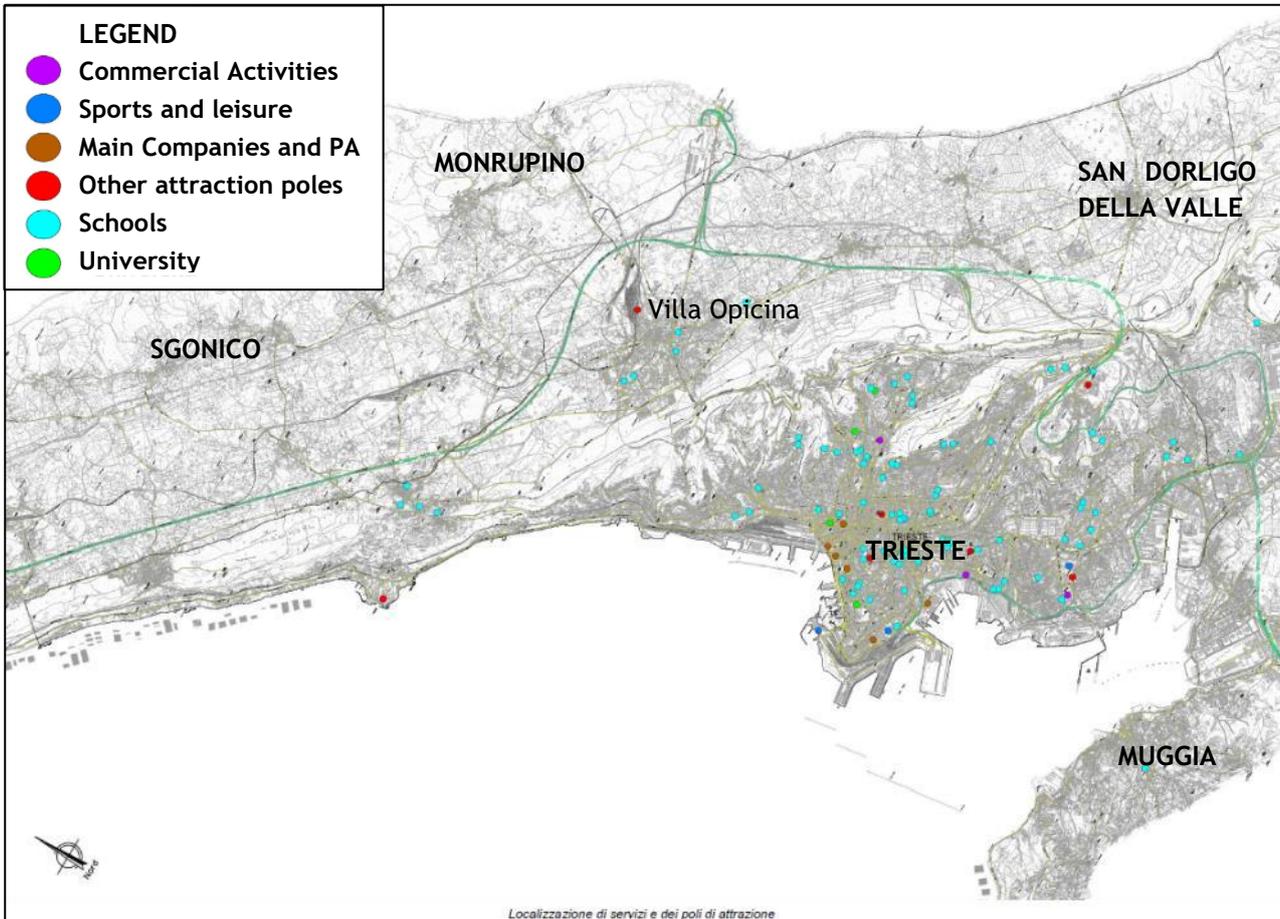


Figure 7 - Location of services and main attraction poles in the Trieste Area. Source: own elaboration on a representation of the Trieste SUMP

Regarding the port, according to a recent study (carried out in 2024⁵), the ports of Trieste and Monfalcone employ a total of 4,058 workers directly within the terminals and related service-providing companies, with the majority of these jobs located in the port of Trieste. Moreover, it is to recall also the connected node of the Interporto located in Ferneti (mainly in the Monrupino municipality), close to the Slovenian border. However, considering the viewpoint of commuting, the Interporto corresponds to a very limited number of employees compared to the port itself. Moreover, a relevant number of commuters are related to logistics and industrial activities near the port area as well as in the hinterland (Bagnoli della Rosandra).

Additionally, other typologies of attractors (see red dots in Figure 7 and Figure 8) include hospitals such as the Cattinara Hospital, which, with more than 800 beds, is the largest healthcare facility in the Friuli Venezia Giulia region (together with other relevant structures as the Burlo Garofalo and the hospital in the city centre). In the area northeast of Trieste's city centre, specifically in the localities of Padriciano and Basovizza, lies the Area Science Park, a significant hub for research and innovation, which hosts the internationally renowned Elettra Sincrotrone Trieste⁶. Located on the Karst Plateau, these campuses are strategically positioned near the Slovenian border, attracting commuters from across the region, including

⁵ "Valutazione dell'impatto economico delle attività nei porti di Trieste e Monfalcone in termini occupazionali, di valore aggiunto e di entrate fiscali", published by AIOM - Agenzia Imprenditoriale Operatori Marittimi di Trieste <https://www.adspmao.it/it/notiziecomunicati/valutazione-dell2019impatto-economico-delle-attivitai-nei-porti-di-trieste-e-monfalcone-in-termini-occupazionali-di-valore-aggiunto-e-di-entrate-fiscali>

⁶ Elettra Sincrotrone Trieste is a state-of-the-art synchrotron light source and free-electron laser facility specialized in advanced materials and life sciences research.



cross-border workers. The park hosts over 64 research centres and companies, employing more than 2,700 people in fields such as life sciences, ICT, and energy.

Moreover, other important attractors of commuters (in this case, mostly for study purposes) are represented by university premises, marked by green dots in Figure 7 and Figure 8.

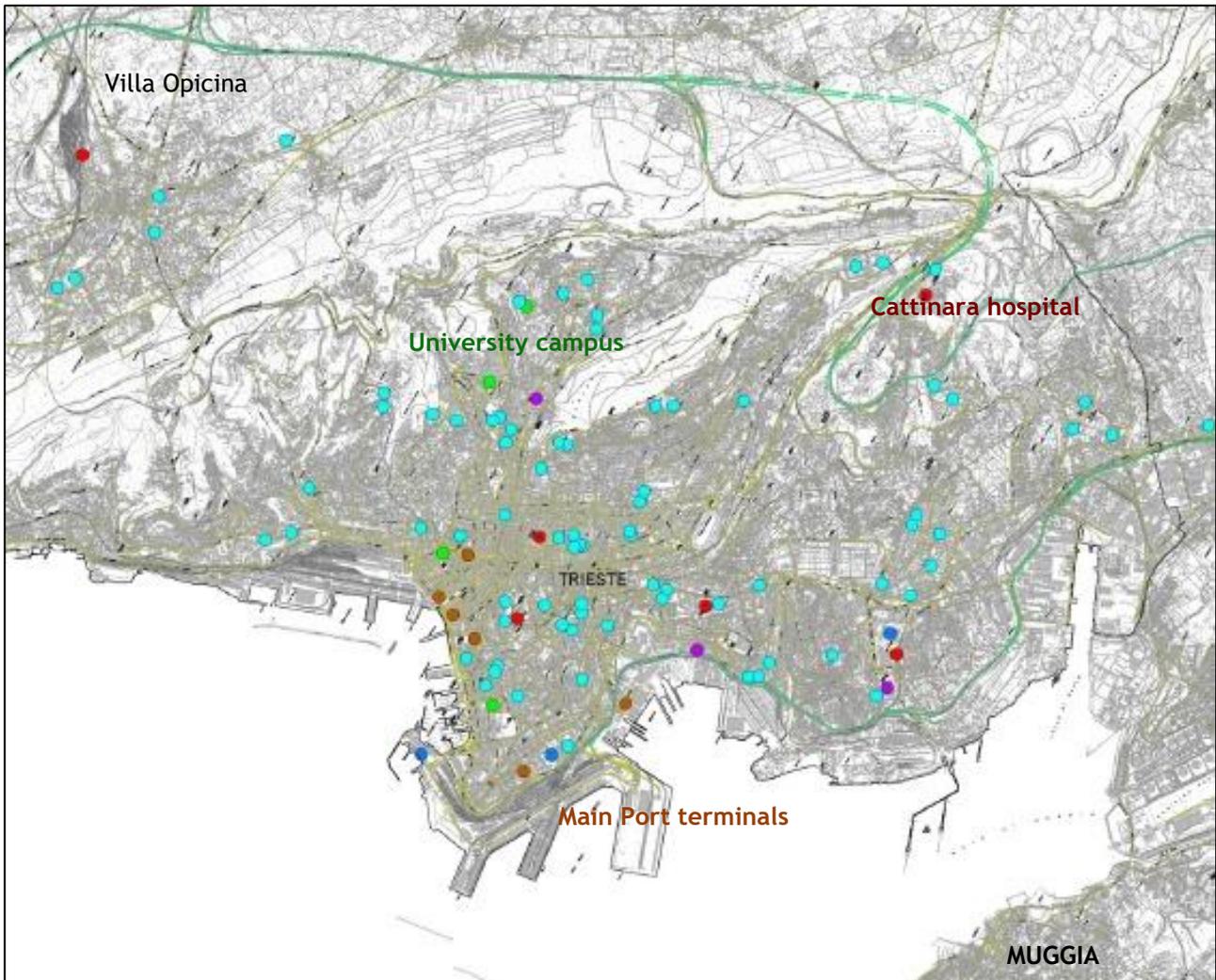


Figure 8 - Location of services and main attraction poles - Zoomed view in the Trieste city centre. Source: own elaboration on a representation of the Trieste SUMP



Figure 9 - Zoning of the Trieste centre with industrial area in violet and port areas in light blue colour (including planned new piers). Source: Trieste Master Plan (“Piano Regolatore Generale”)

The main campus is located in Piazzale Europa, overlooking the city, and houses most of the departments and administrative offices of the University of Trieste (which, overall, registered more than 16,000 students in the year 2023).

2.2. The cross-border dimension

Since the present study focuses on cross-border commuting, it is essential to expand the analyses by briefly introducing the neighbouring Slovenian regions and municipalities. Looking at the Slovenian NUTS3 area, this applies in particular to the Coastal-Karst Statistical Region, referred to hereafter by its Slovene name, Obalno-kraška region.



Figure 10 - NUTS 3 of Slovenia close to the Trieste FUA. Source: own elaborations on SURS data.



The Obalno-kraška region spans an area of 1,043 square kilometres, making it one of the smallest regions in Slovenia by land area. It has a population of approximately 119,000 inhabitants, accounting for around 6% of Slovenia's total population. This corresponds to a population density of 114 inhabitants per square kilometre, which is slightly higher than the national average of 104 inhabitants per square kilometre. Regarding car ownership, the region ranks fourth nationally, with 606 cars per 1,000 residents. Concerning municipalities (which are represented in red colour in the following Figure 11), the region includes the eight listed in Table 4.



Figure 11 - NUTS 3, municipalities and settlements of Slovenia close to the Trieste FUA. Source: own elaboration on SURS, MNRSP and ISTAT data

Municipality	Population	Proportion of population aged 15-64 (%)	Surface area (km ²)	Population Density (Inhabitants/km ²)	Cluster
KOMEN	3509	61.3	103	34	KARST
SEŽANA	13839	61.9	217	64	KARST
DIVAČA	4501	64.7	145	31	KARST
HRPELJE - KOZINA	5181	64.6	195	27	KARST
ANKARAN	3325	62.3	8	412	COAST
KOPER	54252	63.6	303	179	COAST
IZOLA	16479	60.7	29	578	COAST
PIRAN	18119	62.1	44	417	COAST

Table 4 - Key data of the municipalities in the Obalno-kraška region (reference year 2024). Source: SURS data and own elaborations



In general, these municipalities are quite large, with an average surface area of about 130 km², with Koper registering the highest value, exceeding 300 km². On the other hand, an exception is represented by the case of Ankaran, whose surface is only 8 km². Additionally, Izola and Piran are relatively small, each one covering less than 50 km².

To achieve a more detailed subdivision, settlements are utilised as a finer statistical unit (see the related thematic representation in Figure 11).

As mirrored in the name of the NUTS3 region and considering the previously mentioned geomorphological differences, two distinct clusters of municipalities can be identified: the "Coast," which includes all Slovenian municipalities along the Adriatic Sea, and the "Karst," encompassing municipalities situated in the hinterland characterised by the Karst Plateau. This classification is also illustrated in the last column on the right of Table 4.

Recalling the difference in the urbanisation level mentioned previously, the municipalities in the first cluster are all classified as "Towns and suburbs" while those in the Karst all belong to the category "Rural areas". This stark contrast is also reflected in the data presented in Table 5. In fact, over 75% of the population lives in the Coastal municipalities, which account for less than 37% of the total surface area. Correspondingly, the population density in these municipalities reaches 397 inhabitants per square kilometre, significantly higher than the regional average of 114 inhabitants per square kilometre and more than ten times the density observed in the Karst municipalities (39 inhabitants per square kilometre).

Municipality	Population		Surface area (km ²)		Population Density (Inhabitants/km ²)
	Value	%	Value	%	
KARST	27030	22,7%	660	63,3%	39
COAST	92175	77,3%	384	36,8%	397
Entire OBALNO-KRAŠKA	119205	100%	1043	100%	114

Table 5 - Key data for the two identified clusters and the entire Obalno-kraška region (reference year: 2024). Source: SURS and own elaborations

More specifically, the area of interest for the present study is not exactly and exclusively represented by the Obalno-kraška region.

First of all, it is considered appropriate to exclude the municipality of Komen, located in the northernmost part of the Obalno-kraška region, from the main focus of the analysis presented in the following chapters. This decision is based on its considerable distance from the main centres and attractors of the Trieste Functional Area, as well as from the related transport routes examined in this project. Additionally, it is to highlight its proximity to other centres in the Gorizia area, such as Monfalcone, accessible via the orographically favoured route through the Brestovica Valley (Brestoviški dol).

On the other hand, it is appropriate to consider a few additional cases related to the Primorsko-notranjska region (e.g. Postojna, Ilirska Bistrica, and Cerknica) and the Osrednjeslovenska region (esp. Ljubljana).

Drivers and Dynamics in the Integration process towards a possible Cross-Border FUA



The analysis of cross-border commuting and its relevance can be associated with an extension of the concept of FUA beyond the national border. However, despite extensive research efforts⁷, at present, there is no formal identification of such typologies in the whole EU. Nonetheless, it is important to analyse the phenomena (esp., commuting) to identify even a partial tendency towards the actual development of conditions that could be associated with the concept of FUA even across national borders.

In this regard, a context such as Trieste FUA and neighbouring Slovenian areas could play a relevant role as an interesting laboratory and observatory of urban and cross-border integration dynamics⁸.

Obviously, this entails additional aspects that are partially addressed in the following chapters and partially fall beyond the scope of the present document. Nonetheless, some key elements can already be outlined, particularly with reference to the socio-cultural framework. Their relevance is also tied to the specific focus of the analysis on cross-border commuting (see, in particular, the following chapters 4-6), as they concern segments of the population more inclined or contexts more favourable toward cross-border movements due to the absence of the linguistic barrier.

In particular, linguistic minorities and the resulting bilingual areas are present on both sides of the border as follows:

- A Slovenian-speaking minority on the Italian side, particularly in the hinterland areas of the Karst plateau. Its entity is particularly relevant in the municipalities of Duino-Aurisina, Sgonico, Dorigo della Valle and in the hinterland areas of Trieste;
- An Italian-speaking minority in the coastal municipalities of Slovenia (see “Coast” cluster in Obalno-kraška region).

As pointed out in an analysis by the Managing Authority and Joint Secretariat of the Italy-Slovenia Cross-border Cooperation Programme⁹, the linguistic minorities on both sides “have already planned to implement a permanent bilingual mass media for Cross Border Cooperation” and are contributing to a general effort for overcoming the linguistic barrier, which is perceived as one of the more relevant in limiting the cross-border cooperation and integration.

Moreover, in recent decades (especially after Slovenia entered the EU in 2004 and the Schengen Area in 2007 while also adopting the Euro as its currency), a growing number of Italians have reportedly been settling in the Slovenian municipalities close to the border, particularly in the Karst area (e.g., Sežana)¹⁰. This trend could correspond to a common suburbanisation phenomenon where individuals working in a major urban centre, like Trieste, choose to reside in the hinterland due to various reasons, including different opportunities in the real estate market. This dynamic reflects the complementary relationship between city and hinterland conditions, which is a key factor in identifying a FUA.

As a preliminary takeaway, assessing the number of cross-border commuters toward the Trieste Functional Urban Area (FUA) provides a metric, both currently and prospectively, for evaluating progress toward an

⁷ See for instance: , or remarks on “Regions with the potential to become cross-border functional area” outlined within the Implications for the next generation of INTERREG programmes (beyond 2027) in https://ec.europa.eu/regional_policy/sources/policy/how/future-cohesion-policy/Expert_paper_Boehm_230621.pdf

⁸ Still in the case of FVG Region and neighboring Slovenian area another interesting case (with its own peculiar aspects) is given by the case of the Gorizia-Nova Gorica urban area.

⁹ Analysis on 2014-2020 project applications through the concept of functional areas available at

¹⁰ In this regard, see also a PhD thesis issued in 2010 giving a thorough insight into this example of spatial mobility in EU “internal” border areas <https://www.openstarts.units.it/server/api/core/bitstreams/f0122f71-14b4-49f7-b12a-392ece7d8f3d/content>



effective cross-border FUA. This aligns with the EU-OECD commuting area criterion requiring at least 15% of employed residents in surrounding areas to work in the core city.



3. The multimodal transport system of the analysed area

In this chapter, a brief description of the multimodal transport system and public transport services within the Trieste FUA is provided. Additionally, key characteristics of the public transport system in neighbouring Slovenian regions are outlined as well, given the specific focus of the present deliverable. More generally, in the case of Trieste, attaining the full role of transport hub implies, almost inevitably, dealing with the cross-border dimension in a context with a high transnational vocation but also challenging issues. Finally, this description is complemented by an overview of key regional and local level planning documents on sustainable mobility that are relevant to the analysed area.

3.1. Overview of the multimodal transport network of the analysed area

The geographical and geomorphological characteristics described previously, over the years, have significantly contributed to shaping the Trieste FUA transport network. Looking from a wide perspective, it is to underline the presence of a port endowed with a natural deep-sea floor and located in correspondence with the northernmost reach of both the Adriatic and the Mediterranean Sea.

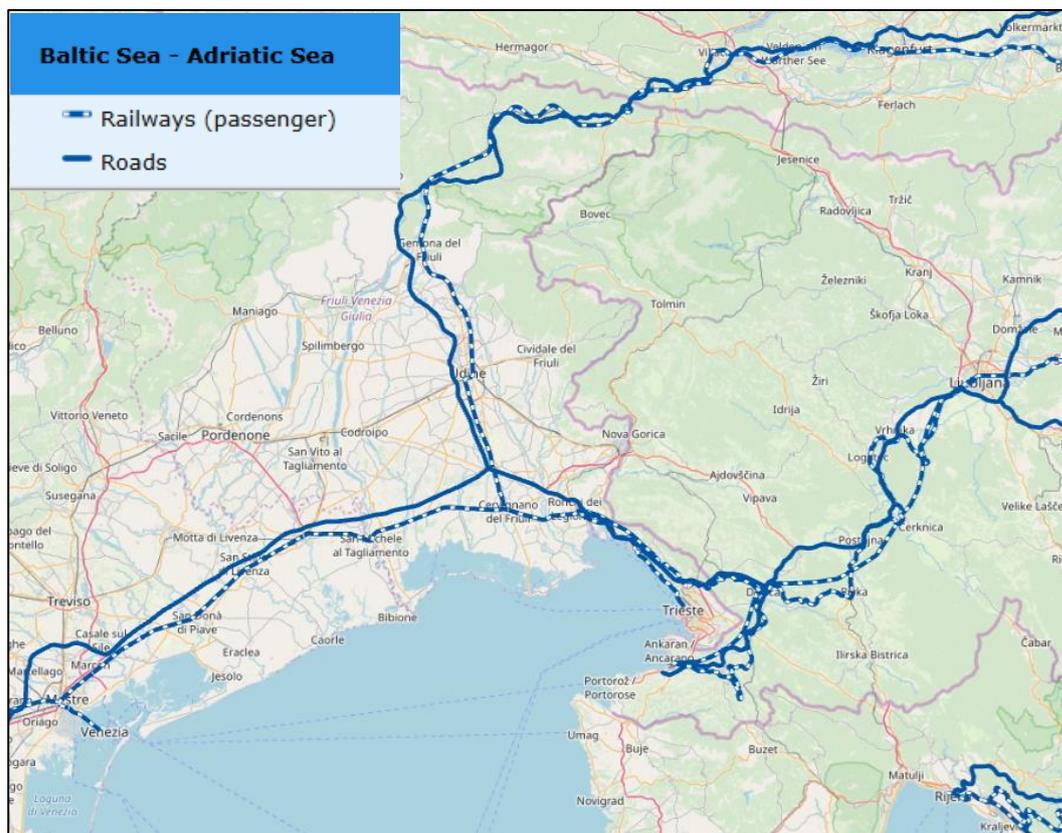


Figure 12 - The TEN-T Baltic-Adriatic core network corridor – zoomed view. Source: TENtec

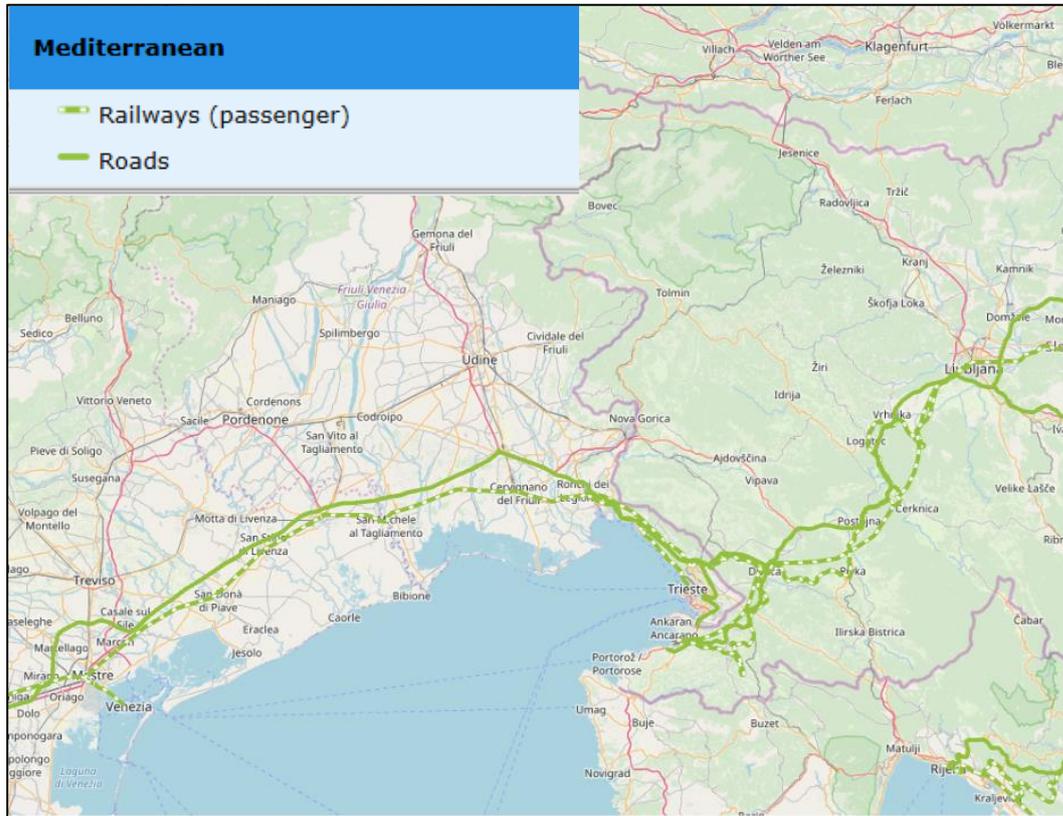


Figure 13 - The TEN-T Mediterranean core network corridor – zoomed view. Source: TENtec

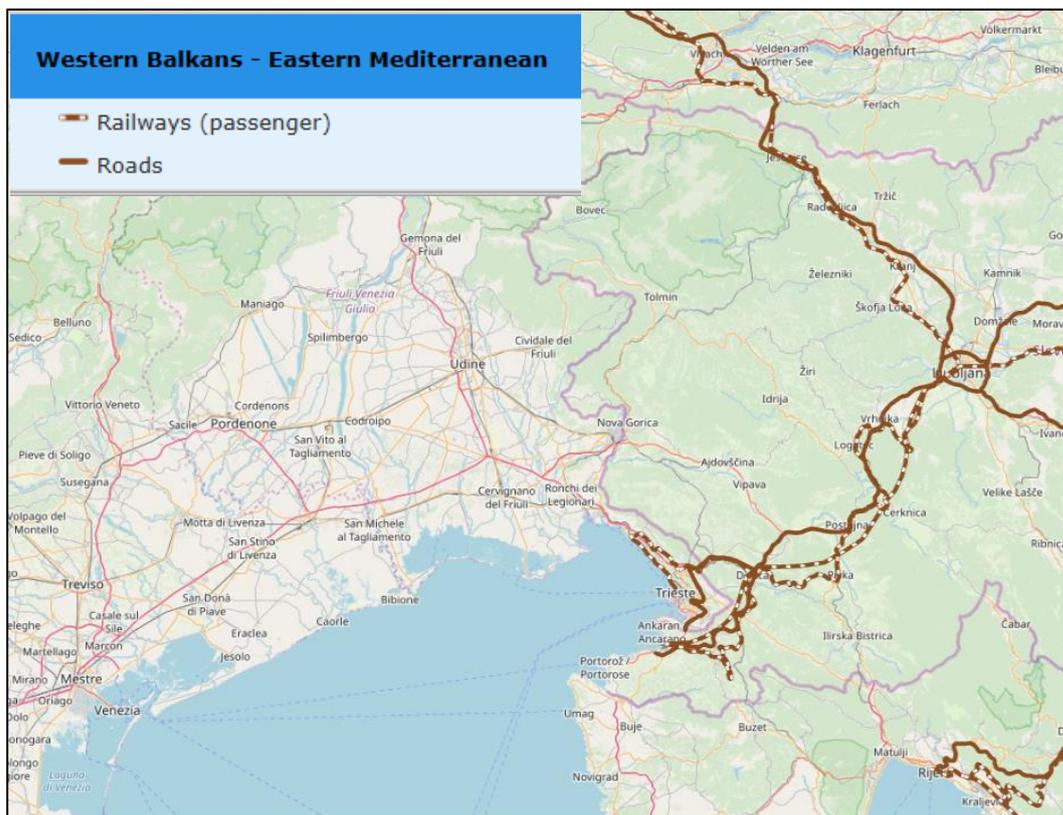


Figure 14 - The TEN-T Western Balkans core network corridor – zoomed view. Source: TENtec



On the surface transport side, the presence of three core network corridors of the TEN-T network (Baltic-Adriatic, Mediterranean and Western Balkans - Eastern Mediterranean) testifies to the strategic relevance of the multimodal connections passing through the Trieste FUA (see, respectively, Figure 12, Figure 13 and Figure 14).

On the other end, it is to underline that the main rail station (Trieste Centrale) is a terminus station of the Italian railway network, thus limiting seamless rail connections.

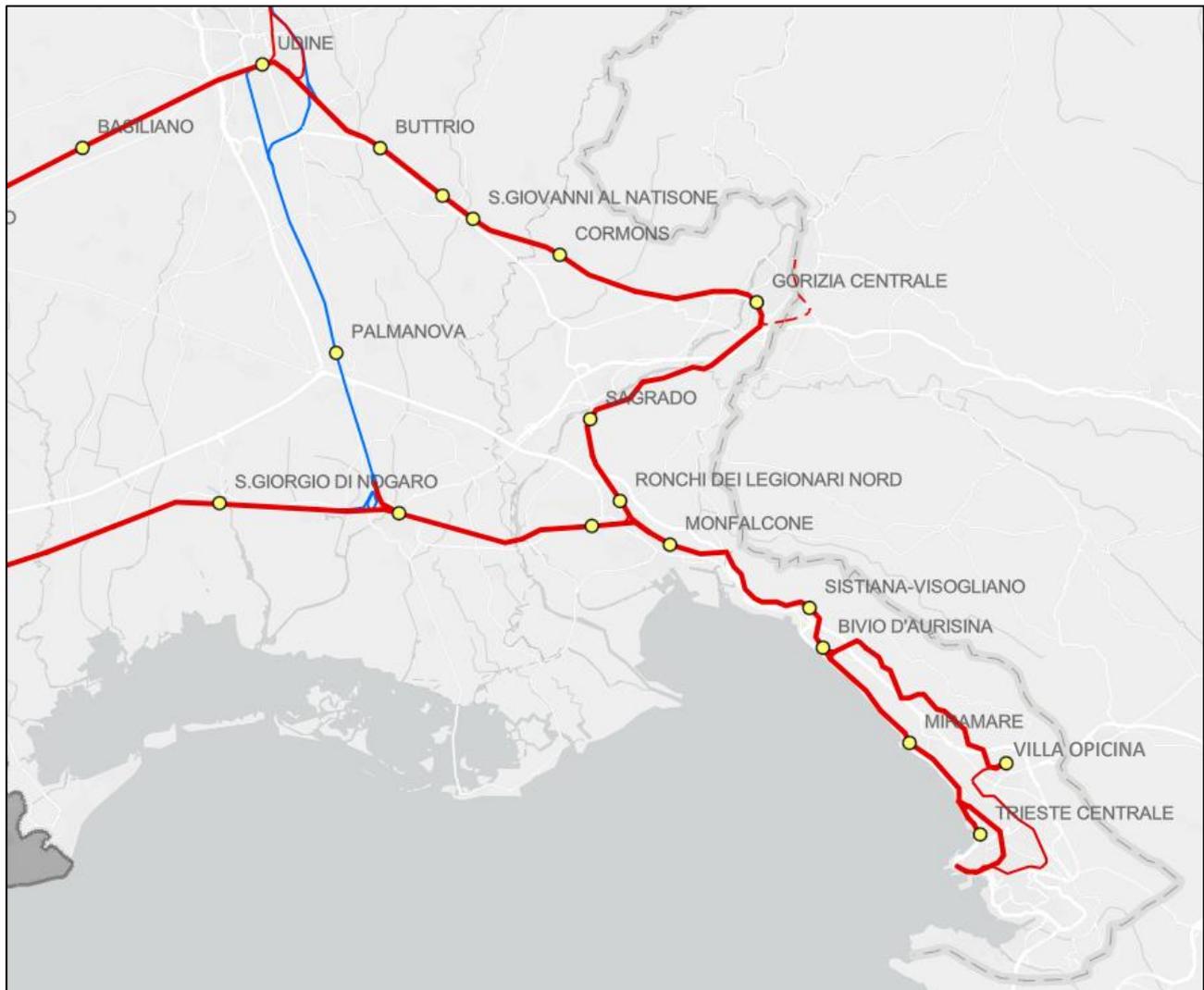


Figure 15 - The Friuli Venezia Giulia railway network – zoomed view in Trieste FUA and neighbouring areas. Source: RFI¹¹

More specifically (see **Errore. L'origine riferimento non è stata trovata.**), the passenger train stations located within the Trieste FUA are:

- Sistiana-Visogliano, in the municipality of Duino Aurisina
- Bivio D'Aurisina, in municipality of Duino Aurisina;
- Miramare, in municipality of Trieste

¹¹ See also https://www.rfi.it/it/rete/la-rete-oggi/La_rete_oggi_regione_per_regione/friuli-venezia-giulia.html



- Trieste Centrale, in the municipality of Trieste
- Villa Opicina, in municipality of Trieste

It is worth noting that the link from Monfalcone (in the province of Gorizia) to Bivio Aurisina connects with the rest of the Italian railway network. Moreover, this link is shared by connections to/from Slovenia (and Ljubljana) and to/from the city of Trieste. From Bivio Aurisina onward (in an eastward direction), the two connections split (as indicated by the Italian term "bivio" included in the name of the station). Consequently, the only station within the municipality of Trieste on the line linking to Slovenia and Ljubljana is Villa Opicina, which is located in a minor settlement about 7 kilometres from the city centre.

It is also the border station in the railway network, which has relevant implications for interoperability aspects. Notably, both Italy and Slovenia use a 3 kV DC electricity supply. However, each Country has its own safety and signalling systems – SCMT in Italy and INDUSI in Slovenia – posing significant interoperability challenges. Specifically, this necessitates specific technical requirements for rolling stock and procedures, including crew changes, at border crossings like Villa Opicina, resulting in waiting times of up to 20 minutes. For this purpose, a relevant improvement is related to the adoption of the “European Railway Traffic Management System” (ERTMS) that, among other things, is meant to provide a unifying framework to the TEN-T core network corridors. In this regard, it is to report its achievement only on the Slovenian side, covering the section from the border up to Ljubljana and beyond.

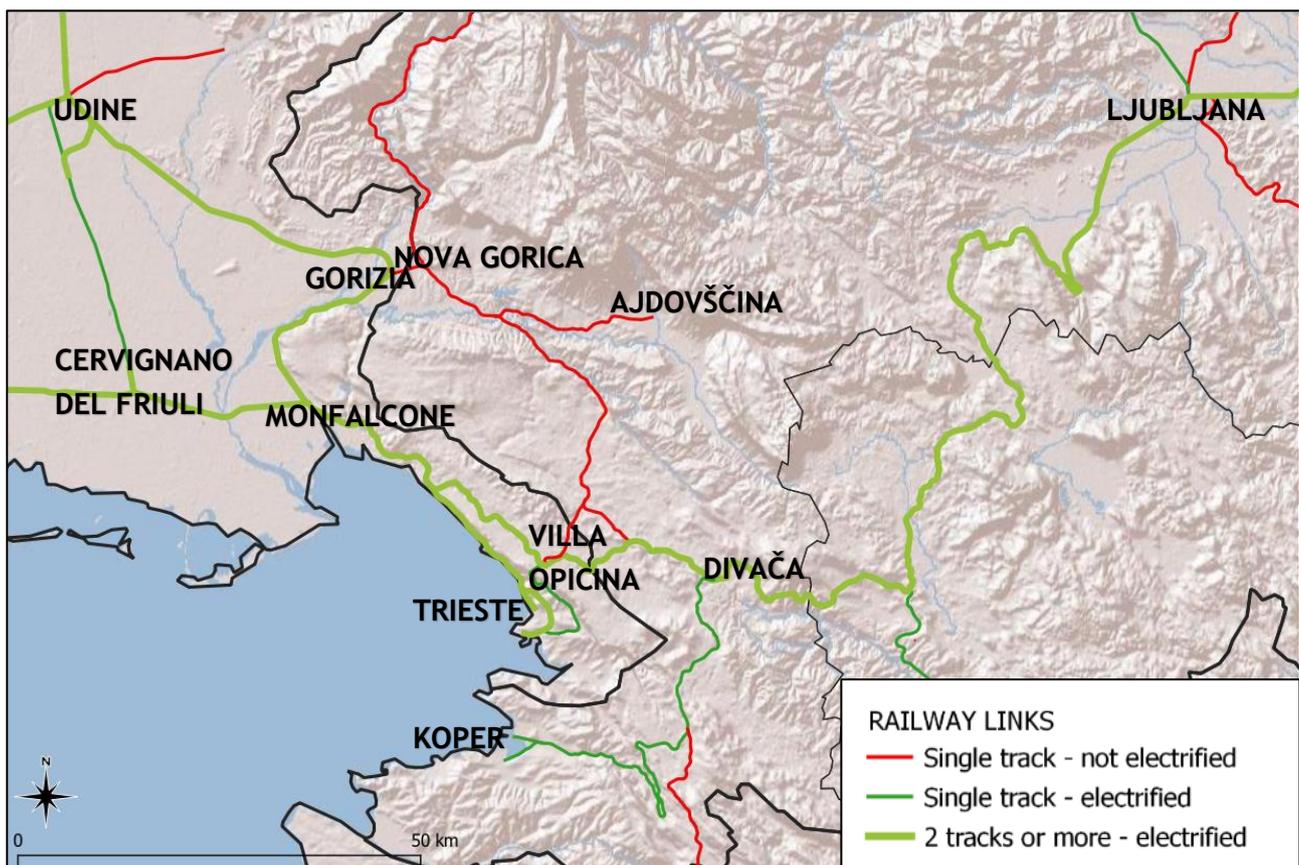


Figure 16 - The railway network infrastructures in the cross-border area. Source: Own elaborations on RFI and SŽ data

It is also important to underline that the border crossing at Villa Opicina, located on a two-track electrified line, is one of the two railway connections linking Italy and Slovenia. The other connection is the section



between Gorizia and Šempeter pri Gorici, which continues to Nova Gorica. This section is a single-track line, and its electrification and upgrade are currently underway. Notably, Šempeter pri Gorici and Nova Gorica are situated on the "Transalpina" line, which is a non-electrified single-track line.

In this regard, Figure 16 presents a thematic map illustrating the number of tracks and the presence (or absence) of a railway electrification system, which supplies electric power to trains.

These two factors are crucial for the performance of rail links. In fact, they are fundamental in assessing the capacity of a link, which is defined as the maximum number of trains that can traverse a section of the link within a given time interval. As regards to future improvements, it is important to mention the ongoing realisation of the new link between Koper and Divača in Slovenia.

In order to provide a more complete picture also of the usage of these links, Figure 17 (excerpted from the previous CROSSMOBY project of the Italy-Slovenia Programme) shows a thematic representation of the number of daily passenger trains in the different links on an average working day¹².

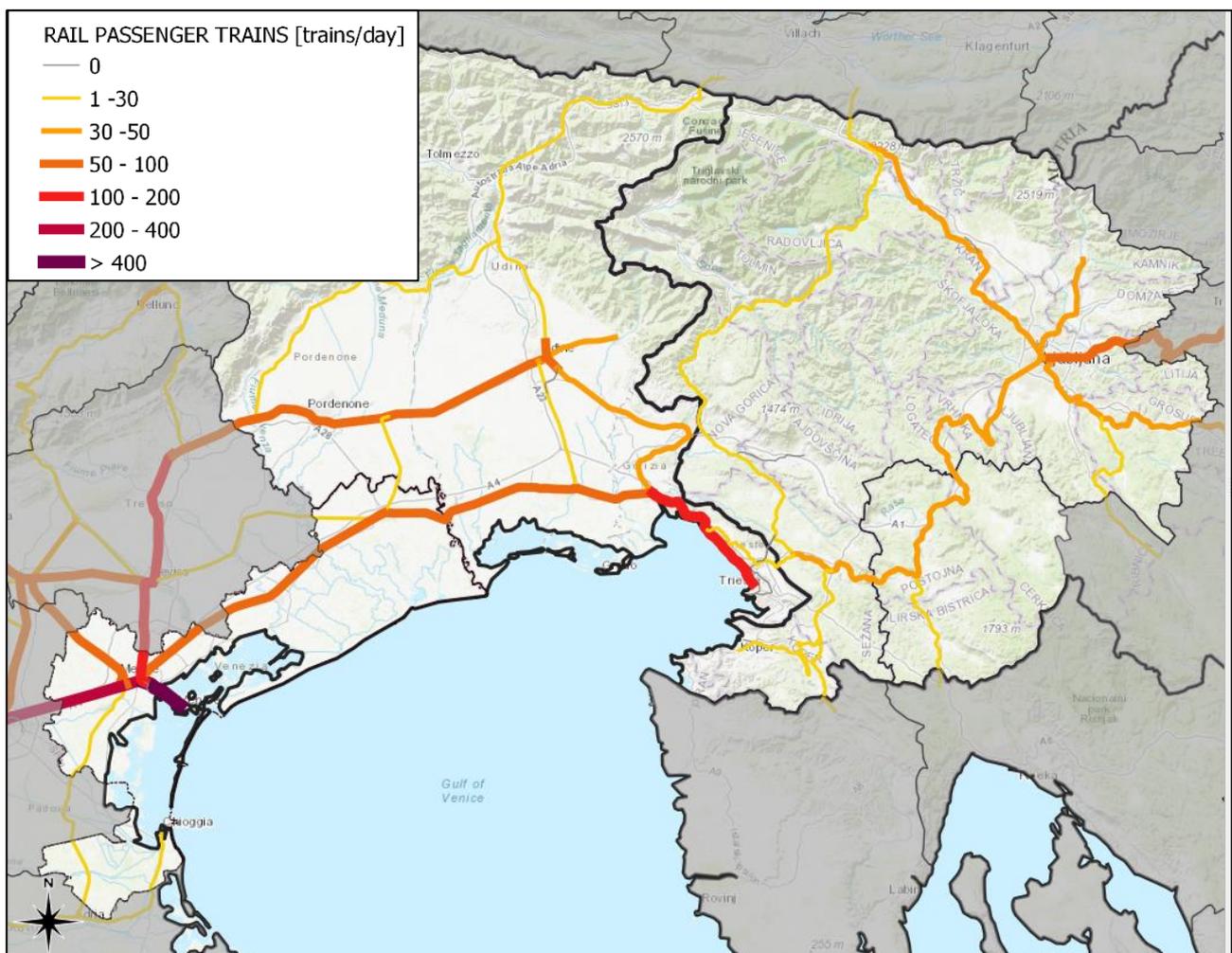


Figure 17 - Railway network passenger train flows in the IT-SI Programme area. Source: CROSSMOBY project (Italy-Slovenia Programme)

¹² 1). Reference year 2020 This figure is representing the situation in the reference year 2020 out of the contingent changes due to measures taken for tackling the COVID-19 pandemic (e.g. temporary cancelling of cross-border services).



In this regard, it is also important to recall and highlight that since the rail network is also used by freight trains, the corresponding figures are also needed in order to evaluate the level of saturation and, consequently, the possibility of introducing new services (either passengers or freight ones).

Among others, it is to highlight that a remarkable number of passenger trains are registered in the Monfalcone-Trieste Centrale section.

These high values in the coastal rail line to Trieste contrast with the gap at the cross-border level, which different initiatives are addressing. In fact, also thanks to the co-financing opportunity and cooperation efforts carried out through Interreg Projects, it was possible to re-establish (previously cancelled) connections. In this regard, it is worth mentioning the CROSSMOBY project (Italy-Slovenia Programme), which re-activated a passenger train connection linking Udine/Trieste and Ljubljana. More recently (2024), the Trieste (namely, Villa Opicina border station)-Rijeka connection was also activated within the SUSTANCE project (Interreg Central Europe Programme).



Figure 18 - Train service linking Udine/Trieste with Ljubljana activated through the SUSTANCE project.

Source: SUSTANCE project (Interreg Central Europe Programme)



Figure 19 – Train service linking Udine/Trieste with Ljubljana activated through the CROSSMOBY project.
Source: CROSSMOBY project (Italy-Slovenia Programme)

Concerning the road network, the following Figure 20 shows the main road links of the Trieste FUA.

The Trieste FUA is connected to the rest of Italy through two main road networks: the A4 Motorway Turin - Sostina (TS), which continues towards Trieste with the classification RA 13 (“Raccordo Autostradale”) and the SS 14 national road along the coast. The RA 13 motorway link continues with the “Grande Viabilità Triestina” (SS 202), a partial ring road around the city. From this ring, two main connections branch off towards the two cross-border crossings of Ferneti (RA14), towards the direction of Sežana (and further away, Ljubljana), and Rabuiese, towards Koper.

The SS14, instead, after reaching the centre of Trieste, continues climbing onto the Carso up to the cross-border crossing in the locality of Pesek (a locality in the municipality of San Dorligo della Valle). An additional secondary road route is constituted by the SR TS 1 (former SP1), which goes along a more internal direction, branching off from the SS14 at Sostina and then reconnecting to it in the area of the settlement of Basovizza.

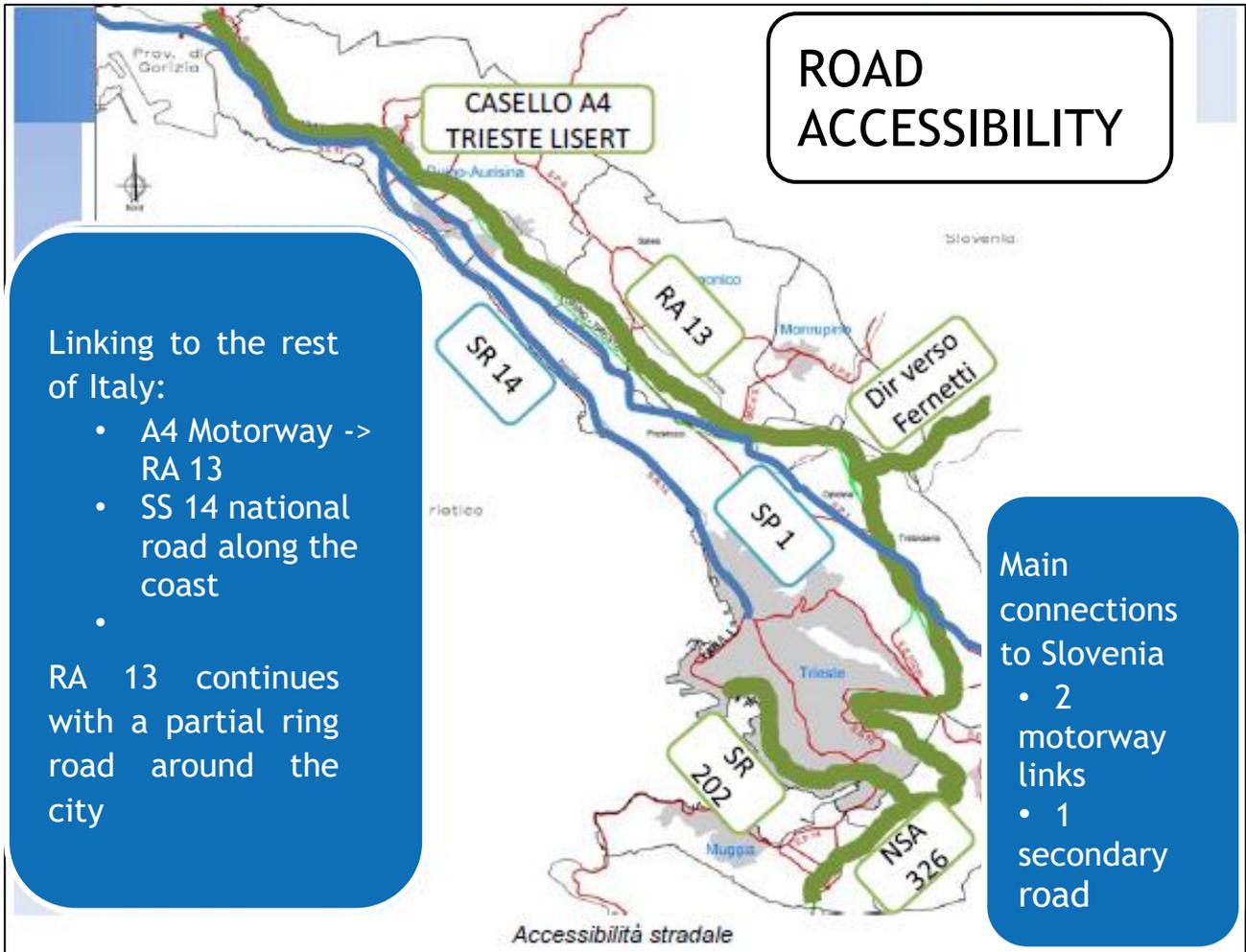


Figure 20 - The main road links of the Trieste FUA. Source: adapted from Trieste SUMP mobility baseline analysis



3.2. Local public transport services of the Trieste FUA

Apart from existing infrastructure and long-distance connectivity ensured by rail services, a key focus in the present analysis is represented by the local public transport services carried out in the analysed area. In fact, they could provide the multimodal accessibility needed to cater for the transport demand for commuting trips at the cross-border level.

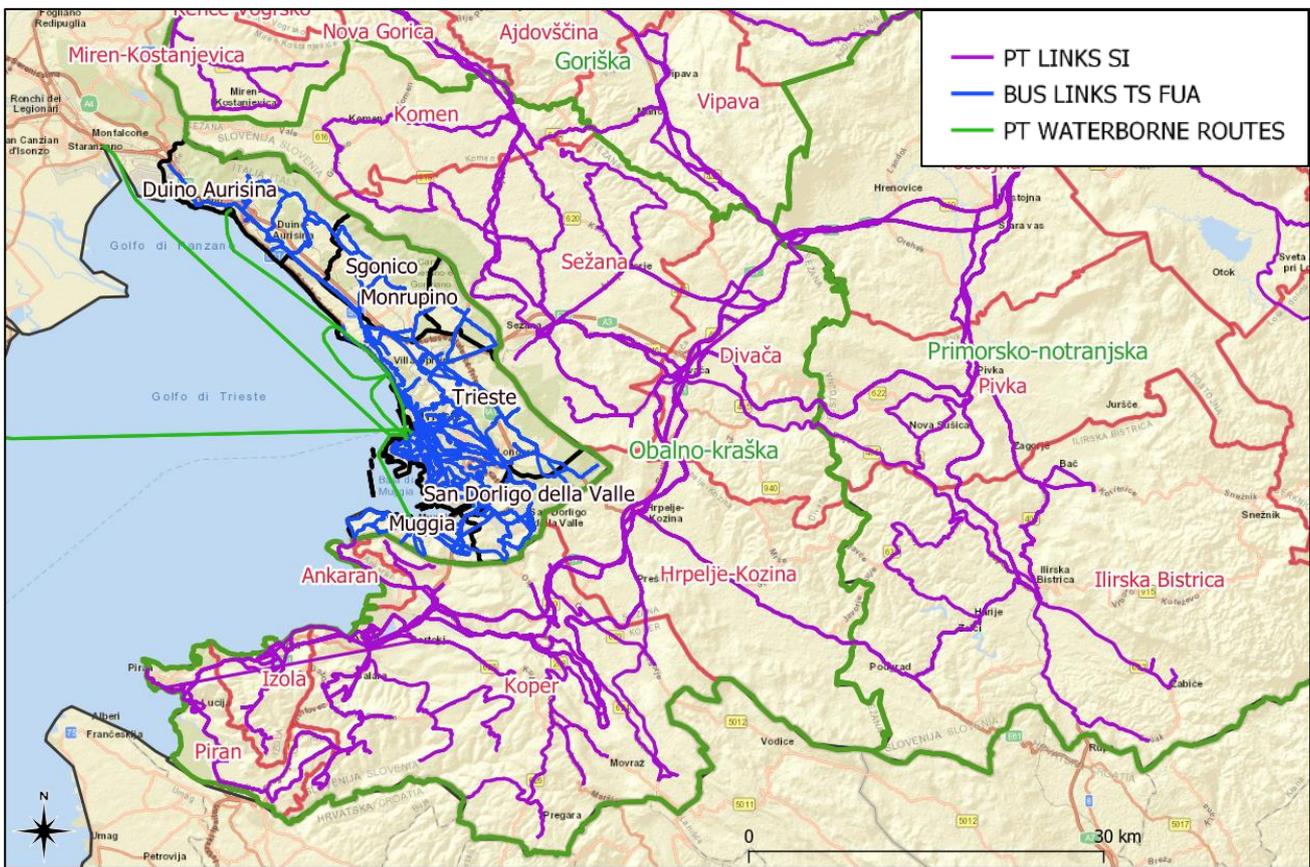


Figure 21 – The LPT services in the analysed area. Source: Italian and Slovenian NAPs

Essentially, this local-level accessibility is currently provided by the bus services whose routes in the Trieste AFU and Slovenian neighbouring areas are represented, respectively, in blue and violet lines¹³ in Figure 21 and Figure 22. As a general remark, there is already a relevant network of services, which is particularly dense in the urban core of Trieste, as testified by the number of stops, represented in light blue dots in Figure 22 (while the stops in the Slovenian network are represented in yellow dots). However, there are relevant gaps due, in particular, to the missing integration and lack of cross-border local bus services going across the national border. These gaps are focused on and addressed in more detail in the last chapters of this deliverable.

¹³ These representations are based on the availability of data sources on public transport services described in the following chapter 5.

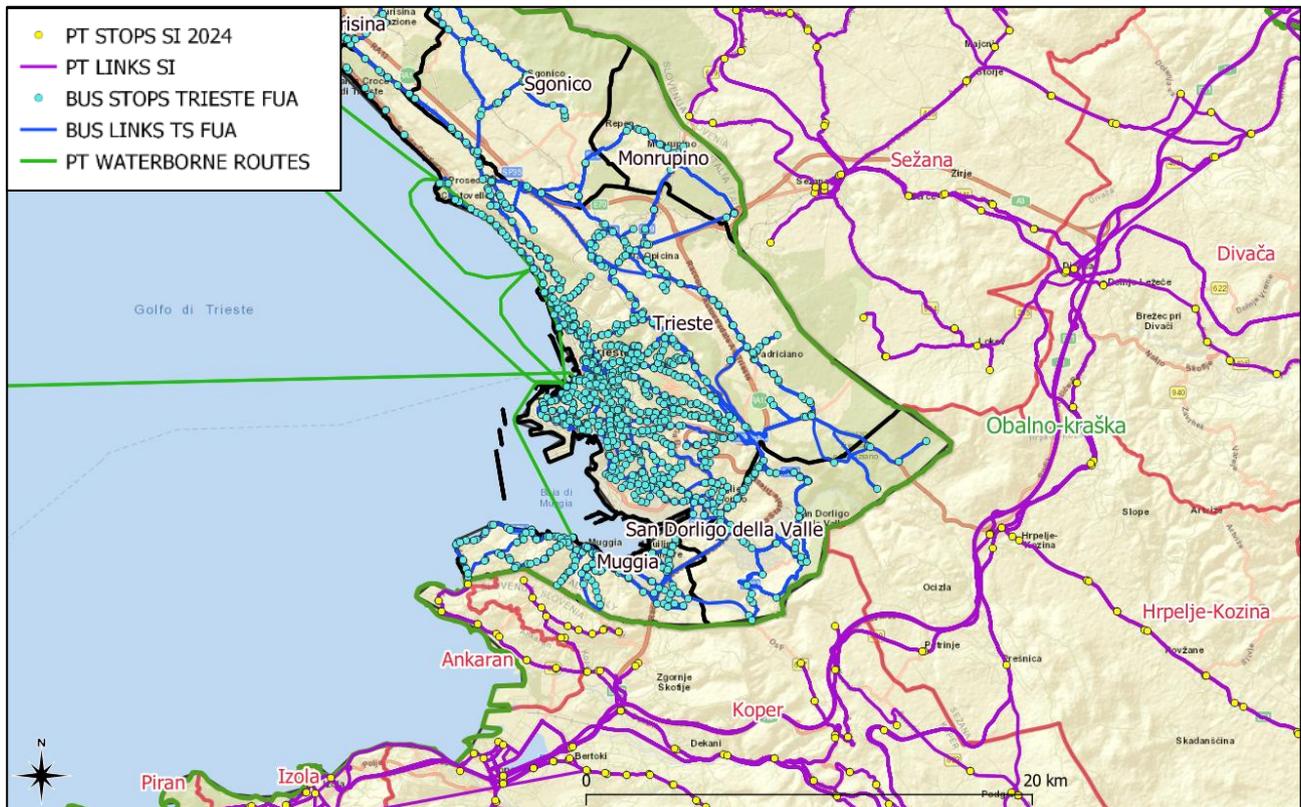


Figure 22 – The LPT services in the analysed area – zoomed view. Source: Italian and Slovenian NAPs

3.2.1. Bus and maritime services of the Trieste FUA

The local public transport in the Trieste FUA is operated by TPL FVG under a 10-year service contract awarded in 2019. Within this framework, public transportation in the Trieste area is managed by Trieste Trasporti, a member of the consortium that established TPL FVG. Its network includes over 50 bus lines covering the city and extending into the Karst plateau, ensuring accessibility to various neighbourhoods and nearby towns. The bus system operates with high frequency, particularly during peak hours, making it a reliable option for daily commutes.

The extensive coverage of the network is also evident from its density, with 57.6 kilometres of service per inhabitant in the Trieste area, compared to a regional average of 36.5 and a national average of 29.5 kilometres per inhabitant.

One of the most iconic features of Trieste's public transport is the Trieste-Opicina tramway, a hybrid tram and funicular railway connecting the city centre with Villa Opicina. After being closed for maintenance and due to the pandemic, the tramway resumed operations in February 2025.

Moreover, it is to underline the introduction of Demand-Responsive Transport (DRT) services, which are operating in the city centre on Fridays and Saturdays from 10:00 PM to 4:00 AM, and also on Wednesdays from September to June.

Furthermore, particular attention is paid to the possibility of developing cross-border services, which are envisioned in both planning and contractual documents in terms of flexibility threshold, especially in light of possible emerging needs. This will be further detailed in Chapter 8 of the relevant document.



Additionally, Trieste offers maritime services with ferry connections to coastal towns such as Muggia, Barcola, Grignano, and Sistiana. These services are especially popular during the summer when tourism peaks.

A relevant deal is also paid to the cross-border dimension in the case of maritime transport. In this regard, the FVG Regional Plan for Local Public Transport issued in 2013 has highlighted the relevance of the two maritime connections shown in the following Figure 23. These connections have been addressed by various projects stemming from the EA SEA-WAY project, co-funded by the CBC IPA-Adriatic Programme 2007-2013, through which it implemented a new maritime service between Trieste, Piran (Slovenia), Rovinj (Croatia) and Pula (Croatia). More recently, the extension to Mali Lošinj Island was introduced through the MOSES Project (Italy-Croatia Programme), while the stop in Pula, instead, was cancelled. Moreover, the INTERCONNECT project (Adriatic Programme) case study proposed further improvements in intermodal connections and accessibility, pivoting on the existing maritime services connections. In one of the two analysed sub-cases, the potential and development of a new maritime service linking (Trieste-)Muggia-Koper was also addressed. Furthermore, the feasibility of the new IT-SI maritime connection was further explored in the FORTIS project (Italy-Slovenia Programme).

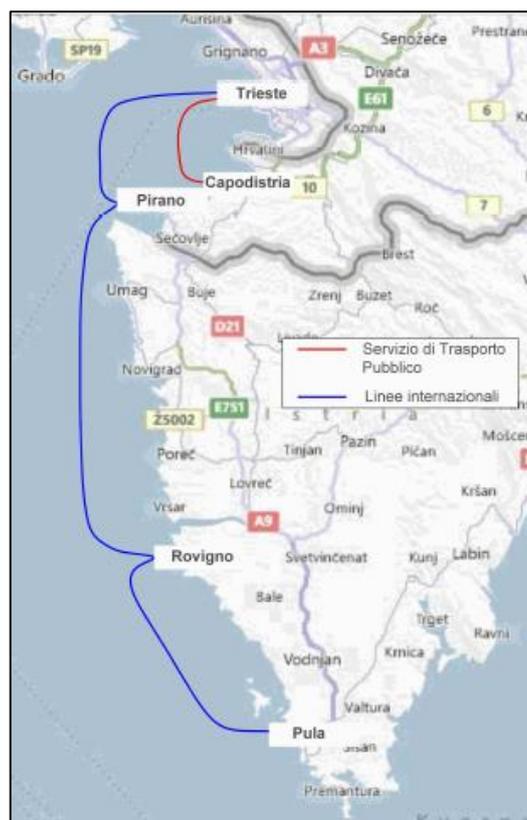


Figure 23 – The international (blue) and ITA-SI CB line (red) as envisaged in the FVG regional PT plan. Source: “Piano Regionale del Trasporto Pubblico Locale” – PRTP, 2013



3.2.2. Public transport services of the neighbouring areas in Slovenia

The public transport system in the Obalno-Kraška region in Slovenia is primarily reliant on bus services operated by Arriva Slovenia, on the basis of a national-level contract issued in 2023. In general, urban hubs like Koper benefit from better connectivity. In any case, rural Karst areas are also served by quite frequent bus services with a good level of coverage, thus providing accessibility across the region. In fact, in a recent study¹⁴, the region has low mobility poverty (in terms of residents lacking public transport stops within 500 meters of their homes) if compared with other Slovenian regions, as for instance, Goriška (see Figure 24).

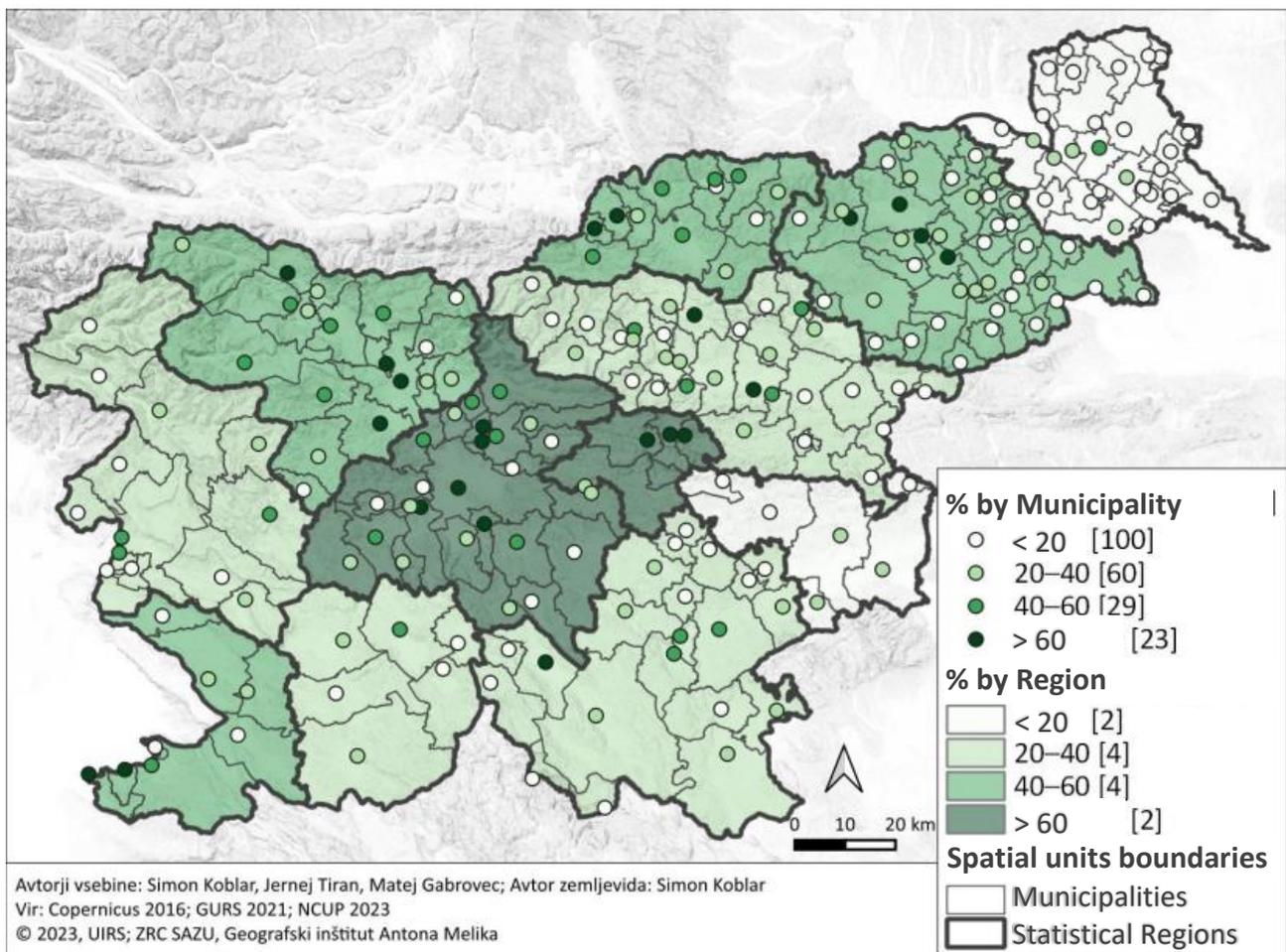


Figure 24 – Proportion of the population with a reasonable frequency of public transport journeys by the municipality and statistical region (within 500 m). Source: Mobility Poverty Overview in Central and Eastern Europe – Slovenia (2023)

3.3. Synopsis of the planning activities on sustainable mobility

Planning documents on sustainable mobility issued at the regional and local levels represent key sources of data for supporting the technical analyses presented in the next chapters of the present document. Furthermore, they provide insight on possible measures and initiatives to be developed.

¹⁴ https://focus.si/wp-content/uploads/2023/03/Slovenia_en.pdf



Two key documents provide the strategic reference concerning transport planning for Friuli Venezia Giulia Autonomous Region (FVG):

- The Regional Plan of Transport Infrastructure, Freight Transport and Logistics (“Piano regionale delle Infrastrutture di Trasporto, della Mobilità, delle Merci e della Logistica” - PRITMML), issued in 2012
- The Regional Public Transport Plan (“Piano Regionale del Trasporto Pubblico Locale” - PRTPL), issued in 2013 (approved by Decree of the President of the Autonomous Region n. 80, 15 April 2013).

It is important to underline the attention paid within the Regional Public Transport Plan to cross-border accessibility and connectivity. In fact, in the case of the FVG Autonomous Region, the subdivision of competencies in the fields of road network and (multimodal) transport between the national and the regional level is ruled by the Legislative Decree n. 111/2004. In particular, it prescribes that cross-border transport within a specified range is under the competence of the Region. Hence, these specific aspects will be deepened in Chapter 8 of this report.

Moreover, it is worth mentioning the ongoing development of the updated version of the PRITMML. The related data collection and survey process also contributes to the data sources for the present analysis, listed in the following Chapter 5.

A regard to the Slovenian national level, the following documents must be mentioned:

- The Transport Development Strategy of the Republic of Slovenia until 2030, adopted in 2015.
- The “National Programme for the Development of Transport of the Republic of Slovenia until 2030”

Moreover, at the local level, different Sustainable Urban Mobility Plans (SUMPS)¹⁵ have been developed in the last years, both in the Italian and Slovenian contexts. In particular, it is worth mentioning the cases reported in the following Table 6.

Municipality	Name	Adoption Year	Link
Trieste	Piano Urbano della Mobilità Sostenibile del Comune di Trieste	2021	https://mobilitasostenibile.online.trieste.it/piano-urbano-della-mobilita-sostenibile-pums-di-trieste-approvazione/
Sežana	Celostna prometna strategija Občine Sežana	2018	https://www.sptm.si/application/files/8816/1657/5386/Sezana-CPS-2018.pdf
Ankaran	Piano urbano della mobilità sostenibile (PUMS) del Comune di Ancarano 2021-2025 / Celostna Prometna Strategija Občine Ankaran (CPS)	2020	https://obcina-ankaran.si/it/la-vita-ad-ancarano/traffico/piano-urbano-della-mobilita-sostenibile-pums-del-comune-di-ancarano-2021-2025
Koper	CPS (2017) - Veljavna Celostna prometna strategija	2017	https://www.koper.si/obcina/obcinska-uprava/urad-za-gospodarske-dejavnosti-okolje-in-promet/obcinska-celostna-prometna-strategija/

¹⁵ For the search of related documents, it is important to recall that a SUMP in Italian they correspond to the “Piano Urbano della Mobilità Sostenibile” (PUMS) and in Slovenian to the “(Občinska) Celostna Prometna Strategija” (CPS).



Izola	Celostna prometna strategija v Občini Izola	2017	https://www.izola.si/objava/550155
Piran	Celostna prometna strategija Občine Piran	2017	https://www.piran.si/objava/238574

Table 6 - Sustainable Urban Mobility Plans in the analysed area.

Furthermore, in addition to the already developed planning documents, it is important to mention the ongoing development process of the municipal comprehensive transport strategy (OCPS) for the municipalities of Sežana, Hrpelje-Kozina, Divača, Komen, and Miren-Kostanjevica¹⁶.

Among other things, this strategy aims to the improvement of public passenger transport through sustainable solutions for public transport, such as continuing the pilot project for On-Demand Transport - the ToyotaGo app, establishing intermodal public lines in the area of participating municipalities.

Moreover, an update on the SUMP is currently ongoing in the municipalities of Koper and Izola.

¹⁶ <https://www.divaca.si/post/959372>.



4. Analysis of transport flows from mobile phones data in the Friuli Venezia Giulia Region

In this chapter, the application of innovative technology and methodology in studying mobility demand, based on mobile phone users' location data, is addressed. To this end, the following paragraphs first provide a brief introduction to the key general methodological aspects and provide an overview of the resulting main commuter flows within the Trieste FUA. Then, the last paragraph focuses on the application of this methodology to cross-border commuting, which is the subject of this study.

4.1. An innovative solution to the need for mobility demand data: the methodological approach

Transport demand represents a key aspect of the transport system, expressing the mobility needs that must be met. Unfortunately, obtaining reliable and complete data for this purpose proves particularly challenging. Available statistics often lack comprehensive coverage and are limited to specific areas, time periods, or components of overall mobility.

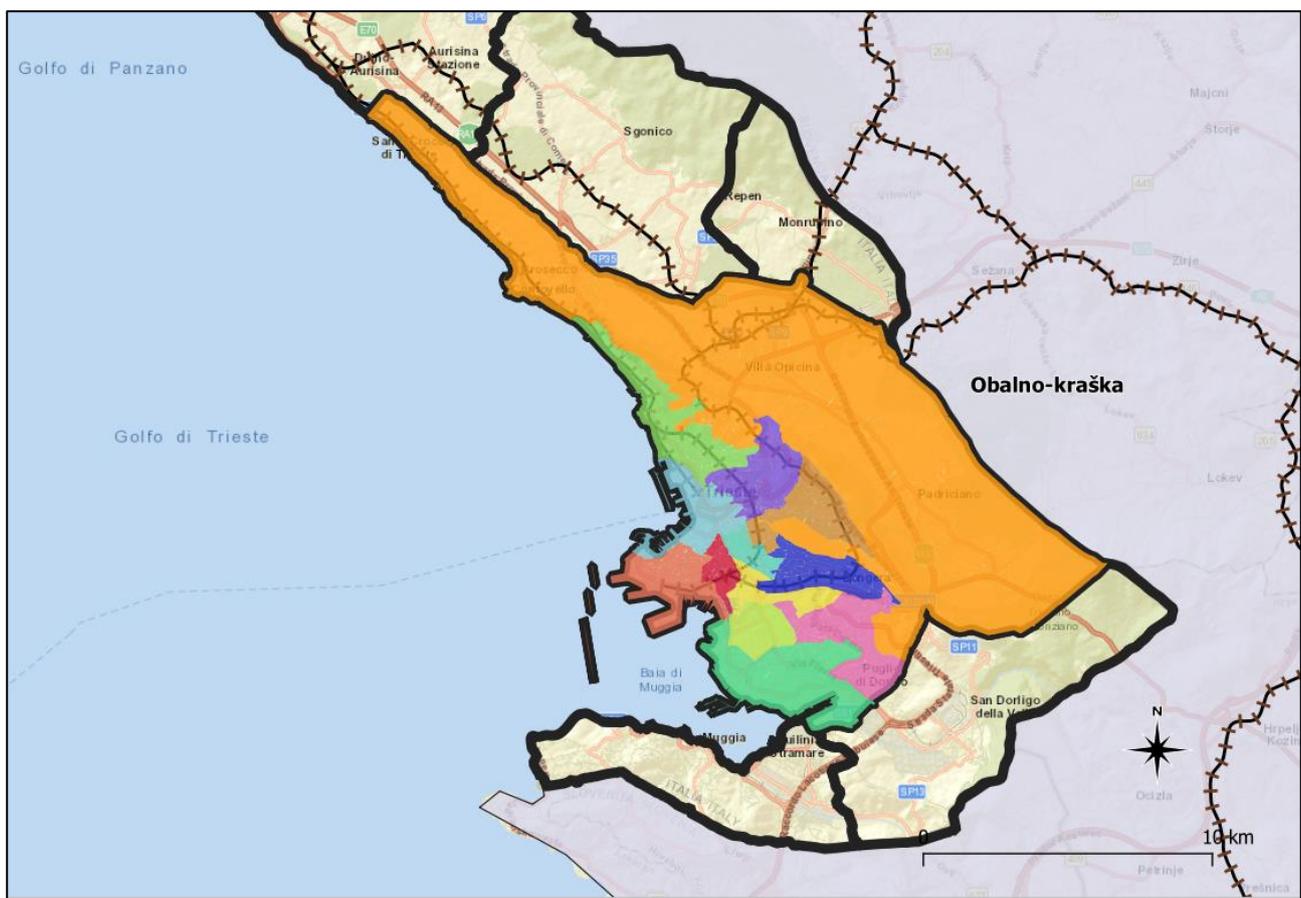


Figure 25 – Zoning of mobile phone users data in the Trieste FUA – detailed view on the Trieste ACE. Source: Own elaborations on FVG and ISTAT data.



To address these shortcomings, a notable and innovative approach is now being provided by the use of mobile phone users' location data. In this regard, starting from 2017, the Friuli Venezia Giulia Region offices have tested the analysis of transport flows based on this innovative method.

Considering the relevance that this methodological approach could have in better assessing the phenomenon of cross-border commuting, the regional administration, as an associated partner of the GreenPATH Project, has made available - for the purposes of this study - extracts from the dataset for the year 2024.

This dataset is based on municipal-level zoning of the entire regional territory, with further subdivision into ISTAT "census areas" (ACE) in the case of provincial capitals. In the case of Trieste, the respective ACEs are shown in Figure 25. Notably, the more peripheral zone (coloured orange) includes different access routes to the Trieste city centre. These routes encompass both the main connections to the rest of the Italian territory and two distinct cross-border routes leading to the Ferneti and Pesek border crossings.

Overall, the zoning adopted in the Trieste FUA area, including both municipalities and ACE subdivisions, is represented in Figure 26.



Figure 26 – Zoning of mobile phone users data in the Trieste FUA. Source: Own elaborations on FVG and ISTAT data.

With reference to user categories, the overall data has been segmented based on nationality, distinguishing between Italians and foreign passengers.

Italians are further subdivided (based on a statistical sampling of their frequency of presence in a given area during different hours of the day) into:

- residents (those with a confirmed residence in the area)
- commuters (city users with a residence outside the analysis area but within the province, visiting more than 20 times in the last 30 days)



- visitors (persons with occasional presence registered in the area, further divided into provincial, regional, and national).

The data also provide breakdowns by gender and age groups (18-24, 25-34, 35-44, 45-54, 55-64, 65+), derived from SIM contract data. These data are generally representative, although there are limitations for younger age groups, as they may have SIMs registered to older family members.

Foreigners, instead, are associated with particular categories of visitors (European and intercontinental categories) and further subdivided into nationalities based on their SIM's country of reference.

As regards to temporal subdivisions and coverage, the data cover all days of the year and are divided into eight daily time slots (0:00-3:00, 3:00-6:00, 6:00-9:00, 9:00-12:00, 12:00-15:00, 15:00-18:00, 18:00-21:00, 21:00-24:00).

On the basis of these categories, the resulting dataset provides estimates of the number of people located in a certain zone within a given time slot. A second output, particularly relevant for the present study, is the number of users travelling between each couple of zones (i.e. the data making up an Origin/Destination matrix). A third output is the number of daily visitors to certain Points Of Interest (POI), such as key nodes, and touristic or commercial attractions.

Lastly, it is crucial to highlight that the original data provider (i.e. in this case, the mobile phone operator Wind Tre S.p.A.) implements statistical procedures to prevent double counting of individuals and to achieve consistent estimates applicable to the entire population based on the sample provided by their users' data, which corresponds to about one third of the whole Market.

4.2. Summarising the resulting picture of Trieste FUA commuting

As clarified in the previous paragraphs, data on mobile phone users allows for insights into various types of trips. However, this section focuses on the topic of commuter mobility within the Trieste FUA. In this regard, a general overview is provided to contextualise and relatively assess cross-border commuter mobility, which is the primary objective of this analysis and will be presented in the following paragraph.

In compliance with the methodological approach described previously, the characterisation of commuter trips is derived indirectly through a statistical evaluation of the presumed residence of individuals corresponding to the detected SIMs. More specifically, commuting between different municipalities can be estimated, with a certain degree of approximation, by counting individuals who make trips to a municipality where they are not residents during the time slot 6:00-9:00 on weekdays in an Autumn month, such as October (also used in past ISTAT censuses¹⁷). The results reported here are related only to Italian commuters, while the results related to similar analyses for cross-border commuters are reported in the following chapter.

The resulting attractors are represented in the thematic map reported in Figure 27, while the main destinations are reported in Figure 28.

¹⁷ For instance, the data collection for the 15th General Census of Population and Housing, conducted by ISTAT at the national level, was referred to Wednesday, 9 October 2011. Subsequently, a different approach was adopted, involving a reduced sample of the population in a "permanent census" that begins annually on October 1st and concludes by December.

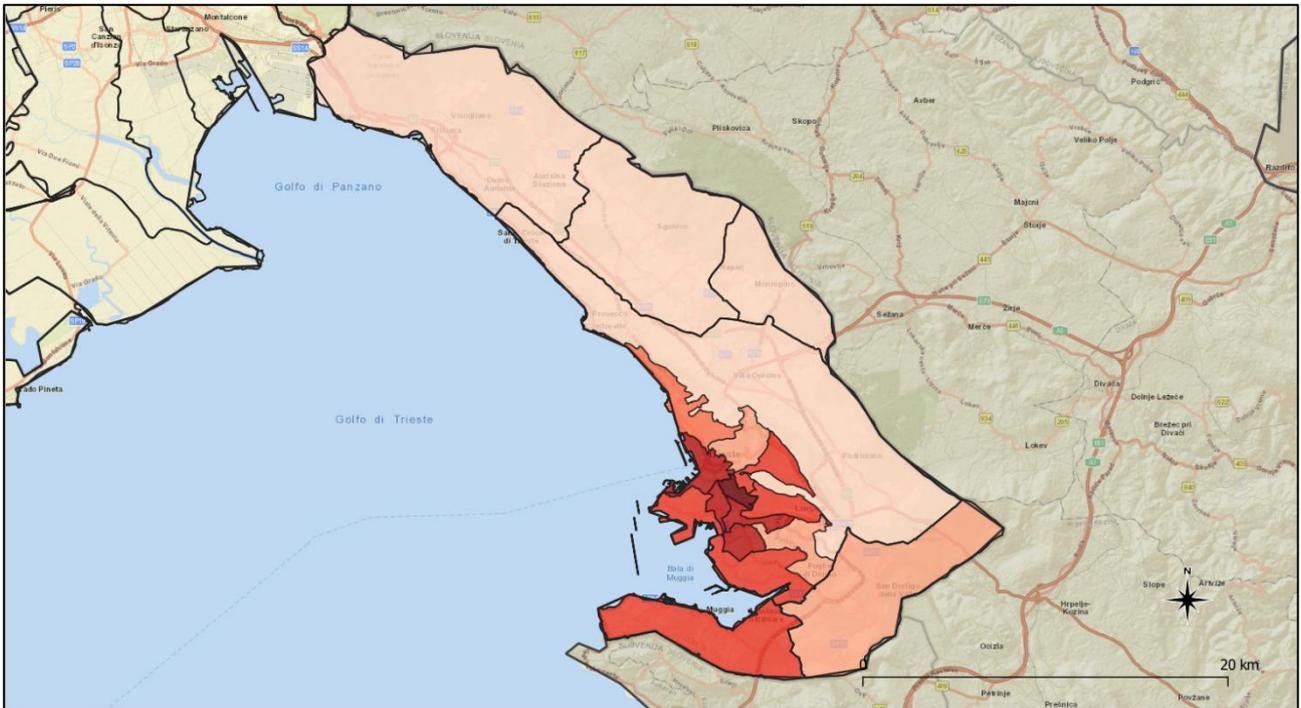


Figure 27 – Density of originated trips per zone in the 06-09 AM time slot. Source: Own elaborations on FVG and ISTAT data.

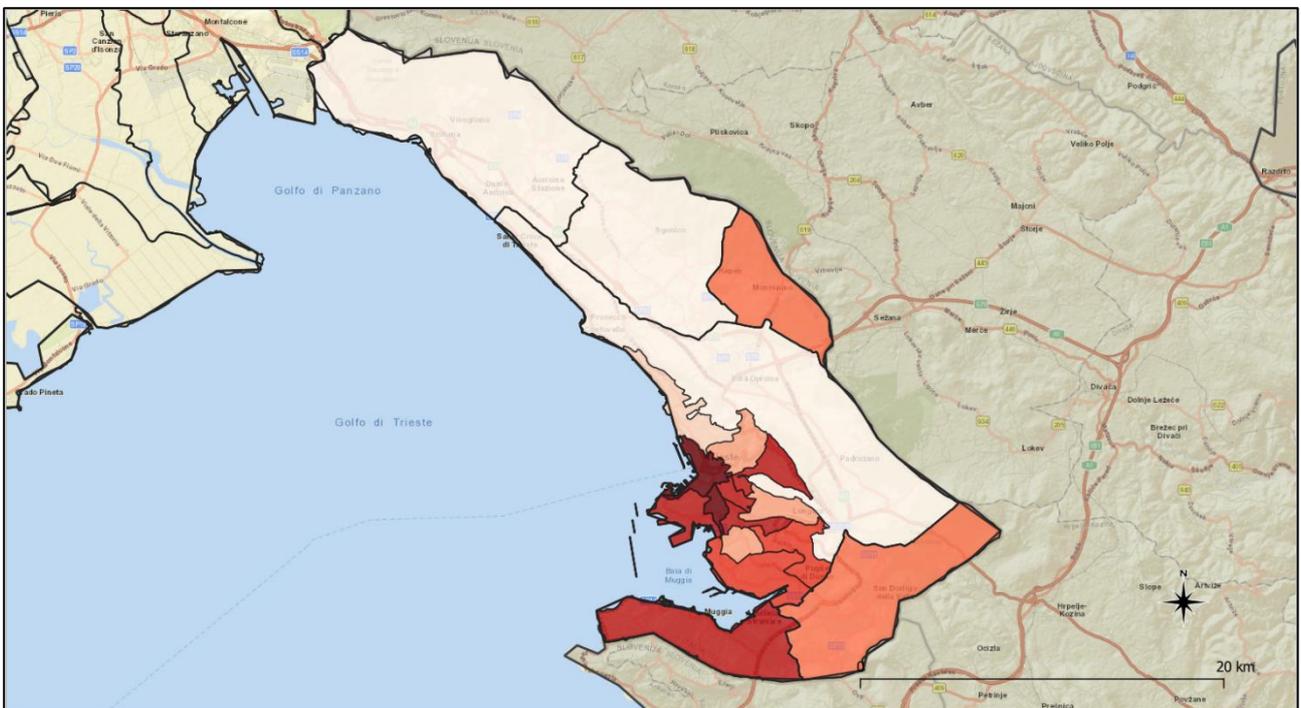


Figure 28 – Density of destined trips per zone in the 06-09 AM time slot. Source: Own elaborations on FVG and ISTAT data.



The following table reports the 10 main O/D relations ascertained in terms of estimated flows (counting individuals who make trips to a municipality where they are not residents) within the FUA, grouping at the municipality level.

Origin	Destination	Trips 06-09	Daily trips
Trieste	Muggia	2448	10454
Muggia	Trieste	2382	6724
Trieste	San Dorligo della Valle	1410	5420
Duino Aurisina	Trieste	1132	2897
San Dorligo della Valle	Trieste	689	2176
Trieste	Duino Aurisina	605	3006
Trieste	Monrupino	524	2352
Trieste	Sgonico	367	1334
Sgonico	Trieste	266	875
Monrupino	Trieste	255	1144

Table 7 - Main O/D relations between Trieste FUA municipalities arising from the mobile phones dataset in the morning phase associated with commuting mobility and in the whole day.

The resulting picture allows to ascertain the predominant attractiveness of the area of Trieste and Muggia in the relationship between different municipalities within the Trieste FUA. In this regard, it is also worth noting how all the reported 10 higher values of O/D relationships include Trieste either as origin or destination.

Once analysing this data, it is important to recall that bordering municipalities, as almost all those in FUA are also playing the role of fictitious origin and destination of trips from/to the external (e.g. Slovenia). Hence, the registered numbers are higher than those related to the mere origins and destinations of trips by Italians from the concerned municipalities.

On the other hand, Trieste represent an attractor for trips originating also beyond the FUA. In this regard, the following representation reports the O/D relations based on the ISTAT 2011 Census, allowing to have a more widespread representation of commuting relationships.

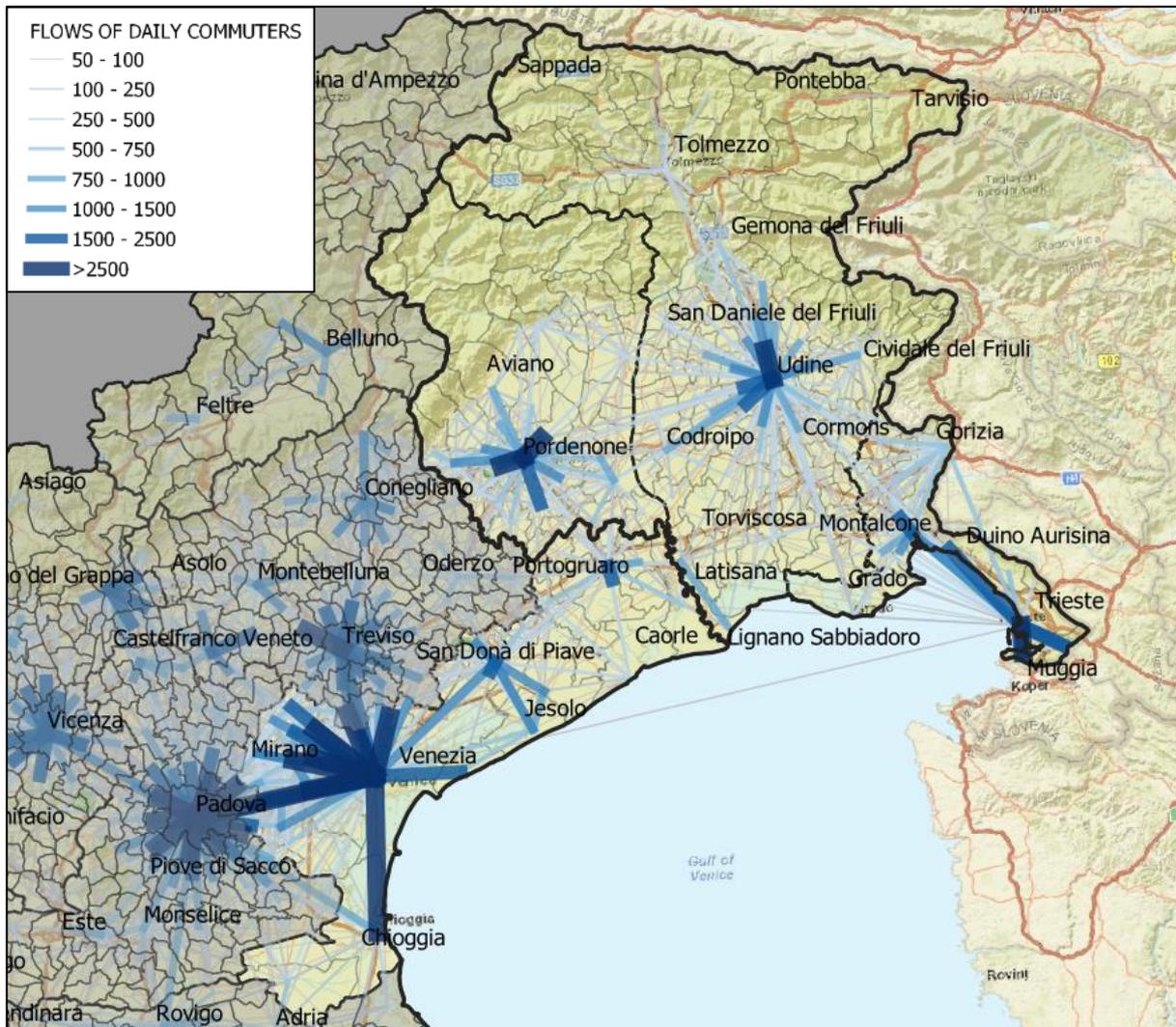


Figure 29 – Desire lines of transport demand for commuting purposes between Italian municipalities in the morning peak hour. Source: CROSSMOBY project elaborations on ISTAT 2011 census data.



4.3. Focusing on cross-border commuting

In this paragraph is focused on the usage of data from mobile phone operators to the key objective of the present study, cross-border commuting. To this end, the only relevant information in terms of segmentation of users is the nationality (of their SIM card).

The following table presents these values in detail, also in comparison with those of the other mainly registered nationalities. As foreseeable, the Slovenian is by far the most common one, followed by Croatian. The predominance of these two nationalities in comparison to other ones is accentuated in the morning peak hour, which can be explained by the presence of commuters.

Nationality	Total recorded trips	Average Daily Trips	Average 06-09 AM Trips
Slovenia	96573	6438	1376
Croatia	11705	780	159
Austria	10908	727	44
Germany	8846	590	31
UK	5697	380	46
USA	4432	295	30
Poland	4104	274	37
France	2820	188	18
Ukraine	2176	145	13
Netherland	1997	133	22

Table 8 - The number of trips by nationality of foreign visitors in the dataset from mobile phone operators (month of October, weekdays between Tuesday and Thursday). Source: elaborations on data by FVG

Moreover, since the zoning of the provided dataset is limited to the municipalities within the FVG Region, and no information is provided to movements external to them, the analysis of cross-border movements is carried out by making reference by identifying entry points represented to bordering areas (especially in correspondence with the relevant crossing focused on in the present study).

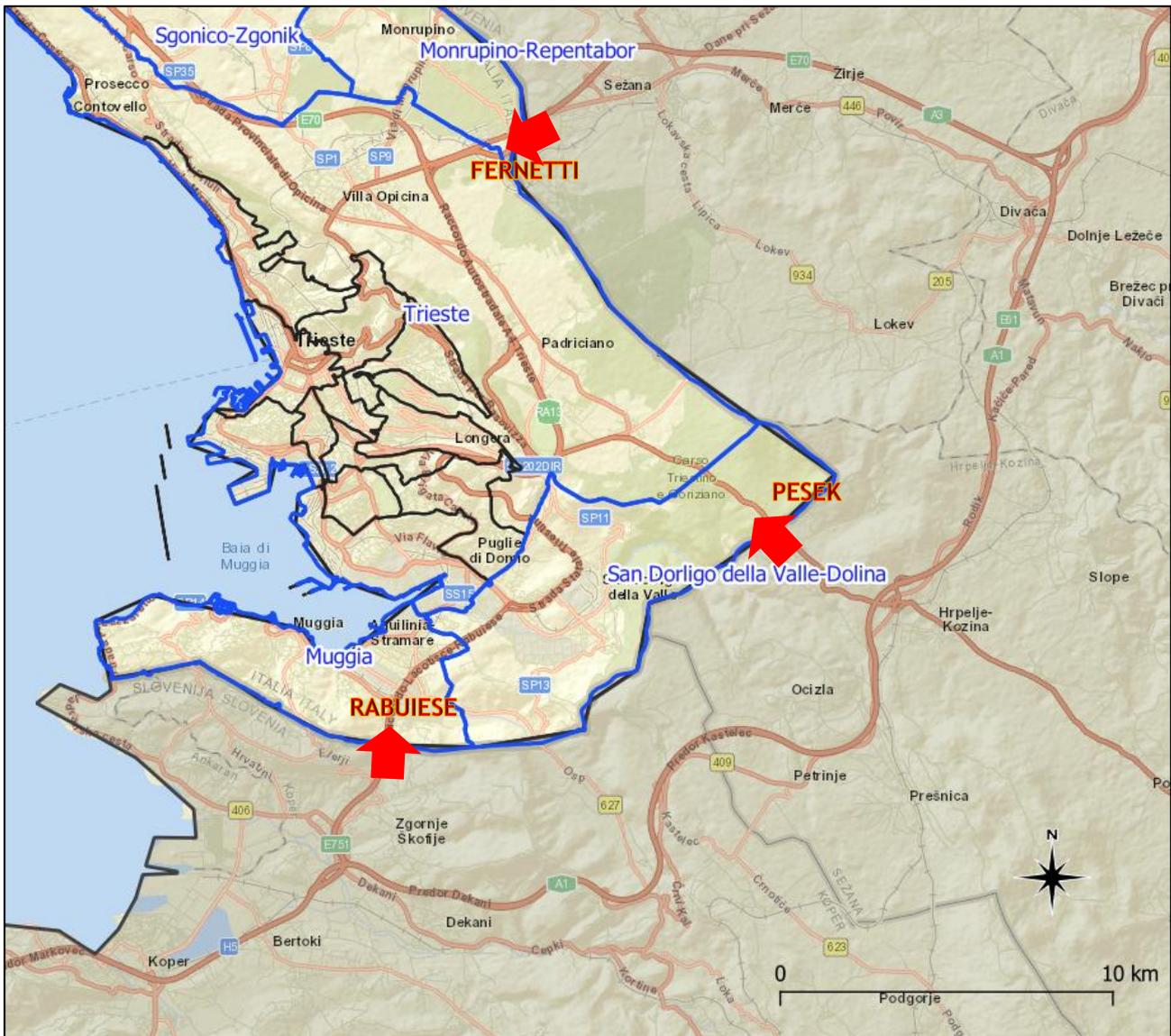


Figure 30 – Border crossing and related zones for mobile phone operator data

In particular, looking at Figure 30, a correspondence, reported in Table 9, can be made between the main border crossings and the adopted zoning.

BORDER CROSSING	ROAD (ITALIAN SIDE)	ZONE/MUNICIPALITY
Ferneti	RA14	Monrupino
Pesek	SS14	San Dorligo della Valle
Rabuiese	Sistiana-Rabuiese Motorway	Muggia

Table 9 - Main border crossings analyses and corresponding zones/municipalities



Consequently, the data about cross-border commuters can be associated with the number of trips of Slovenian SIMs having (fictitious) origin in those municipalities carried out within the 06-09 AM time slot.

In this regard, a particular remark can be made concerning the Ferneti border crossing, which falls within the territory of the Municipality of Monrupino only for a very short terminal stretch in Italian territory (less than one kilometre) of the RA14 motorway. This implies a presumably challenging condition in an already peculiar context for the complex signal acquisition and georeferencing processes, both due to the orographic conditions and the transition to a different operator that occurs at the border crossing.

In the following, still making reference to the central weekdays, the analysis results for October, November, and March 2024 (representing average and stable commuting patterns) are presented.

In particular, in the following table, you can see the summary of the relationships between the municipalities analysed. All in all, a certain balance is found concerning the values of the daily flows in the two opposite directions. Differently, in the case of trips in the time slot 06-09 in the morning, as expected, a greater incidence of the values towards the most important polarities is highlighted, first and foremost, Trieste.

Municipality A	Municipality B	A->B Direction		B->A Direction	
		Daily Trips	Trips 06-09	Daily Trips	Trips 06-09
Trieste	Monrupino	561	93	437	122
Trieste	Muggia	1183	158	1035	321
Trieste	San Dorligo della Valle	232	31	225	73
Muggia	San Dorligo della Valle	79	18	75	11

Table 10 - Summary of O-D flows between the analysed municipalities on the basis of the mobile phone data source. Source: own elaborations on data by FVG



5. Review of data sources on cross-border mobility and commuting

Starting from this chapter (as partially anticipated in the final paragraph of the previous one), the study focuses on cross-border commuting, which represents the central theme of this research. Following an initial methodological overview, each subsequent paragraph examines a distinct data source relevant to this analysis. The key findings derived from these sources will be further elaborated and developed in the subsequent chapters of the document.

5.1. Methodological explanation and overview of the data collection process

A key starting point of the present analysis lies in the observation that there is a lack of data sources, especially on transport demand for cross-border commuting. Specifically, the issue stems from the intersection of two aspects where data availability is typically problematic: transport demand data and the availability of integrated and harmonised datasets at the cross-border scale.

In this context, the aim of this study is to address this gap by systematising various partial data sources, which can be retrieved. When combined, as different pieces of a single puzzle, these sources can contribute, at least as a first estimation, to reconstructing the framework of cross-border commuting mobility for working purposes. To achieve this ambitious goal, all available data sources directly or indirectly related to cross-border commuting are reviewed alongside mobile phone operator data presented in the previous chapter. In fact, through their integration and cross-checking, a more comprehensive picture can be obtained.

Since the overall set of data sources is rather complex and a given source may be relevant for more than one aspect, a systematic overview of the sources is given through the tables in the following pages. They refer to the classic distinction between transport supply and demand. Moreover, sources providing traffic flows in specific sections, which are essentially determined by the interaction between supply and demand¹⁸, are reviewed as well. These may include either registered data directly collected through surveys or obtained indirectly through simulations (which, obviously, encompasses a given level of uncertainty in the estimation).

Each row in the tables is marked with an acronym (reported in the first column under the heading REF.) that will serve as a reference identifier. This acronym will be referenced in subsequent paragraphs where the specific data sources providing the elements listed below will be further described.

Regarding the demand data expressible in terms of O/D matrices available, the individual sources available, although not directly presenting the specific final objective of our study (i.e. commuters from Slovenian municipalities to destinations within the Trieste FUA), provide relevant elements to start from.

In fact, we have a set of different datasets (from both sides of the border), which can be further elaborated by integrating them and making certain assumptions or reasonable approximations (e.g. on a certain correspondence between the aforementioned commuters and the number of Slovenian SIM cards entering

¹⁸ which determines the distribution of the different O/D flows in the various routes that can be taken in the transport network.



on weekdays during non-vacation periods, or with the number of vehicles in the O/D matrix of a model developed by one of the two sides of the border coming from/destined to certain "external gates").

REF.	SOURCE	COUNTRY	DESCRIPTION	ZONING	TIME SLOTS	NOTES
D1 ¹⁹	Data from a mobile phone operator in FVG	Italy	Data related to the <u>number of people</u> moving between zones, associated with Slovenian SIMs	Zones are exclusively within Italian territory. <ul style="list-style-type: none"> • 13 ACE areas in the Trieste Municipality • Entire municipal territory in other cases 	Different time slots, which combined ensure full-day coverage	They may include freight transport movements (driver SIMs). Data specifically referred to all single days of the year. Reference year: 2024
D2	Matrices from the Trieste SUMP	Italy	Data on private transport, esp. referring to the <u>number of vehicles</u>	Detailed zoning of the Trieste area, while only "external gates" for the Slovenian areas	Morning peak hour (plus other time slots)	The O/D matrix derives from the calibration of a transport model. Reference year: 2019
D3	Multimodal Transport Model of Slovenia	Slovenia	Traffic flows and demand data referring to the <u>number of vehicles per category</u>	Sub-municipal zoning, with particular reference to the area near the national border	Morning and afternoon peak hours, together with the daily average	Extract of the model made available for the specific purpose of this study. Reference year: 2023.
D4	Dataset of Slovenian Crossborder Commuters (SURS)	Slovenia	<u>Number of commuters</u> for working purposes to Italy	Slovenian municipalities	Not Applicable	Reference year: 2023. There is also data on Italian commuters to Slovenia.
D5	FVG Observatory on the Labour Market	Italy	<u>Number of Slovenian citizens employed</u>	Italian municipalities	Not Applicable	Reference year: 2025.

Table 11 - List of data sources related to transport demand

Furthermore, an important element of verification (also used in the construction of transport simulation models) is provided by the vehicle flow values associated with specific sections of the road network. In this regard, it is clear that the flow recorded at the entrance to a particular section (e.g. the Ferneti road

¹⁹ Even though already presented in the previous chapter, it is reported here as well in order to provide the complete picture.



crossing) must correspond to the sum of the entire demand share that can be deduced as passing through it (e.g. the sum of vehicle flows originating from the external gate of Sežana). In particular, given the focus of this activity and the current situation of multimodal connections, the analysis is concentrated on the road network. In this regard, the following Table 12 reports the related sources taken into account.

REF.	SOURCE	COUNTRY	DESCRIPTION	REFERENCE PERIOD	TIME SLOTS	NOTES
F1	FVG Plan Traffic counts	Italy	Classified count of vehicles by vehicle category from <u>SURVEY</u>	Autumn (October-November) and Summer (July) 2024	Continuous survey with hourly counts for 48 hours	Counts made in a single ad-hoc survey campaign
F2	Trieste SUMP Traffic counts	Italy	Classified count of vehicles by vehicle category from <u>SURVEY</u>	between February and June 2019	Different time slots of the day	Counts made in a single ad-hoc survey campaign
F3	Trieste SUMP traffic flow map	Italy	Flow by vehicle category from simulation model: <u>ESTIMATED</u>	2019	Morning peak hour (7.30-8.30)	
F4	Traffic counts on the Slovenian road network	Slovenia	Classified count of vehicles by vehicle category from <u>SURVEY</u>	Permanent detection system + occasional stations. Data updated to 2023	Different time slots of the day	Systematic monitoring by the Slovenian Ministry of Infrastructure

Table 12 - List of data sources on traffic counts in sections of the road network

Another relevant aspect about which it is necessary to acquire complete and updated data is the supply of the local public transport service. This information, which essentially allows to describe the stops and services carried out according to the official timetables, is collected in datasets relating to the regional context of Friuli Venezia Giulia and the Slovenian territory. Nowadays, they are made available through the respective National Access Points (NAP). In Table 13, the references of these two sources are briefly reported, and (like the previous ones) they will be reviewed in the following paragraphs of this chapter.

REF.	SOURCE	COUNTRY	STANDARD	REFERENCE PERIOD	NOTES
PT1	Italian National Access Point	Italy	Only NETEX	Regularly updated	Available at https://nap-1926.it/nap/mmtis/public/catalog/Dataset
PT2	Slovenian National Access Point	Slovenia	GTFS and NETEX	Regularly updated	Available at https://www.nap.si/en/datasets

Table 13 - List of data sources on the network and timetables of the local public transport services



5.2. Trieste SUMP surveys and transport model (ref. D2, F2 and F3)

Within the development process of the Trieste Sustainable Urban Mobility Plan (SUMP), approved on 27 July 2021, both an in-depth traffic survey and transport modelling analysis were conducted. Documentation on the main findings is available on the website <https://mobilitasostenibile.online.trieste.it/piano-urbano-della-mobilita-sostenibile-pums-di-trieste-approvazione/>.

In particular, the traffic flow survey (Ref. F2) took place between February and June 2019 on a weekday at 49 key road sections, including those showcased in the following figure, in the Trieste FUA.

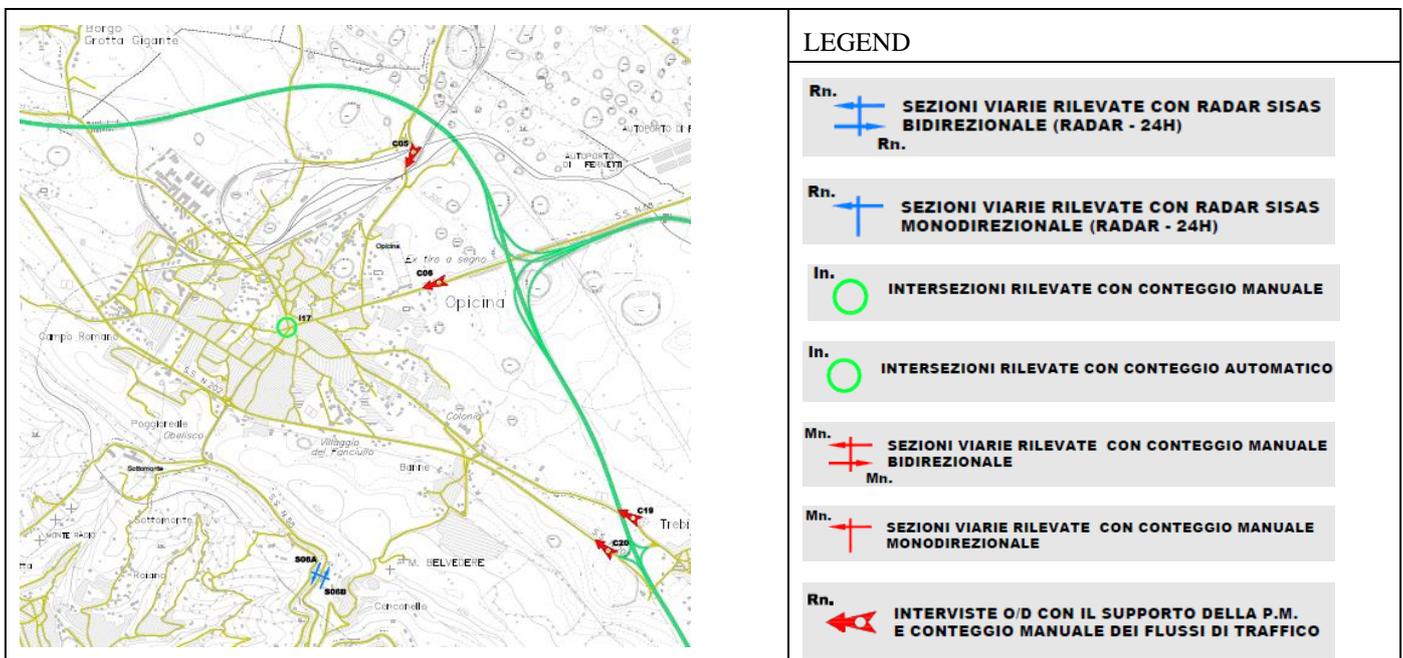


Figure 31 – View of the Villa Opicina area with the survey sections from the Trieste SUMP study and the related general legend. Source: Trieste SUMP.

These traffic surveys, together with other ones (including both counts and interviews), supported the development of a transport simulation model that also involved the reconstruction of the mobility demand. Specifically, this involved the reconstruction of the Origin/Destination matrix (Ref. D2), with respect to a zoning with a high level of detail, especially in the area of the Municipality of Trieste, divided into 83 zones.

In this zoning, there are 7 “external portals” corresponding to the main access road to the Trieste FUA: Cartiere del Timavo, Lisert, Ferneti, Lipizza, Pesek, Rabuiese, Lazzaretto. In particular, it is highlighted how these external gates (as represented by the representation through “desire lines” reported in the following figure) include those cross-border crossings that are particularly focused on in this study.

Furthermore, the materials produced include various thematic representations of private transport flows (distinguishing between different vehicle categories) across the various links in the network (Ref. F3) as obtained from traffic simulation. In particular, those related to border crossings are significant, as they correspond to flows entering or exiting Slovenian territory.

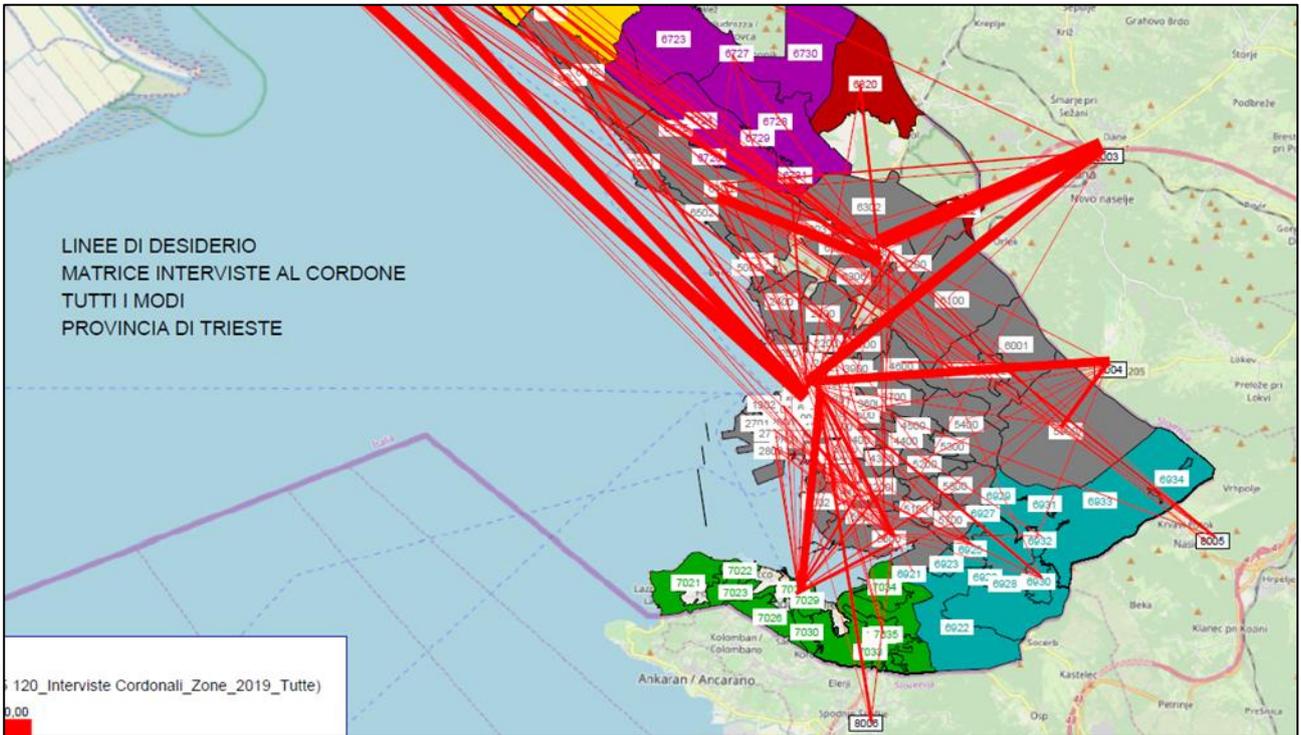


Figure 32 – Detailed view of the central area of Trieste showing the “desire lines” from the Trieste SUMP matrix. Source: Trieste SUMP.

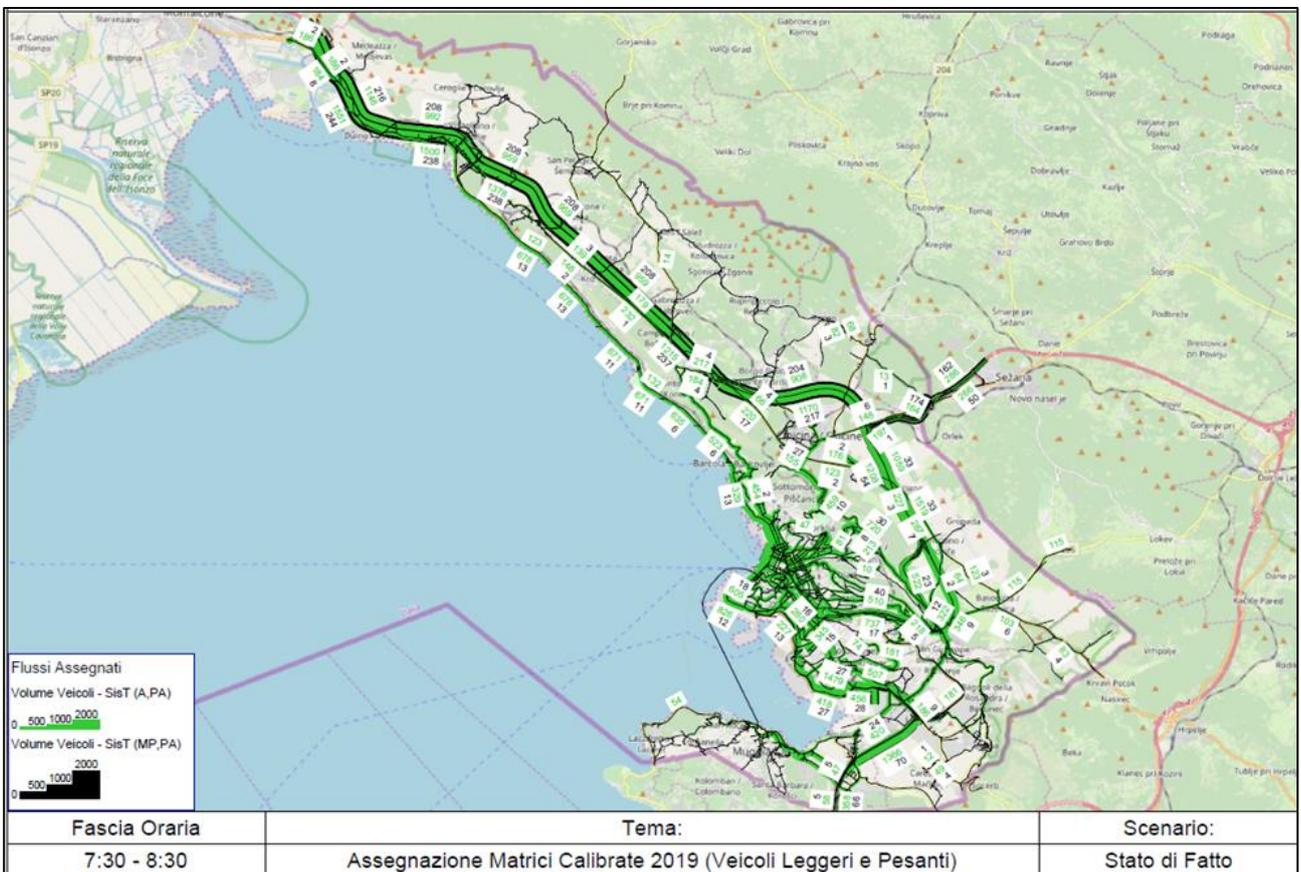


Figure 33 – Thematic representation of traffic flows in the “current state” (2019) on the different links of the FUA road network. Source: Trieste SUMP.



5.3. Slovenian National Transport Model (ref. D3)

A notably relevant source for the completeness of the analysis on the Slovenian side is constituted by the materials related to the national traffic model made available by the Slovenian Ministry of Infrastructure - National Traffic Management Centre (NCUP).

In particular, they include O-D matrices for the Italy-Slovenia border areas and related traffic volumes (reference year, 2023) referring to different vehicle categories (cars, light commercial vehicles, heavy commercial vehicles, and buses) and time slots (morning peak, afternoon peak, and daily average).

Specifically, for the purposes of this study, a partial extraction was made available that ensured coverage of the municipalities in the Obalno-kraška region, represented by the orange zones in Figure 34. In the image, the level of detail is also evident from the green dots that represent the centroids (where the entry/exit points on the network of flows present in the O/D matrix are schematized).



Figure 34 – Representation of the zones of the Slovenian national model to which are referred the O/D matrices provided by the NCUP



5.4. SURS Census of cross-border commuters (ref. D4)

The Statistical Office of the Republic of Slovenia (SURs) provided a dataset that reports the number of commuters travelling daily from (specified) Slovenian municipalities of residence to Italy, where their workplace is located. Additionally, it includes the corresponding data in the reverse direction, i.e., the number of Italian residents commuting to Slovenian municipalities. Specifically, the data refers to the year 2023. In general, with reference to the entire Slovenian territory, the two types of commuters show the following overall values, highlighting a predominance of commuting from the Slovenian to the Italian territory.

Country of Residence	Country of Work Location	N. of cross-border commuters
Slovenia	Italy	1867
Italy	Slovenia	954

Table 14 - Total numbers of cross-border commuters between Italy and Slovenia (reference year: 2023). Source: own elaboration on SURS data

In particular, the data on Slovenian commuters to Italy are derived from datasets that record the number of people who have health insurance in Slovenia and work in Italy.

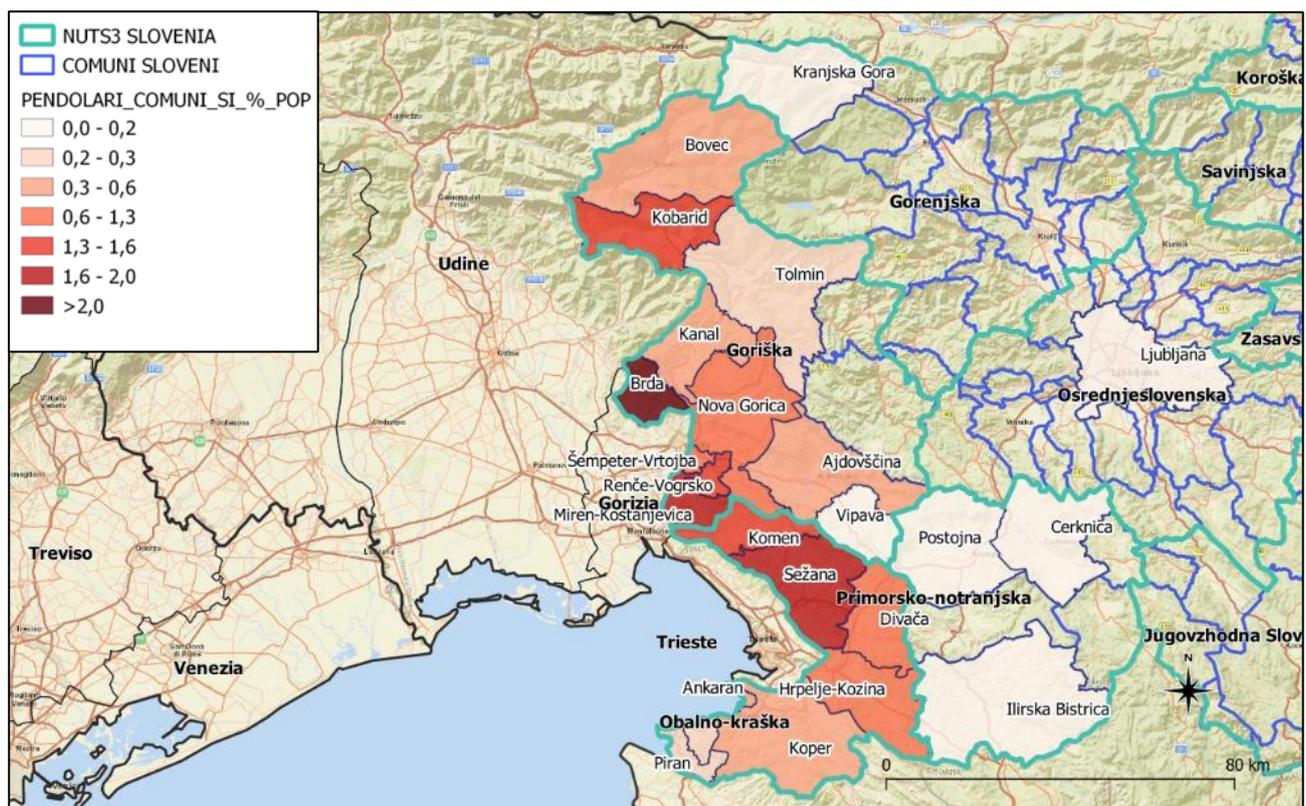


Figure 35 - Thematic map of the percentage incidence of cross-border commuter workers on the resident population by Slovenian Municipality. Source: own elaboration on SURS data

As directly clarified by the SURS, these data “data do not represent all persons working abroad, but only that category of insured persons who are living in Slovenia, but commute to work in Italy and are included in the Slovenian healthcare system. It means that they exercise their rights from compulsory health



insurance in Slovenia, while they are insured for other compulsory social insurances (pension, disability, etc.) in Italy”.

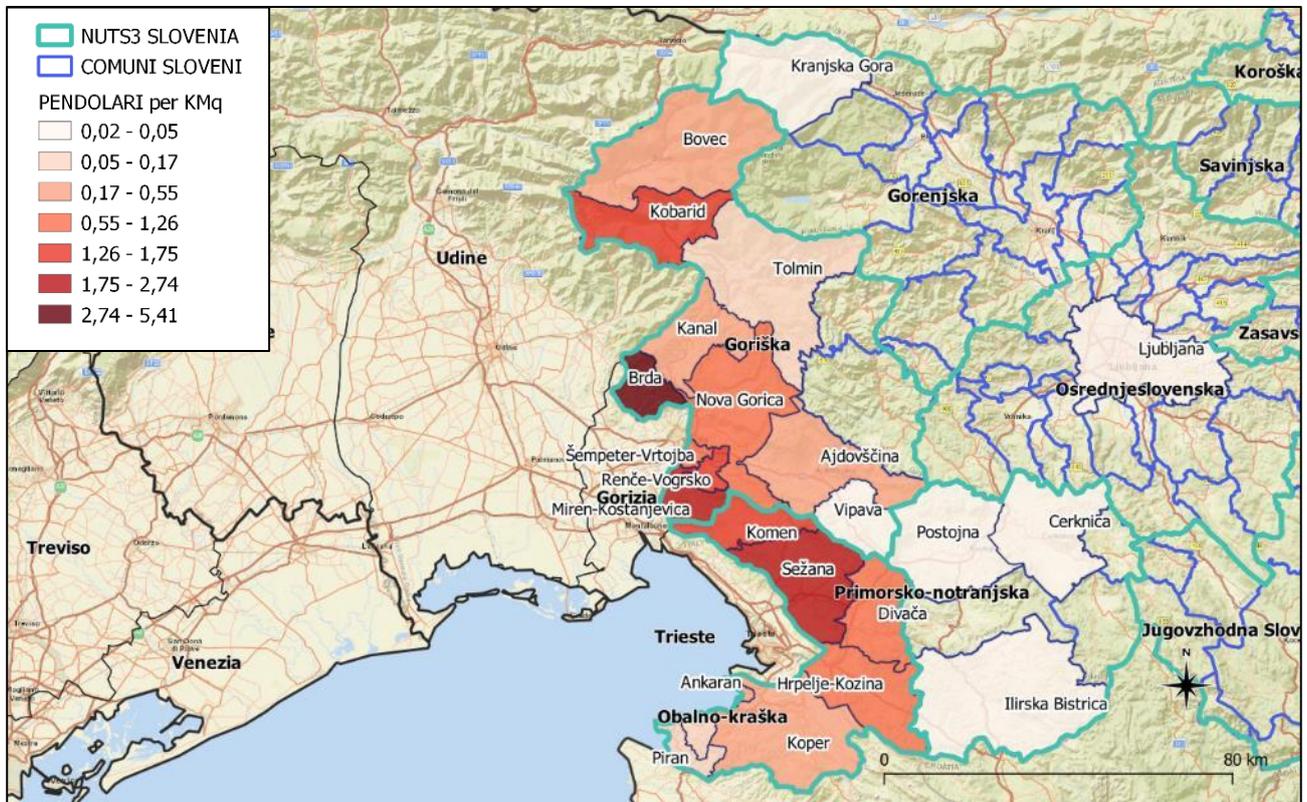


Figure 36 – Thematic map of the density per km² of cross-border commuter workers by the Slovenian municipality of residence. Source: own elaboration on SURS data

Among the possible representations of the dataset, Figure 35 shows a representation of the percentage incidence of cross-border commuter workers on the resident population by Slovenian municipality. This representation allows for an understanding of the level of cross-border integration in the labour market.

Figure 36, on the other hand, shows a thematic map of the density per km² of cross-border commuter workers by the Slovenian municipality of residence. This representation allows for an initial understanding of the effect achievable by extending the multimodal accessibility of the Trieste FUA into the Slovenian territory. On the other hand, it is emphasised that in this type of representation, there may be a penalty in the case of larger municipalities (at least compared to the actual potential of their main centres). Also for this reason, the higher values in the area of interest for this project are found in the case of Ankaran (2.7 per km²) and Izola (1.8 per km²). It is reasonable to assume that similar values will be found in correspondence with the main settlements and in the northern part of the Koper municipality (whose value of 0.9 per km² at the municipal level results from a division over a larger area).

In terms of absolute values, the relevant data are reported in the following Table 15, where the cases considered attributable to the directions of interest for this project are highlighted in bold characters.

They correspond mainly to the Obalno-kraška region, and a few other cases related to the Primorsko-notranjska region (Ilirska Bistrica, Postojna, and Cerknica) and the Osrednjeslovenska region (Ljubljana). In any case, the municipalities in these latter two regions have individual values always below 25 units and collectively sum to 55 units.



NUTS3	Comune di residenza	N°di pendolari verso ITA
Goriška	Nova Gorica	296
Obalno-kraška	Koper/Capodistria	291
Obalno-kraška	Sežana	273
Goriška	Brda	148
Goriška	Miren - Kostanjevica	98
Goriška	Ajdovščina	90
Goriška	Šempeter - Vrtojba	81
Goriška	Renče - Vogrsko	68
Obalno-kraška	Hrpelje - Kozina	63
Goriška	Kobarid	61
Obalno-kraška	Komen	56
Obalno-kraška	Izola/Isola	50
Obalno-kraška	Piran/Pirano	49
Obalno-kraška	Divača	41
Goriška	Tolmin	34
Goriška	Kanal	25
Obalno-kraška	Ankaran/Ancarano	22
Osrednjeslovenska	Ljubljana	21
Primorsko-notranjska	Ilirska Bistrica	16
Goriška	Bovec	15
Primorsko-notranjska	Postojna	14
Goriška	Vipava	10
Gorenjska	Kranjska Gora	8
Primorsko-notranjska	Cerknica	4

Table 15 - Number of commuters towards Italy from single Slovenian municipalities. Source: own elaboration on SURS data

Focusing the analysis on the subset of cases selected accordingly, a total of 844 cross-border commuters is obtained. For these, a preliminary division was made for indicative purposes, assigning the respective values to what appear to be plausible reference routes, as shown in Table 16 below.

The resulting framework reveals a predictable predominance of the Rabuiese and Ferneti border crossings, with slightly higher values in the former case.

Municipality of residence	N. of Commuters towards Italy	Lazzaretto	Rabuiese	Pesek	Ferneti
Koper/Capodistria	291		291		
Sežana	273				273
Hrpelje - Kozina	63			63	
Izola/Isola	50		50		
Piran/Pirano	49		49		
Divača	41				41



Ankaran/Ancarano	22	22			
Ljubljana	21				21
Ilirska Bistrica	16			16	
Postojna	14				14
Cerknica	4				4
TOTAL	844	22	390	79	353

Table 16 - Hypothesis on the attribution of the number of commuters to different relevant border crossings of the Trieste FUA. Source: own elaboration on SURS data

Although not the specific focus of this project, some brief considerations are reported on the inverse phenomenon, namely Italian commuters to Slovenia. However, when comparing the two directions, it is considered necessary to take into account some possible differences related to specific coding modalities.

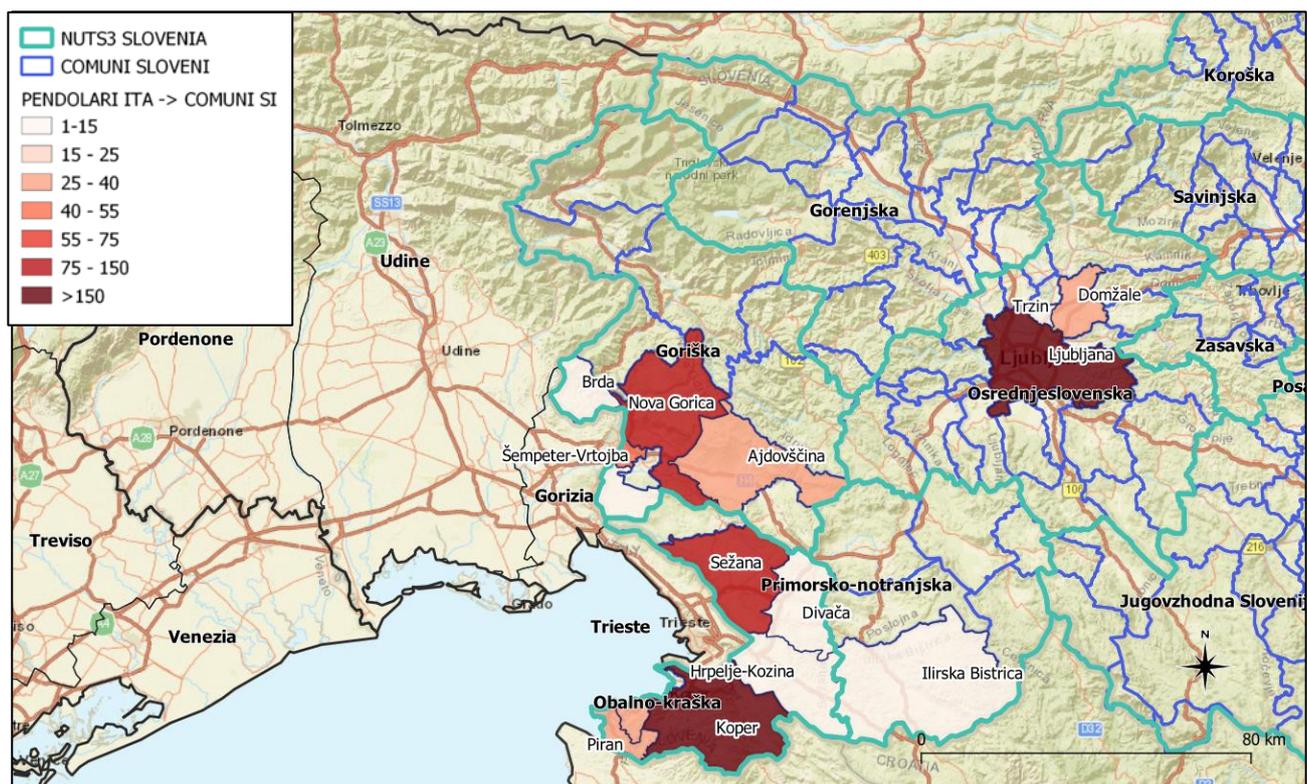


Figure 37 - Thematic map of the number of cross-border Italian commuters by the Slovenian municipality of work location. Source: own elaboration on SURS data

In this regard, a significant presence of long-distance destinations is noted, particularly not only in Ljubljana (which proves to be the case with the maximum value, equal to 234 individuals) and its surroundings but also locations in eastern Slovenia, such as Celje and Maribor. In these latter cases, however, it could be seen as questionable an association to daily trips.

When commenting on the data, a generally lower value is ascertained, and, as expected, a greater concentration towards the main poles (due to their greater role in attracting commuter trips).



5.5. FVG Observatory on the Labour Market (ref. D5)

The Observatory for the Development and Communication of the Labour Market of the FVG Region has provided a dataset containing data on the hiring and employment of Slovenian citizens in Friuli Venezia Giulia, broken down by municipality. In particular, the data in the following table, the number of Slovenian citizens employed per municipality of the Trieste FUA, is particularly relevant for the purposes of this analysis. In fact, even though it does not distinguish between those who are commuting from Slovenia from those who reside in Italy, it definitely represents a relevant source for cross-checking.

In particular, out of the overall number of 781 employed in the FUA of Trieste, 580 work in the Municipality of Trieste. Therefore, compared to the FUA, the Municipality of Trieste represents 74% of the cases. However, it should also be noted that in comparison with the population of the municipalities, the number of Slovenians employed is equal to a lower percentage.

MUNICIPALITY	NUMBER OF SLOVENIAN CITIZENS EMPLOYED
DUINO-AURISINA	44
MONRUPINO	15
MUGGIA	73
SAN DORLIGO DELLA VALLE	42
SGONICO	26
TRIESTE	580
TOTAL	781

Table 17 - Table excerpted from Observatory on the Labour Market with the number of Slovenian citizens employed per municipality of the Trieste FUA. Source: FVG Region



5.6. Traffic survey campaign for the FVG new regional plan - PRITMML (ref. F1)

As part of the preparatory activities for updating the Regional Plan of Transport Infrastructure, Freight Transport and Logistics (PRITMML), a traffic survey was recently conducted by recording traffic flows over 48 continuous hours at 116 sections of the road network. The surveys were carried out in two distinct periods:

- Autumn/school period, between October 21 and November 15, 2024.
- Summer period, between July 8 and July 29, 2024.

The data collection was carried out using automatic vehicle counting and classification equipment with Doppler radar technology and cameras with automatic image decoding.

For the purposes of the present study, the surveys conducted during the autumn period at the following sections within the Trieste FUA are particularly relevant:

- Section 99 - On the national road SS14, between Basovizza and the national border.
- Section 100 - On the Sistiana-Rabuiese motorway (formerly NSA 326).

Both sections correspond to one of the border crossings that will be further analysed in the following chapters.

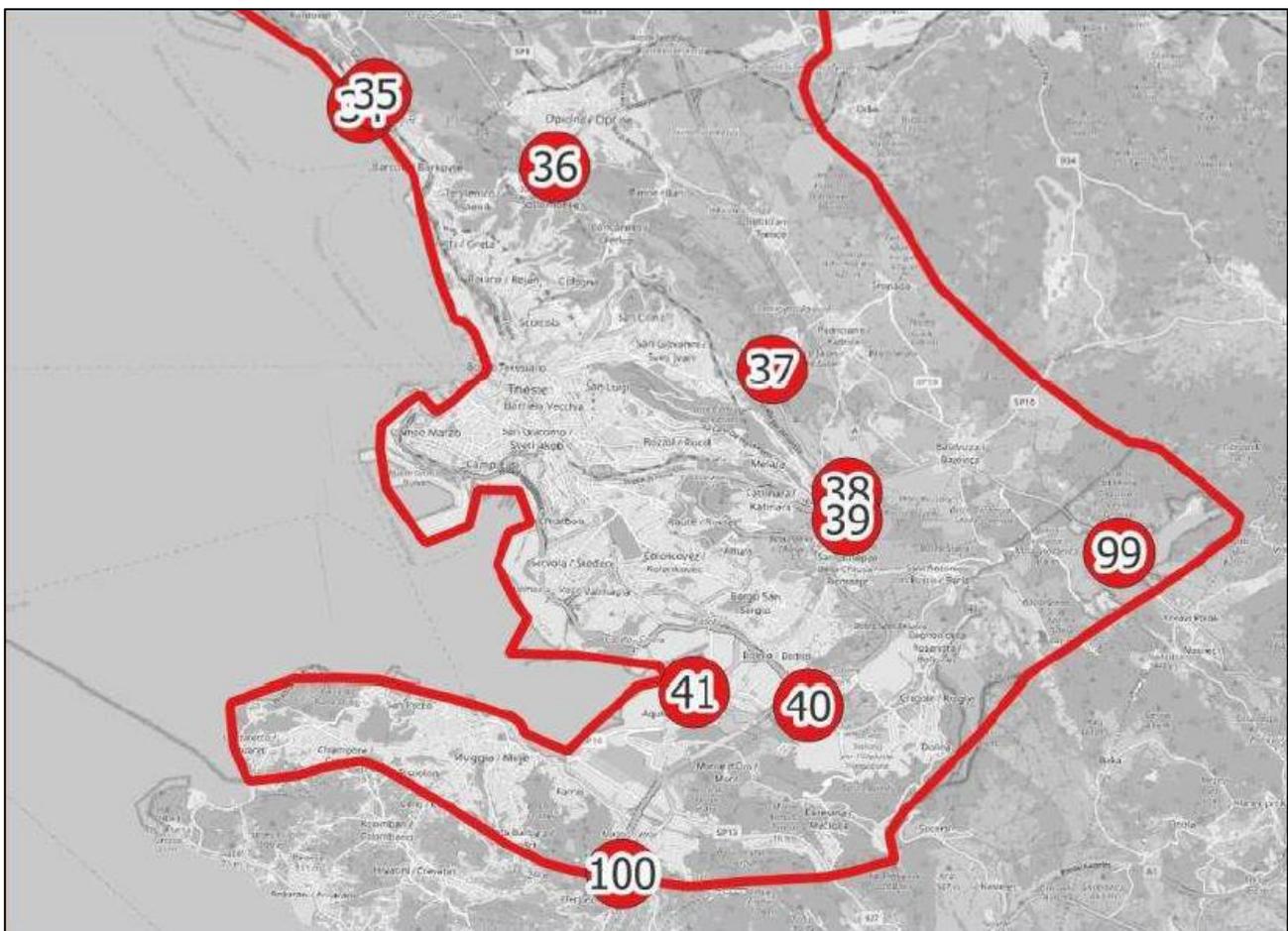


Figure 38 – Location of the sections where traffic surveys took place in Autumn 2024 for the preparation of the PRITMML Regional Plan. Source: Friuli Venezia Giulia Autonomous Region



5.7. Slovenian road network traffic counts (ref. F4)

With reference to the counts on the road network, the material from the electronic publication for the year 2023 regarding traffic surveys conducted on the Slovenian national network by the Slovenian Ministry of Infrastructure was acquired.

As shown in the representation in Figure 39, the monitoring involves a rather dense set of counting stations, mostly automatic, encompassing both permanent and temporary locations.

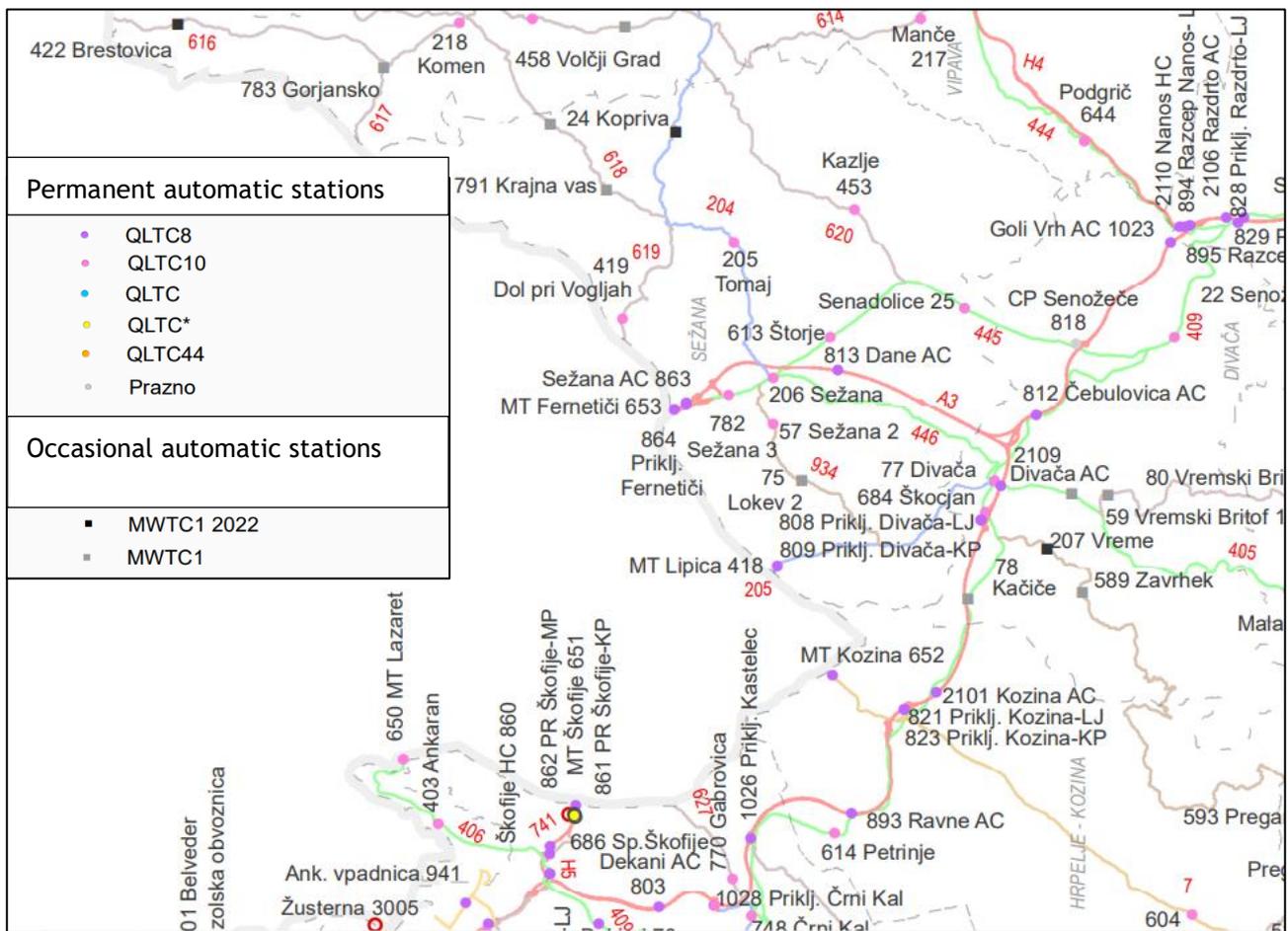


Figure 39 – Detailed view of the area adjacent to the Trieste FUA showing the monitoring stations of the Slovenian road network. Source: Ministry of Infrastructure of the Republic of Slovenia.



5.8. Data on Public transport services and network data (ref. PT1 and PT2)

The data about public transport services and networks are increasingly made available as open data through National Access Points (NAPs), established under the EU Intelligent Transport Systems (ITS) Directive and further harmonised by initiatives like NAPCORE²⁰.

To this end, shared international standards are applied in order to ensure smooth interoperability.

In particular, NETEX is a European standard for exchanging Public Transport Information that is being increasingly used, thus making available a comprehensive set of open datasets.

Another widely used standard is the GTFS (General Transit Feed Specification), which is less comprehensive. Nonetheless, it remains a relevant and practical option, as it effectively stores essential information about public transport networks and their timetables.

More specifically, for the present study, the following data sources were used:

- Public transport data for the entire FVG region were found at the Italian NAP (<https://nap-1926.it/nap/mmtis/public/catalog/Dataset>). The dataset, in NETEX format, included:
 - The local public transport service operated by TPL FVG
 - Railway service operated by Trenitalia
- Public transport data for the entire Slovenia were found at the Slovenian NAP (<https://www.nap.si/en/datasets>); they are made available according to both NETEX and GTFS standards.

²⁰ For more information see also <https://digital-strategy.ec.europa.eu/en/policies/mobility-data>.



6. Assessing cross-border flows and transport demand

In the present chapter the key outcomes arising from the integrated analysis of the data sources previously described are presented, they include both traffic flows at the border sections, which will be presented in the first paragraph, and assessment of the cross-border demand values that could be associated with cross-border commuting, whose key results will be reported in the second paragraph.

6.1. Assessing traffic flows at key cross-border points

In this first paragraph, the traffic flows at the key cross-border points previously described are presented. Each of these points is discussed in a dedicated sub-section. Considering the overall situation, it is noteworthy that all other cross-border points connecting the Trieste Functional Urban Area (FUA) with the Slovenian hinterland exhibit lower traffic volumes. This observation is supported by modelling activities and confirmed by statistics on daily flows at a broader set of border crossings with the Trieste FUA, provided by the Slovenian Ministry of Infrastructure, whose key values are reported in Table 18.

Notably, two sections stand out with significantly higher values: Fernetiči/Fernetti and Škofije/Rabuiese. In fact, they correspond to the motorway sections linking with Koper and Sežana, respectively. While Fernetiči/Fernetti is characterised by the highest overall traffic flows of all vehicles (across all categories), Škofije/Rabuiese shows the highest values for passenger cars. The third-ranked crossing is Kozina/Pesek, which handles nearly 5,000 passenger cars daily. Among the remaining crossings, Lipica/Basovizza records slightly below 4,000 passenger cars, while Lazaret/Lazzaretto remains below 1,500.

Section Code	Section Name SI/IT ²¹	Municipality SI	Municipality ITA	Road	Average Daily Traffic - All Vehicles ²²	Average Daily Traffic - Passenger Cars
<u>653</u>	<u>MT Fernetiči /Fernetti</u>	<u>Sežana</u>	<u>Monrupino</u>	<u>A3</u>	<u>17487</u>	<u>12549</u>
418	MT Lipica/Basovizza	Sežana	Trieste	205	4372	3938
<u>652</u>	<u>MT Kozina/Pesek</u>	<u>Hrpelje - Kozina</u>	<u>San Dorligo della Valle</u>	<u>7</u>	<u>5725</u>	<u>4912</u>
<u>651</u>	<u>MT Škofije/Rabuiese</u>	<u>Koper</u>	<u>Muggia</u>	<u>H5</u>	<u>15537</u>	<u>13188</u>
650	MT Lazaret/Lazzaretto	Ankaran	Muggia	406	1400	1142

Table 18 - Annual Average Daily Traffic at border crossings of the Trieste FUA. Source: Ministry of Infrastructure, Directorate of the Republic of Slovenia for Infrastructure

²¹ The sections located exactly in correspondence of a border crossing are characterised by the sigla “MT”.

²² Including all categories of motor vehicles.



In the following paragraphs, more detailed statistics and representations are presented. In particular, they are focusing on traffic flows registered during the months of October and November (2023) on weekdays from Tuesday to Thursday. In particular, this extensive analysis is based on the most complete available data sources represented by the Slovenian monitoring system. Nonetheless, the other data sources listed in the previous chapter have also been checked for confirmation.

6.1.1. Ferneti

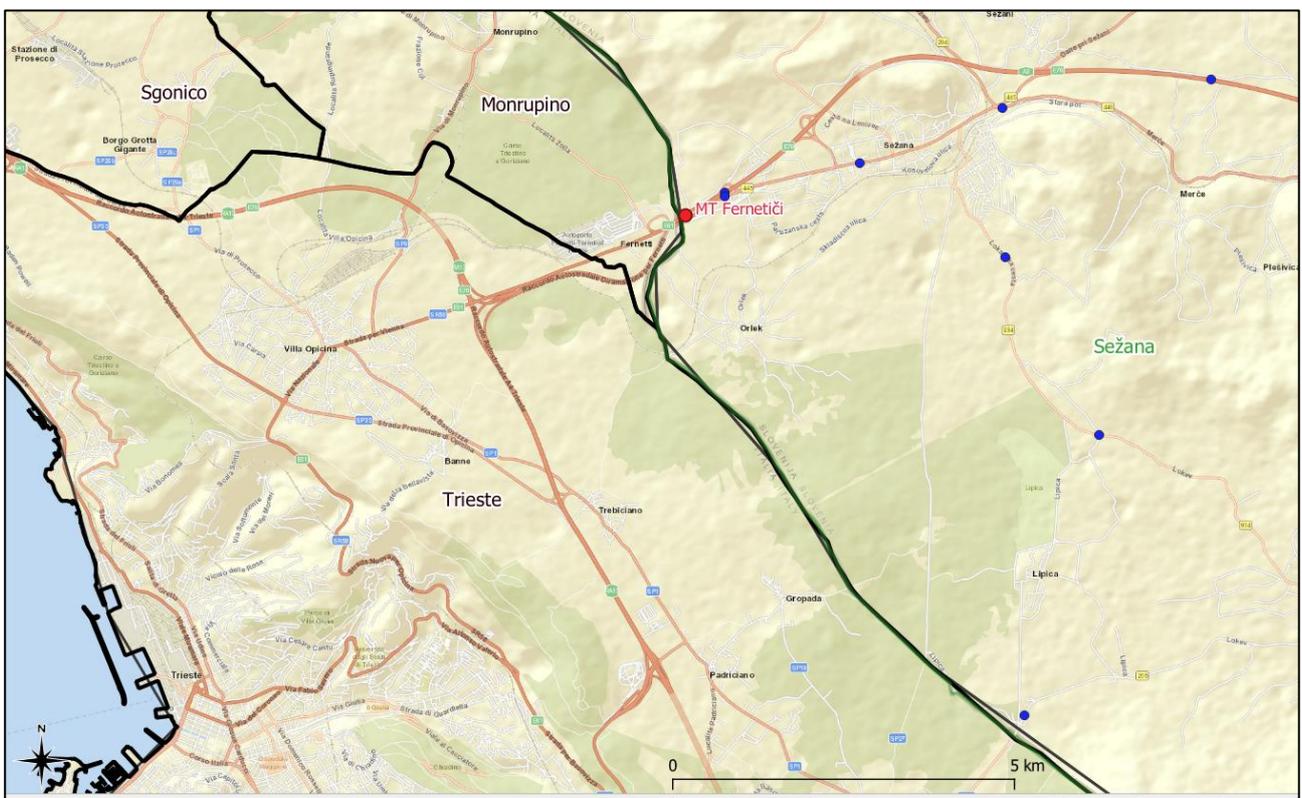


Figure 40 – Location of the Ferneti/Fernetici traffic monitoring section. Source: own elaborations on the Ministry of Infrastructure, Directorate of the Republic of Slovenia for Infrastructure data.

As shown in the previous Table 18, the Ferneti border crossing is characterised by the highest value of Average Daily Traffic (ADT) considering all vehicle categories together. This is presumably due to its location on the main motorway axis leading to Ljubljana and other destinations in Central and Eastern Europe, where heavy vehicles contribute significantly to the traffic volume.

Distinguishing between comprehensive flows and passenger car flows, data from the Slovenian monitoring system reveals the traffic pattern throughout the different hours of an average working day, as illustrated in the following figure.

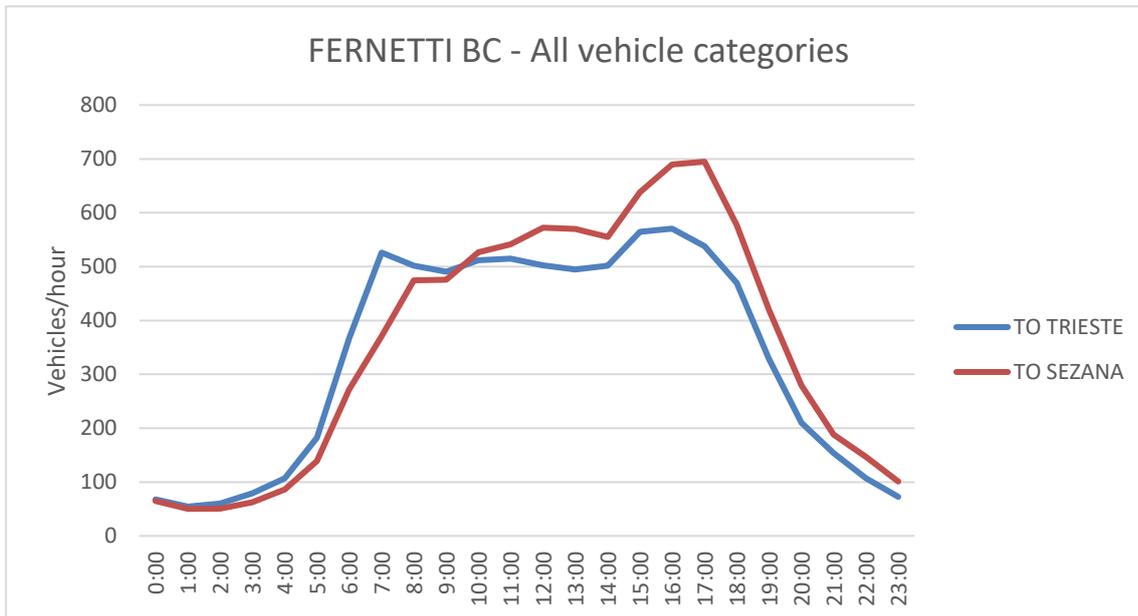


Figure 41 – Traffic flows in the Ferneti/Fernetici traffic monitoring section. Source: own elaborations on the Ministry of Infrastructure, Directorate of the Republic of Slovenia for Infrastructure data.

Focusing on the direction towards Trieste, only a limited peak can be ascertained in the morning phase, which could be associated partially with a certain flow of commuters from Slovenia. In the opposite direction, instead, this peak is absent, and the representation provides a growing pattern with remarkably higher values in the evening.

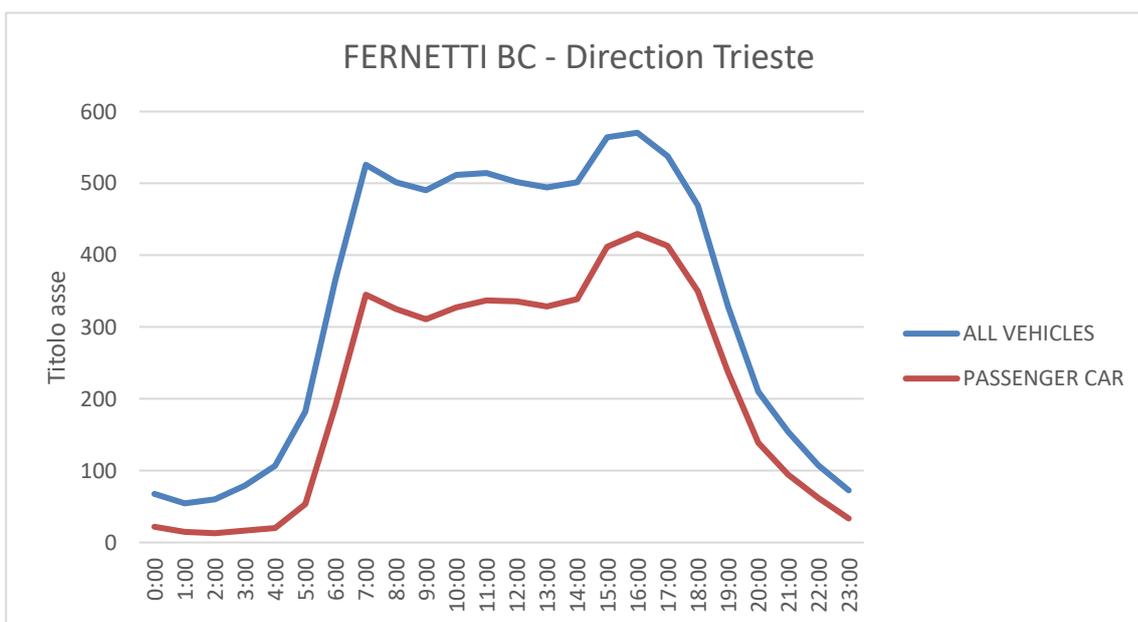


Figure 42 – Traffic flows in the Ferneti/Fernetici traffic monitoring section – Direction Trieste. Source: own elaborations on the Ministry of Infrastructure, Directorate of the Republic of Slovenia for Infrastructure data.



6.1.2. Pesek

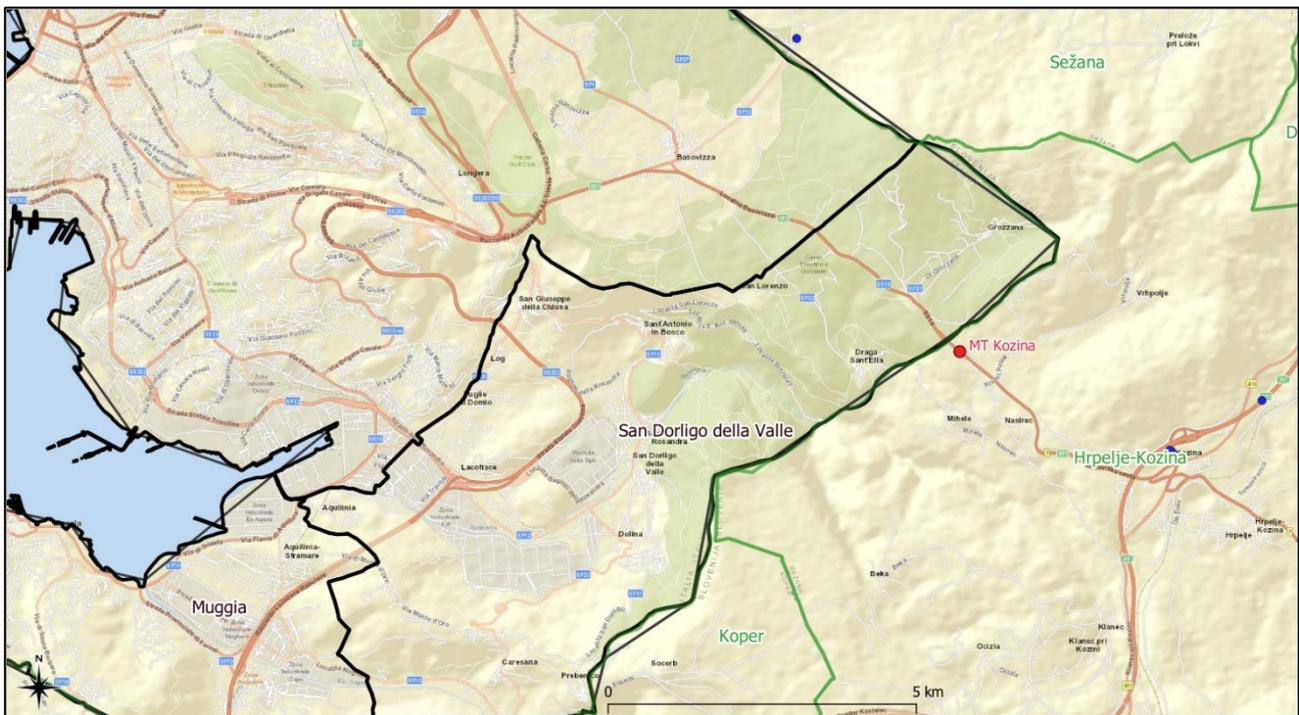


Figure 43 – Location of the Kozina/Pesek traffic monitoring section. Source: own elaborations on the Ministry of Infrastructure, Directorate of the Republic of Slovenia for Infrastructure data.

As shown in the previous Table 18, in the analysed months, the Pesek/Kozina border crossing is characterised by the lowest value of Average Daily Traffic (ADT) of the three BCPs focused on. This remark is valid both when summing up all vehicle categories and when focusing on passenger cars. This is coherent with its characterisation as a secondary road and the absence of main centres in its vicinity on the Slovenian side.

Distinguishing between comprehensive flows and passenger car flows, data from the Slovenian monitoring system reveals the traffic pattern throughout the different hours of an average working day, as illustrated in the following figure.

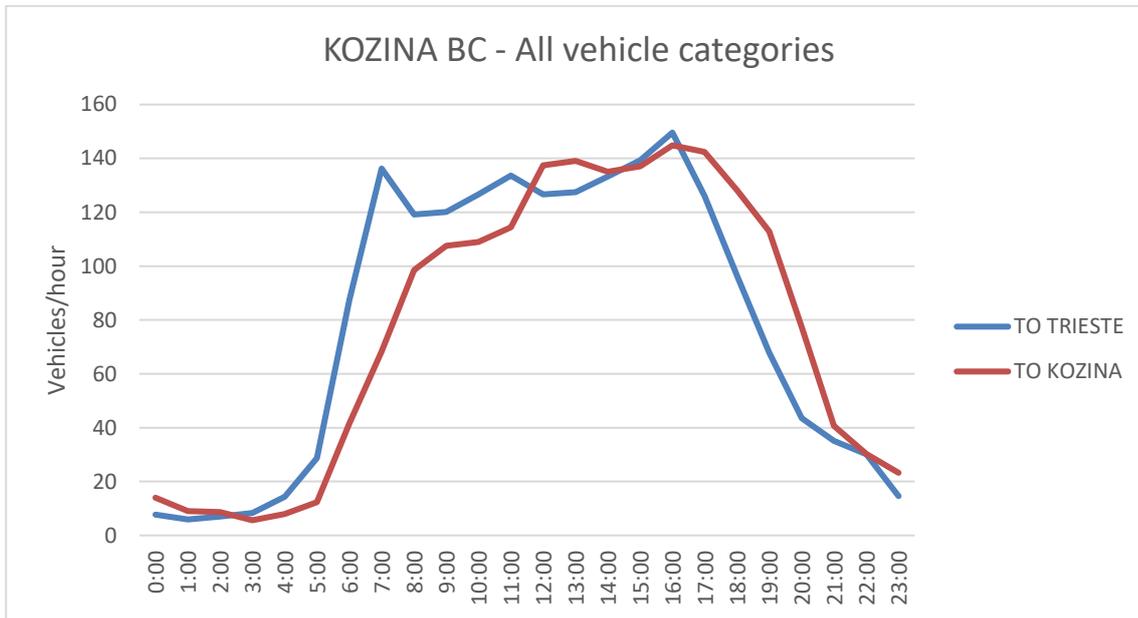


Figure 44 – Traffic flows in the Kozina/Pesek traffic monitoring section. Source: own elaborations on the Ministry of Infrastructure, Directorate of the Republic of Slovenia for Infrastructure data.

Focusing on the direction towards Trieste, only a relative peak can be ascertained in the morning phase, which could be associated partially with a limited flow (in absolute numbers) of commuters from Slovenia. In the opposite direction, instead, this peak is absent, and the representation provides a growing pattern with remarkably higher values in the evening.

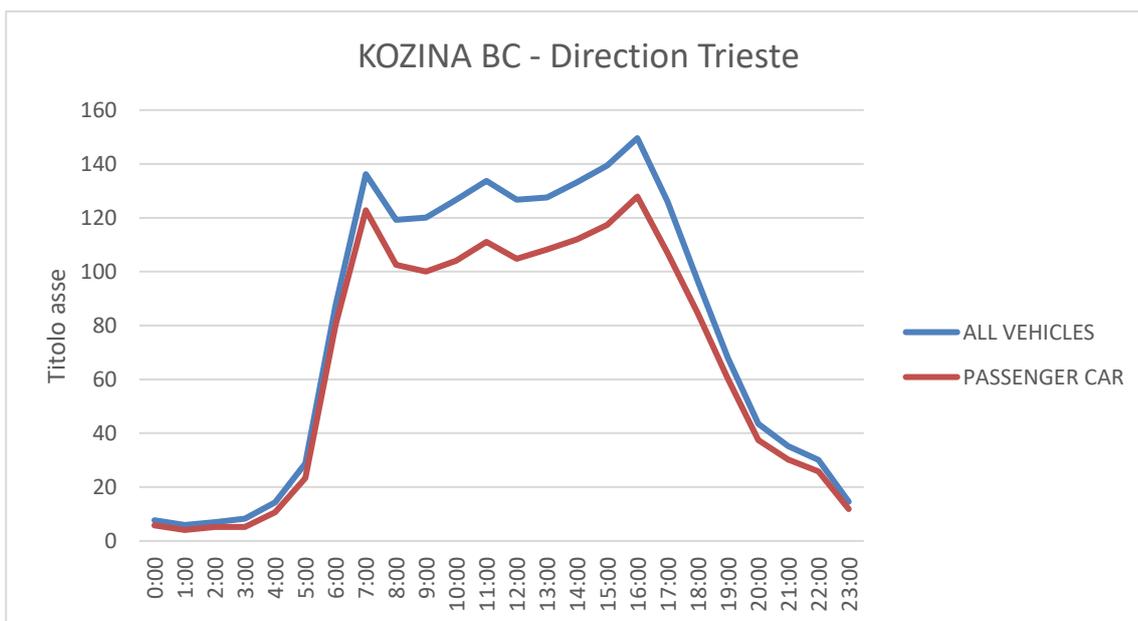


Figure 45 – Traffic flows in the Kozina/Pesek traffic monitoring section – Direction Trieste. Source: own elaborations on the Ministry of Infrastructure, Directorate of the Republic of Slovenia for Infrastructure data.



6.1.3. Rabuiese

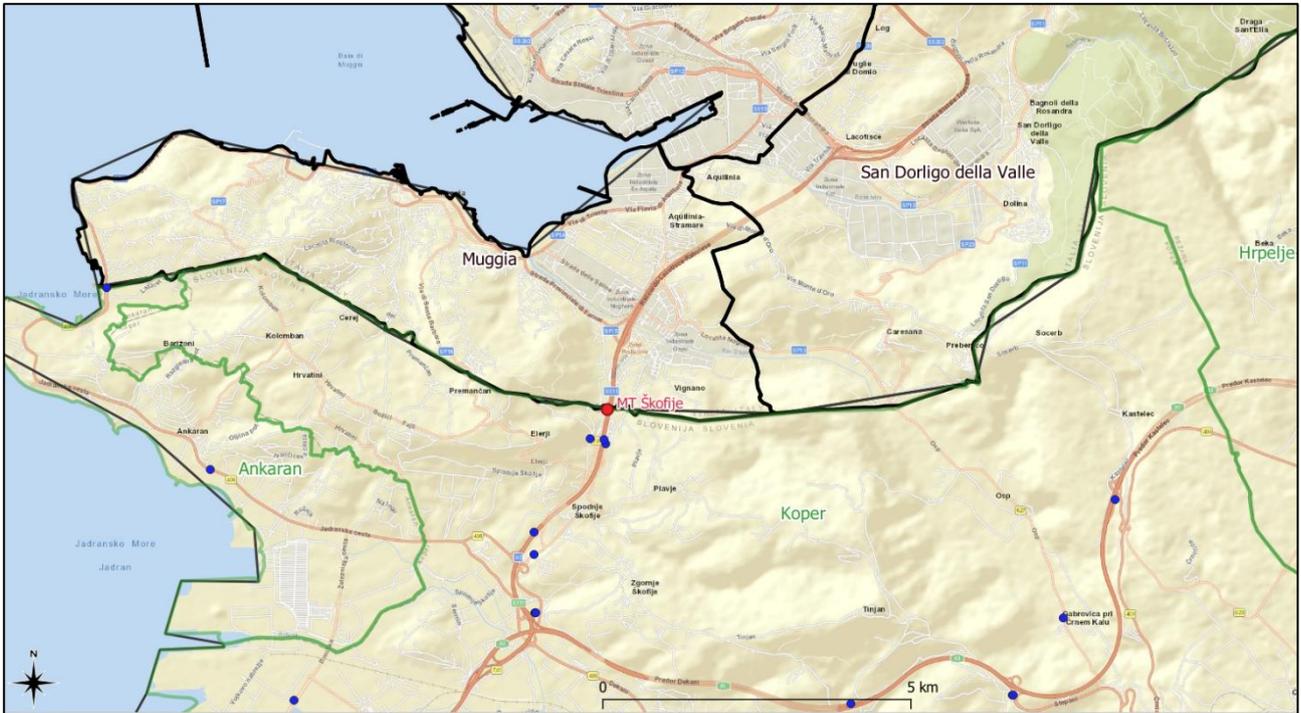


Figure 46 – Location of the Škofije/Rabuiese traffic monitoring section. Source: own elaborations on the Ministry of Infrastructure, Directorate of the Republic of Slovenia for Infrastructure data.

As shown in the previous Table 18, the Rabuiese border crossing is characterised by the highest Average Daily Traffic (ADT) considering only passenger cars. This is likely due to its location between the two main centres of Trieste and Koper.

These traffic volumes are probably associated not only with commuting but also with trips for other purposes (such as shopping at a nearby shopping centre).

Distinguishing between comprehensive flows and passenger car flows, data from the Slovenian monitoring system reveals the traffic pattern throughout the different hours of an average working day, as illustrated in the following figure.

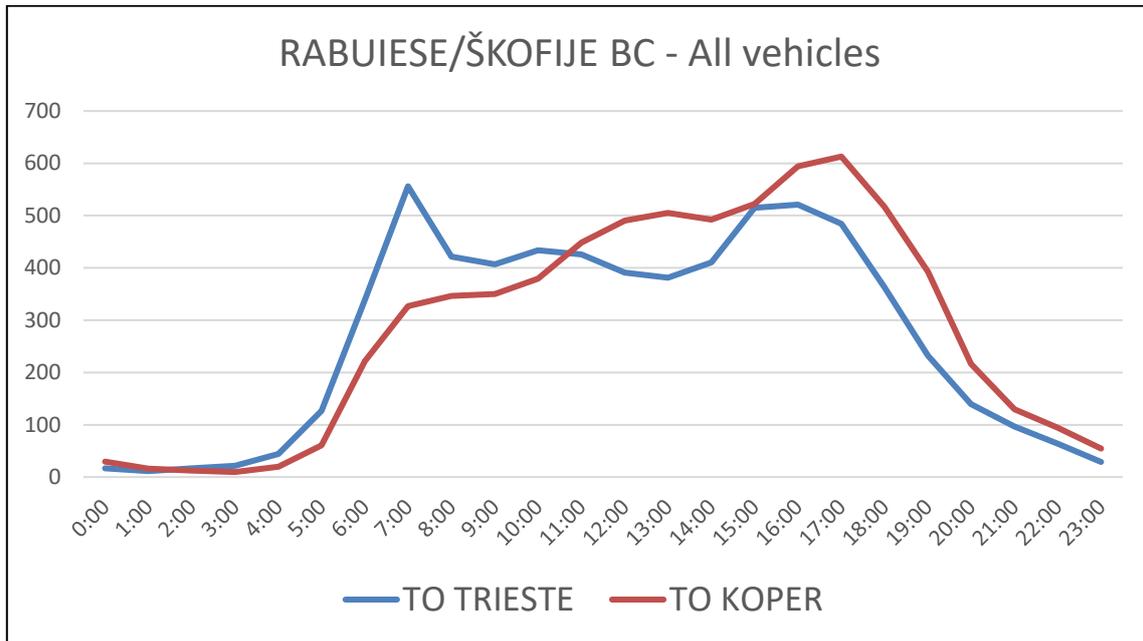


Figure 47 – Traffic flows in the Škofije/Rabuiese traffic monitoring section. Source: own elaborations on the Ministry of Infrastructure, Directorate of the Republic of Slovenia for Infrastructure data.

Focusing on the direction towards Trieste, only a peak can be ascertained in the morning phase, which could be associated also with a certain flow of commuters from Slovenia. In the opposite direction, instead, this peak is absent, and the representation provides a growing pattern with remarkably higher values in the evening.

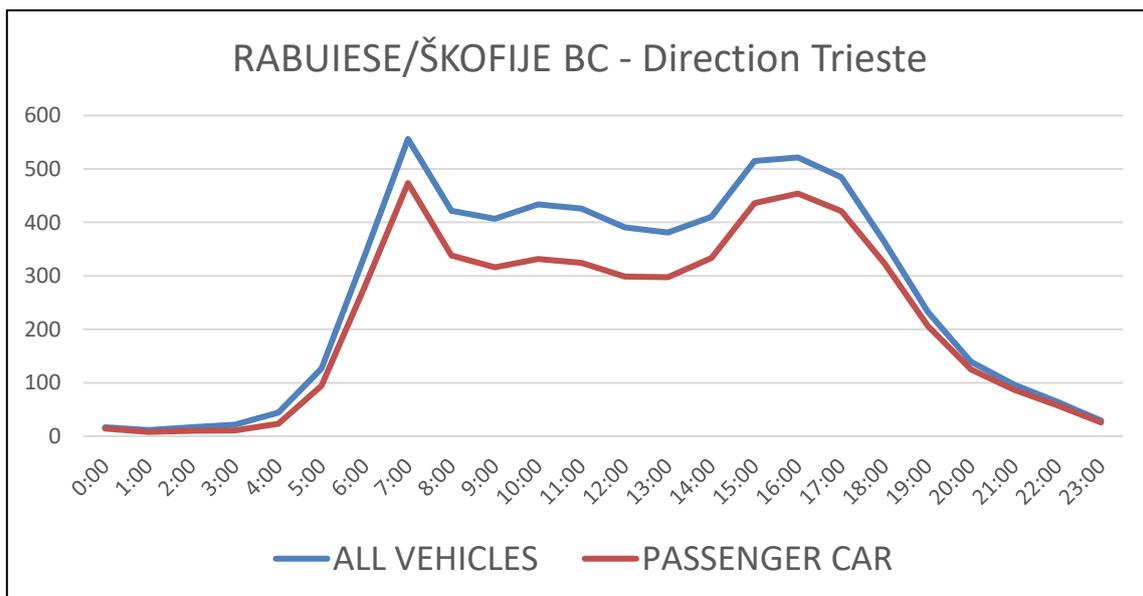


Figure 48 – Traffic flows in the Škofije/Rabuiese traffic monitoring section – Direction Trieste. Source: own elaborations on the Ministry of Infrastructure, Directorate of the Republic of Slovenia for Infrastructure data.



6.2. Cross-checking data about cross-border commuting

The cross-checking of the different sources allows for refining the possible estimate of the actual object of this study, providing quantitative elements about the transport demand linked to cross-border commuting.

However, when considering numbers from different sources, it is important to highlight different aspects and assumptions to be taken into account while comparing them, such as:

- conversion factors that allow passing from the type of data available (e.g. matrix of the movements of Slovenian SIMs in certain time slots or a classified count actually representing vehicle flow);
- different time slots assumed as reference;
- different typologies of trips that could be associated (e.g. datasets encompassing trips related to every possible purpose versus those registering specifically and only the cross-border commuters);
- correspondence between different zonings (e.g. external doors that schematize an entire route or foreign territory as a whole vs. subdivision at a municipal level or lower).

Hence, in presenting these results, (e.g. from values referring to flows of cars vs number of people, Slovenian commuter workers vs. the universe of users of the transport system, flows directed to Trieste compared to overall flows in transit at the border crossings and as regards to the analysed time slots that are not perfectly matching).

In particular, in the following table, the trips towards Trieste from mobile phones associated are compared with entering flows provided by the Trieste SUMP matrix. In this regard, it is important to recall how mobile phone data are associated with the first (FVG) municipality in which a SIM is starting to be registered, instead of a specific border crossing. Nonetheless, a certain comparison with a certain level of similarity can be ascertained as well. In this regard, the lower value of mobile phone data associated with Monrupino (also corresponding to incoming flows from Ferneti) could be explained by the peculiar challenging conditions and limited territorial extension of the area within the municipality.

ORIGIN	DESTINATION	TRIESTE SUMP		MOBILE PHONES DATA	
		ORIGIN	VOLUME	MUNICIPALITY OF ENTRY	FLOWS TO TRIESTE 06-09
FERNETTI	TRIESTE	Ferneti_Port_149	233	Monrupino	122
BASOVIZZA	TRIESTE	Lipizza_Port_150	128	Trieste_0	n.a.
PESEK	TRIESTE	Pese_Port_151	96	San Dorligo della Valle	73
RABUIESE	TRIESTE	Rabuiese_Port_152	241	Muggia	321
LAZZARETTO	TRIESTE	Lazzaretto_Port_153	0		

Table 19 – Comparison of entering flow values in Italy through the main reference border crossings resulting from different Italian sources.

Furthermore, other correspondancies can be ascertained also looking at the Slovenian data sources, as those reported in the the following table



CROSS-BORDER POINT	TRIESTE SUMP O/D MATRIX	MOBILE PHONES DATA (SLOVENIAN SIM 06-09 AM) TOWARDS TRIESTE	ESTIMATION FROM THE DATASET OF SLOVENIAN CROSS-BORDER COMMUTERS	CAR FLOWS TOWARDS ITALY IN THE MORNING PEAK HOUR FROM THE NCUP
FERNETTI	233	122	353	478
BASOVIZZA	128	n.a.	-	-
PESEK	96	73	79	93
RABUIESE	241	321	390	403
LAZZARETTO	0		22	-

Table 20 – Comparison of entering flow values in Italy through the main reference border crossings referring to the morning peak hour

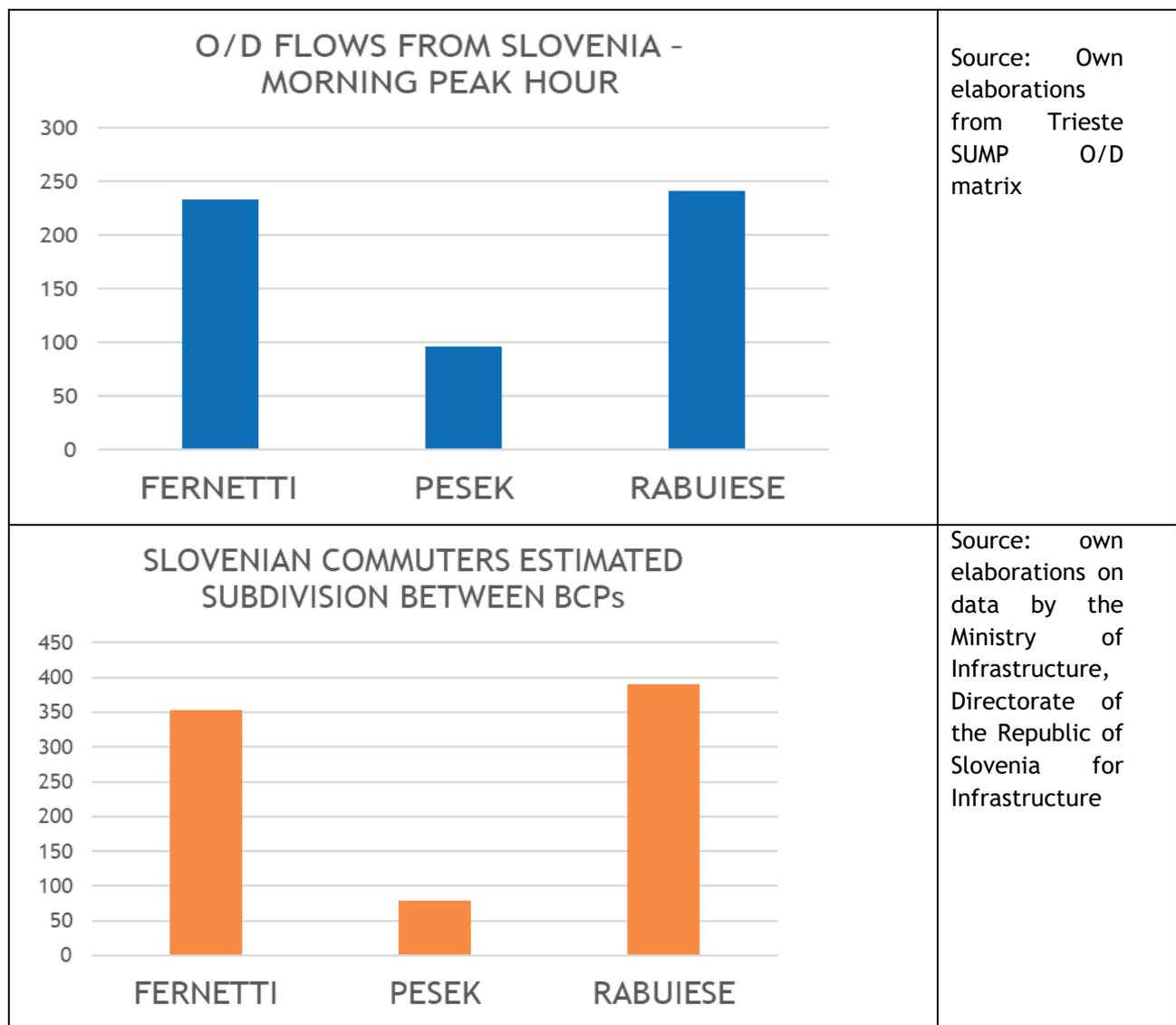


Figure 49 – Visual comparison of the cross-border flows addressing different specific focuses



Overall, a significant convergence can be ascertained, in spite of some differences (which also can be expected and coherent with the aforementioned remarks). For instance, in Figure 49, a similar pattern, emphasising a clearly major role of the Ferneti and Rabuise in comparison with the Pesek border crossing. In particular, the dataset referred specifically to commuters present, between the two major, a slightly higher value is associated with Rabuiese. Furthermore, a good correspondence is also evident with data about traffic flow surveys at border crossings shown in the previous paragraph.



7. Multimodal / PT accessibility and crossborder gaps

After having addressed the demand side in the previous chapter, the present one focuses on the supply side, specifically examining the public transport sector on both sides of the border in the analysed area. This allows for the identification of existing gaps and the assessment of multimodal accessibility related to public transport, with a particular emphasis on local bus services. More specifically, after having provided an overview of the network and cross-border gaps in the first paragraph, in the second one, specific cross-border areas and (missing) connections will be assessed. To this end, both the isochrones representation and analyses of specific public transport lines will be presented.

7.1. The Gaps of the PT network in the cross-border area

As already reported, the data made available by the Italian and Slovenian National Access Points allows for mapping the public transport network. Correspondingly, it is possible to ascertain a relevant gap at the cross-border level given the current missing integration between the two PT systems. Correspondingly, the lack of smooth, integrated solutions hampers the possibility of sustainable cross-border commuting.

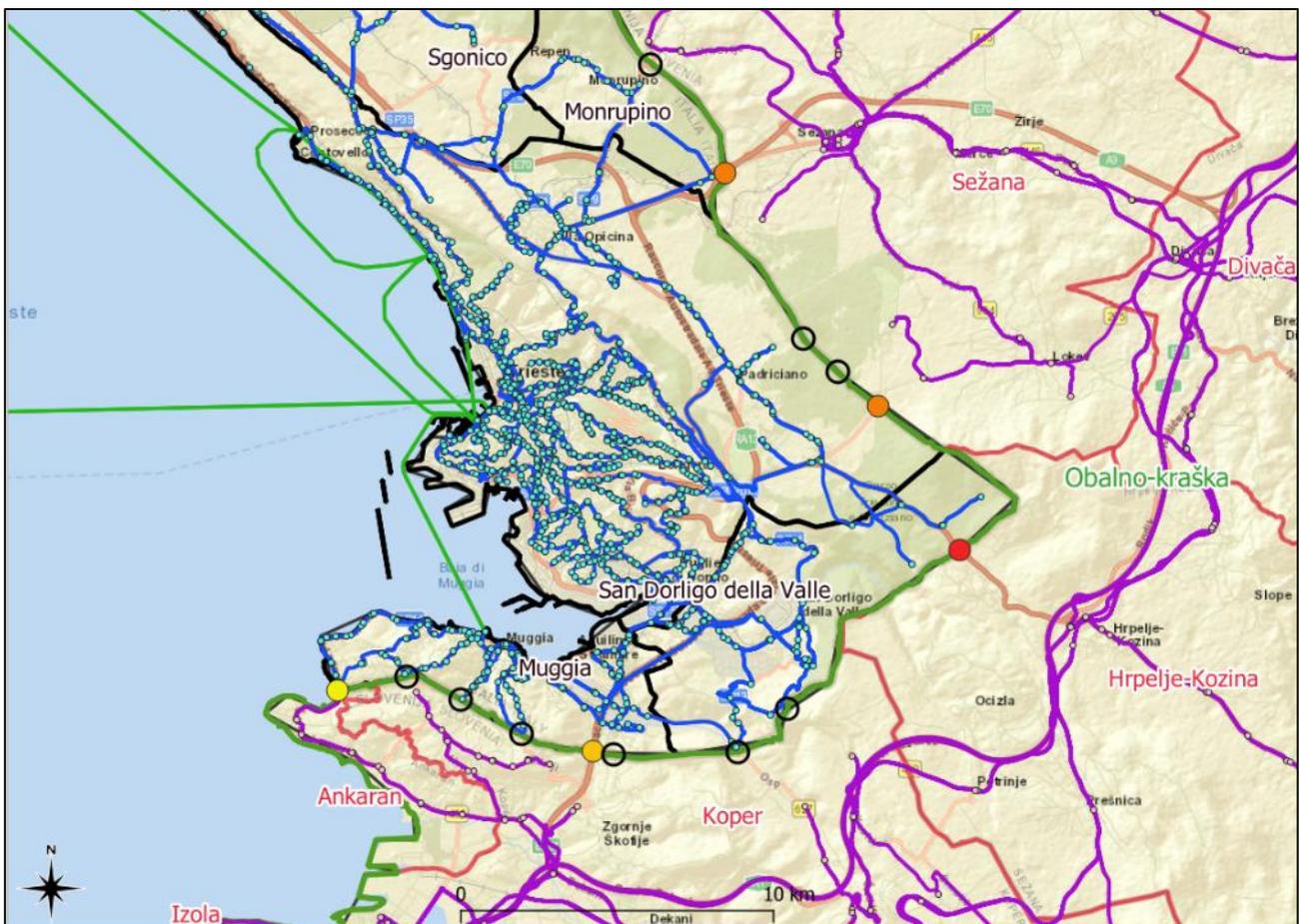


Figure 50 – Detailed view of gaps between the PT service across the border. Source: own elaborations on data by Italian and Slovenian NAPs



In this regard, Figure 50 provides a thematic representation of the gaps in physical distance (in kilometres) between public transport services on the Italian and Slovenian sides in the Trieste area, referenced to the list of relevant border crossing points identified in the Friuli Venezia Giulia public transport plan. Obviously, these border crossings include the three deepened in the previous chapter on transport demand and traffic flows (Ferneti, Pesek and Rabuiese). The gaps are visually indicated by colored circles ranging from yellow to red, reflecting increasing distances. For completeness, other minor road border crossings are also shown, represented by black circles without fill.

As a general remark, it should be underlined that only one of the relevant crossing points (San Bartolomeo-Lazaret), located on the coast between Muggia and Ankaran is characterised by a gap of less than 1 km. Nonetheless, the other crossings register distances below 3.5 km, with the sole exception of Pesek, which corresponds to a gap of about 4 km.

Moreover, the area analysed and represented in Figure 50 includes several other minor crossings. Their density is notably higher in the southern part, especially along the coastal area.

For completeness, it is also important to report that, in addition to the local public transport services whose data (feeding the previous representations) are made available through the NAP, Arriva d.o.o. currently operates an international transfer service from Koper to Trieste (via Rabuiese), which will be further described in the following paragraph.

7.2. Multimodal accessibility assessment PT network through relevant connections in the cross-border area

In this paragraph, the analysis is further deepened with reference to specific cross-border areas, and (missing) connections will be assessed. In particular, considering both the higher volumes of demand and the relatively limited gaps in the public transport network, the crossings of Ferneti and Rabuiese are particularly focused on. In the case of Pesek, it is to register both the lowest level demand and the longest cross border gap in the public transport network.

Obviously, to assess the potential effect of network integration, it is necessary to evaluate not only the reduction of the distance between transport networks at the stops closest to the border but also how these stops are connected to the rest of the network. In this regard, particular attention is given to the mutual accessibility of the Slovenian hinterland, which is characterised by a lower density of stops and services compared to the urban core of Trieste, where the majority of potential commuter destinations are concentrated.

To this end, the following isochrones represent public transport accessibility for trips starting at 7:00 AM on a typical weekday, showing the outcomes with reference to various relevant origins. An isochrone depicts the areas reachable from a given starting point within a specified time frame, beginning at the indicated hour. It is important to note that these representations showcase some accessibility outcomes making reference to a specific time, rather than over the entire peak hour. The results were generated using the open-source software OpenTripPlanner (OTP) applied to the dataset available in the NAP.

For instance, in the case of Sežana (Figure 51), the proximity to the national border crossing not served by PT and relevant connections with Divača implies a quite asymmetrical area reachable in a given span of time.

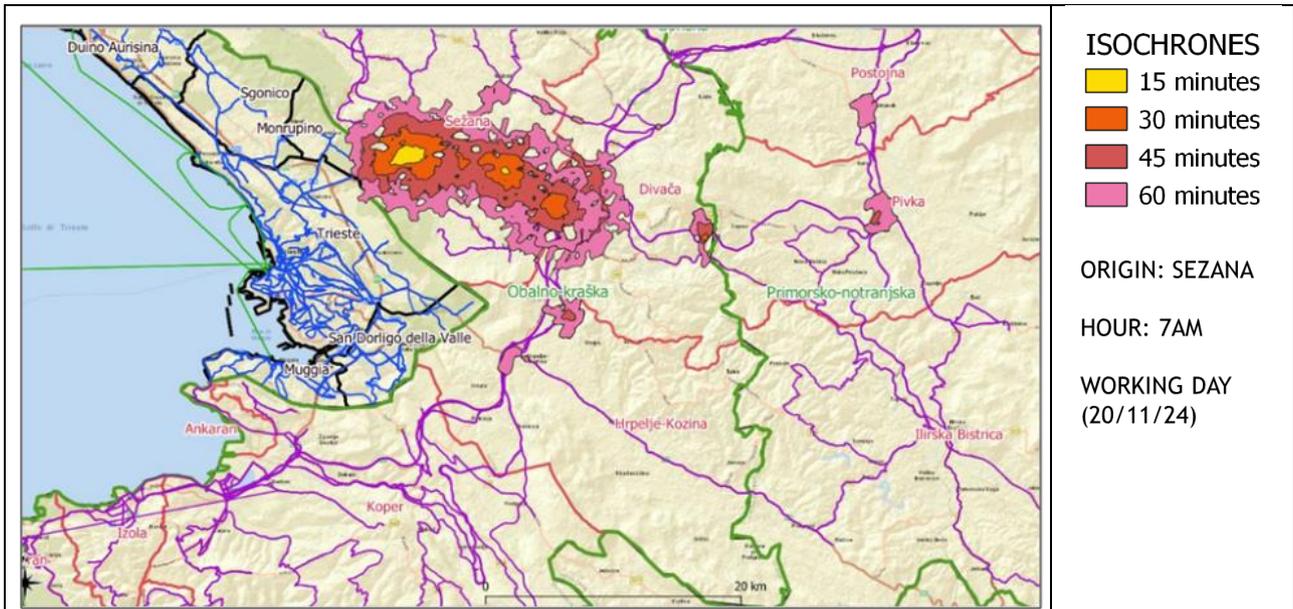


Figure 51 – Isochrones for PT trips starting from Sezana on the morning peak hour. Source: own elaborations on data by Italian and Slovenian NAPs

Correspondingly, the isochrones from Divača (Figure 52) show a good reachability of Sežana.

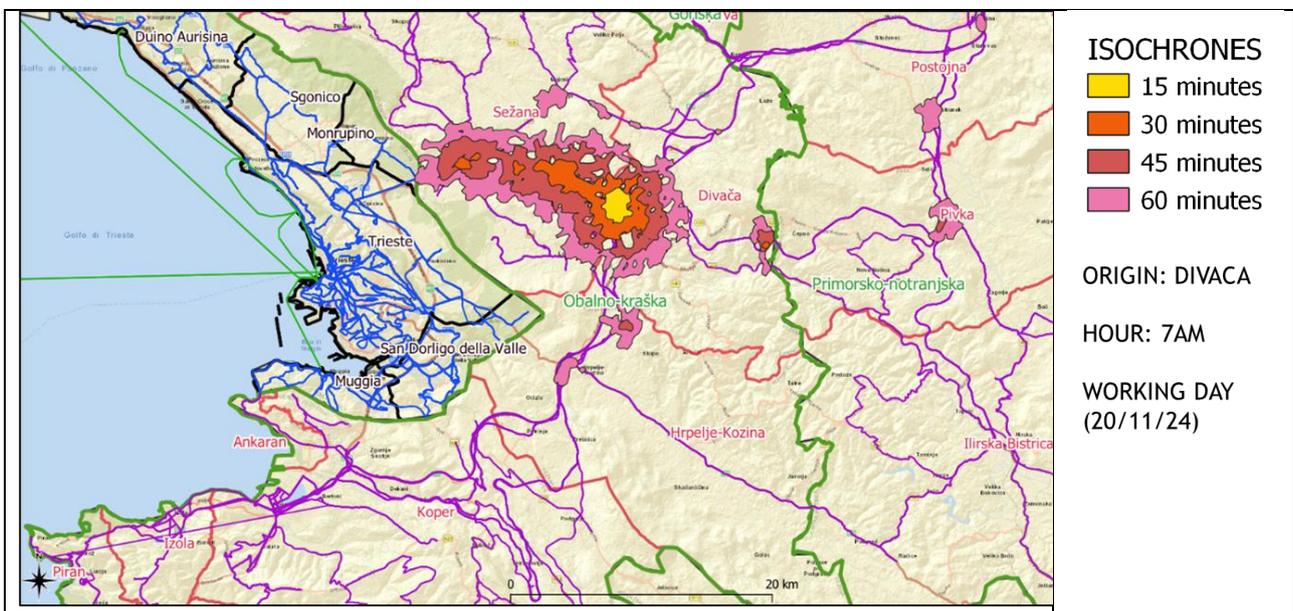


Figure 52 – Isochrones for PT trips starting from Divača on the morning peak hour. Source: own elaborations on data by Italian and Slovenian NAPs

For instance, in the case of Koper (Figure 53), it shows a good reachability with isochrones covering a relevant part of the coast as well as of the hinterland. Among others, they reach relevant destinations, including the settlement of Škofije, close to the Rabuiese border crossing.



GreenPATH

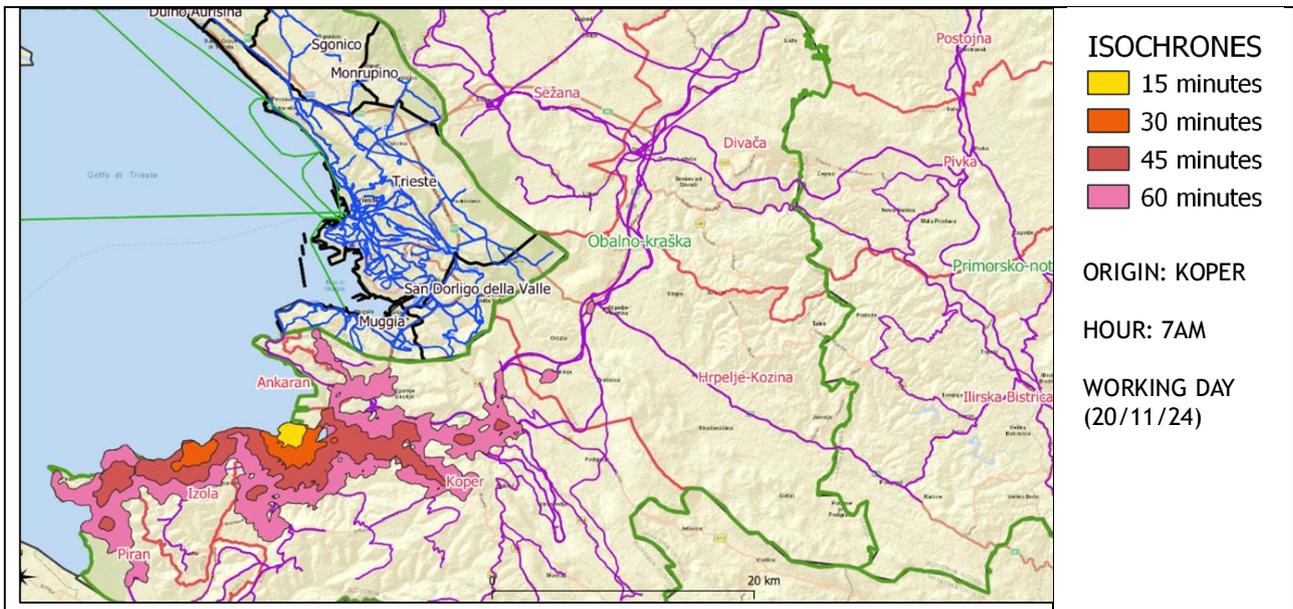


Figure 53 – Isochrones for PT trips starting from Koper on the morning peak hour. Source: own elaborations on data by Italian and Slovenian NAPs

Correspondingly, the isochrones from Piran (Figure 54) show a more limited coverage, though reaching the key node of Koper.

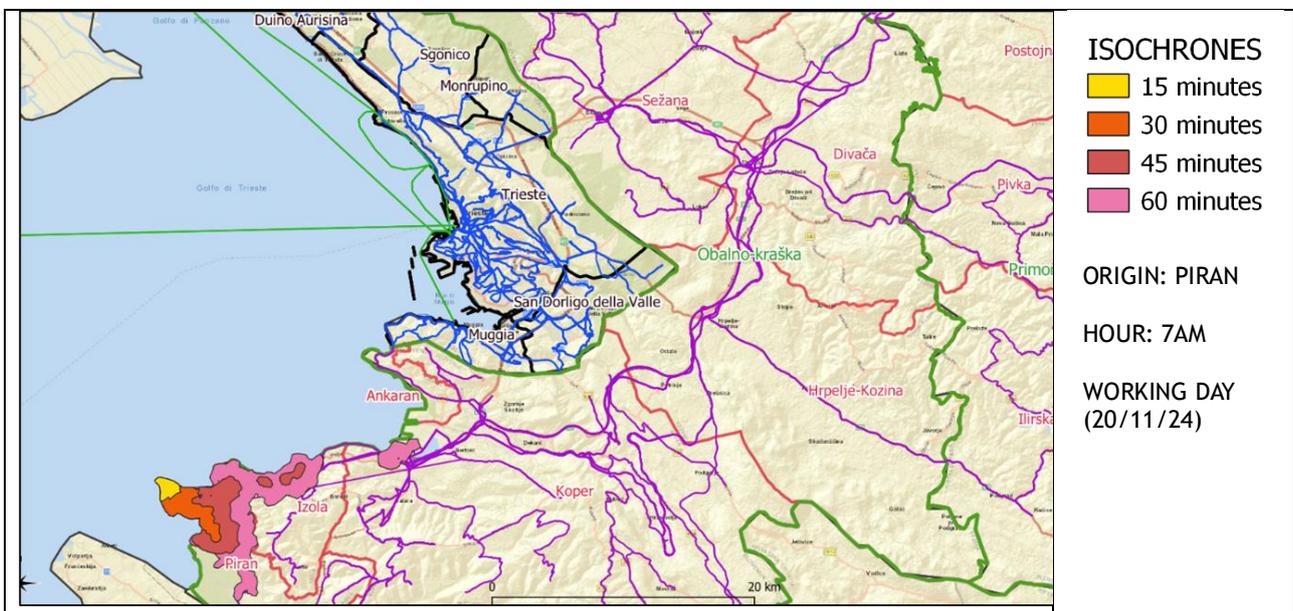


Figure 54 – Isochrones for PT trips starting from Piran on the morning peak hour. Source: own elaborations on data by Italian and Slovenian NAPs

Focusing more specifically on the actual missing links, in the case of Ferneti, the gap in the public transport network could be filled in pivoting on the stop in Ferneti, named “località Ferneti 3/A (casa di riposo)”, represented in sky blue colour in Figure 55, and the bus station in Sežana, represented in yellow colour.



Both stops are already served by relevant PT services. In fact, while the stop in Fernetti is served by the 64 and 62 lines represented in the figure below, the station in Sežana is served by the various lines in orange colour.

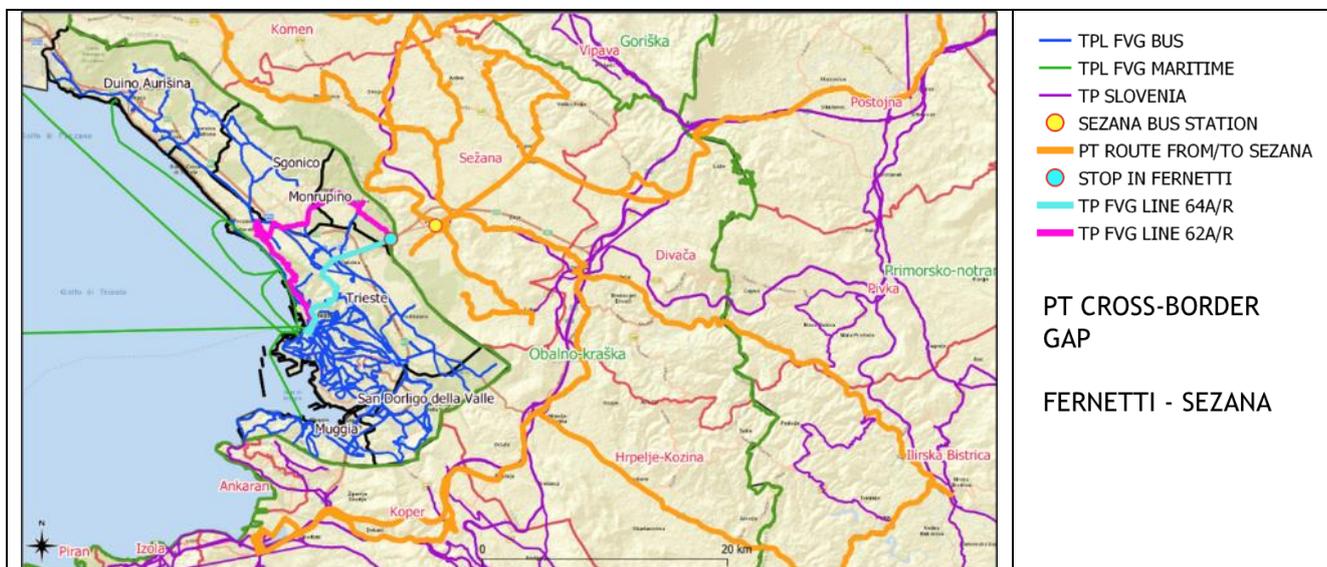


Figure 55 – PT lines and main stops on the two sides of the PT cross-border gap between Fernetti and Sežana.
Source: own elaborations on data by Italian and Slovenian NAPs

Focusing more on the case of Rabuiese border crossing, instead, there is a relevant gap between the closest settlement in the southwestern part of the Muggia municipality and the Škofije settlement on the Slovenian side.

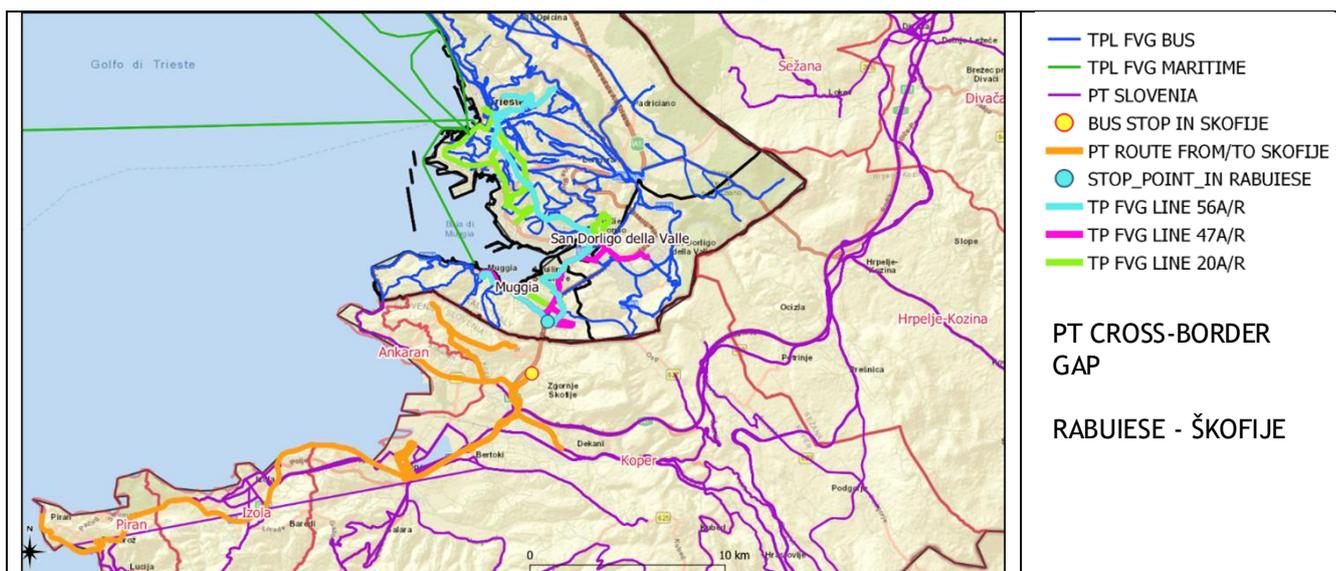


Figure 56 – PT lines and main stops on the two sides of the PT cross-border gap between Rabuiese and Škofije.
Source: own elaborations on data by Italian and Slovenian NAPs



The related areas are already served by relevant local PT services. In fact, the stops at a relatively close distance of the border crossing on the Italian side are served by the 20, 47 and 56 lines represented in the figure above. On the Slovenian side, instead, the bus stop in Škofije is served by the lines in orange colour.

Additionally, it is important to consider (and possibly to integrate) the international transfer carried out by the bus operator Arriva Slovenija linking Koper and Trieste²³. In fact, this service provides a connection with an overall trip duration of 39 minutes from Koper to Trieste, each 30 minutes (within the morning peak hour). The related timetable envisages 8 stops, almost completely on the Slovenian side, as reported in the following table.

BUS STOPS	RUN 1	RUN 2	RUN 3	RUN 4	...
Koper	06:00	07:00	07:30	08:30	...
Bertoki ZAD	06:08	07:08	07:38	08:38	...
Ankaran	06:11	07:11	07:41	08:41	...
Škofije	06:14	07:14	07:44	08:44	...
Škofije meja	06:17	07:17	07:47	08:47	...
Škofije MP	06:18	07:18	07:48	08:48	...
Rabuiese MP	06:19	07:19	07:49	08:49	...
Trieste bus station	06:39	07:39	08:09	09:09	...

Table 21 – Koper- Trieste international transfer line - excerpt from the timetable in the morning peak hour. Source: Arriva Slovenija

Hence, this service (though with a different characterisation) already provides a relevant connection through the Rabuiese border crossing.

Nonetheless, a full integration in the PT could provide further advantages and interconnections. In this regard, for instance, it is to consider that after the Rabuiese border crossing, it stops only in Trieste Autostazione.

²³ See https://arriva.si/en/international_transfers/koper-trst-trieste/



8. Towards a future implementation: remarks on different challenges to be addressed

Following the assessment of the existing cross-border demand and the identification of certain gaps in the public transport system, this chapter provides an overview of various aspects, ideas, and constraints of different character (technical, operational, legal, and institutional) to be further deepened in any future steps towards implementation.

8.1. Technical issues and approaches to be considered

The development of cross-border public transport services in the Trieste FUA requires careful planning to ensure that any new or extended services harmonise effectively within the existing complex transport system. It is essential to maintain current service levels while strategically extending and “stitching together” the transport supply on both sides of the border. Achieving full integration within the public transport network is important to address the fragmented nature of cross-border mobility and to enhance overall accessibility. In this way, it will be possible to enable efficient links between the dispersed origins of commuter trips - mainly centres and settlements on the Slovenian side - and the diverse employment destinations - consisting of different attractors potentially located in different parts of the municipality of Trieste.

Furthermore, different operational models should be evaluated, including traditional fixed-schedule services and more flexible demand-responsive transport (DRT) options. The latter has already been tested and is currently applied (though with a different typology of users and within the national border area) in the Trieste context, demonstrating the potential for adapting service provision to variable demand patterns and improving coverage in less dense or peripheral areas. Selecting the appropriate solution or mix of these approaches will depend on technical feasibility, demand levels, and cost-effectiveness, all of which must be carefully assessed in subsequent planning phases to ensure sustainable and user-oriented cross-border transport solutions.

8.2. Legal constraints and provisions

The regulatory framework for the implementation of cross-border public transport services in the Friuli Venezia Giulia Autonomous Region is defined by Legislative Decree N. 111/2004, which delineates the division of competencies between national and regional authorities in the fields of road networks and multimodal transport. According to this decree, the Autonomous Region is responsible for regulating cross-border transport services within a specified range from the national border.

In particular, public bus services are qualified as cross-border and are tendered under the rule of the Regional Administration when connecting origin and destinations in territorial areas within a 40 km radius (i.e. distance calculated through a straight line, as the crow flies) with respect to at least one of the 9 road CB passes located along the state border marked as red points in the following Figure 57 (which includes also 3 crossings related to the Italy-Austria border).

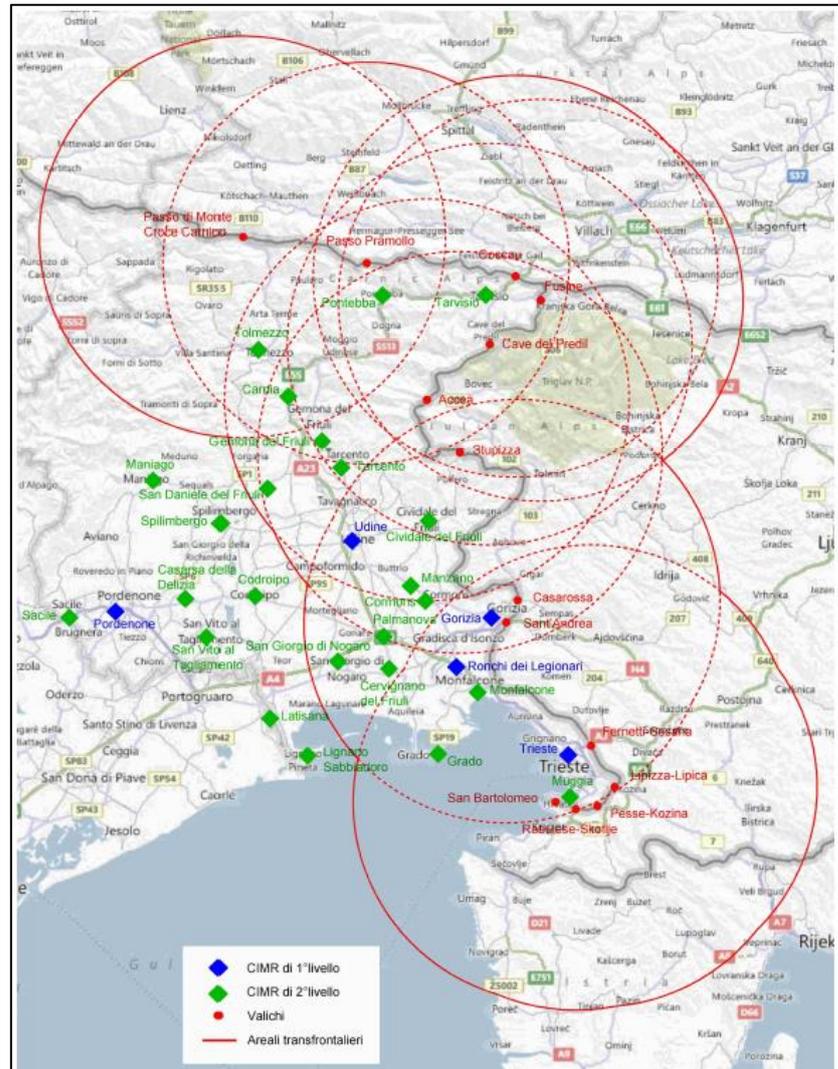


Figure 57 - Overview of relevant transit points (in red) acknowledged in the FVG regional PT plan. Source: "Piano Regionale del Trasporto Pubblico Locale" – PRTP/L, 2013

CLUSTER	NAME	ROAD CODE - ITA SIDE	ROAD CODE - SLO SIDE	MUNICIPALITY - ITA SIDE	MUNICIPALITY - SLO SIDE
Trieste	Fernetti - Sežana	RA14	A3/445	Monrupino	Sežana
Trieste	Lipizza – Lipica	SP10	205	Trieste	Sežana
Trieste	Pesek – Kozina	SS14	7	San Dorligo della Valle	Hrpelje-Kozina
Trieste	Rabuiese – Skofije	NSA326	H5	Muggia	Koper
Trieste	S. Bartolomeo - Lazaret	SP14	406	Muggia	Ankaran

Table 22 – List of relevant transit points acknowledged in the FVG regional PT plan

For maritime transport, instead, the threshold is extended to 150 km from the border (which is enough to cover all possible connections with any port located on the Slovenian coast).



Additional cross-border public transport services can also be incorporated within the framework of the current service contract of regional public transport with the operator TPL FVG, allowing for operational flexibility and the integration of new routes as mobility needs evolve.

A key regulatory challenge is the prohibition of cabotage, which restricts the possibility of foreign operators to carry domestic passengers within the territory of another Country territory (Articles 2 and 3 of Regulation (EC) No 1073/2009, which define cabotage operations and set the conditions for the freedom to provide international coach and bus services within the EU). However, targeted solutions are feasible through bilateral agreements and derogations permitted by the EU legislation itself (Article 25 of Regulation (EC) No 1073/2009). Moreover, practical solutions have been developed, as demonstrated by the successful activation of the Gorizia/Nova Gorica urban cross-border bus line²⁴, where specific agreements and operational arrangements have enabled compliant and effective cross-border services. Addressing these regulatory and contractual aspects is essential for the seamless planning and implementation of future cross-border public transport solutions, ensuring both legal compliance and service continuity across the Italian-Slovenian border.

8.3. Economic sustainability

The need to ensure the economic and, more specifically, financial sustainability of new transport services is a key success factor. Two main drivers underpin this goal: securing a critical mass of users who contribute to cost recovery through fare payments, and leveraging available funding sources.

Considering the possibility of setting up the service as an additional zone within the current regional public transport contract with the operator TPL FVG (on the Italian Side), it is important to recall the related funding mechanism. The regional contract is based on a public service obligation model, where the operator receives funding from the Regional administration to cover service costs not recovered through ticket revenues. Therefore, achieving a sufficient ridership level is essential to maximise farebox recovery (i.e. the fraction of operating expenses which are met by the fares paid by passengers) and reduce the financial burden on public budgets.

Additional funding sources, such as EU projects, can support (at least partly) the critical start-up phase of new services and allow for testing and step-by-step fine-tuning. In this regard, best practices from cross-border and/or innovative services established in the analysed context provide valuable examples and lessons learned.

Ultimately, appropriate fine-tuning and selecting the most suitable service model among those described earlier will be crucial to ensuring economic sustainability. Flexible services or marginal extensions of existing routes across the border can represent cost-effective options, provided that performance levels and user appeal are maintained and that the overall public transport service organisation is not disrupted.

²⁴ See also <https://www.go-borderless.eu/it/splodne-informacije> and

<https://tplfvg.it/it/news-e-aggiornamenti/news/2022/9/16/riattivata-dal-19-settembre-la-linea-urbana-internazionale-gorizia-nova-gorica/>



8.4. Coordination and governance

The set of aspects outlined in the previous paragraphs highlights the importance of a coordination and planning process that becomes even more crucial and critical given the cross-border dimension involved. In this regard, as also noted in relation to regulatory issues, it is necessary to establish coordination mechanisms among decision-makers on both sides of the border. More generally, it will be essential to adopt a multi-level coordination approach addressing legal, technical, and operational aspects.

In fact, even from a technical and operational perspective, maximising the effectiveness of implementation efforts cannot be limited to introducing new services or extending existing ones but must encompass a range of aspects related to integration within the broader public transport system. This concerns both the coordination of timetables and the integration, or at least interoperability, of ticketing systems. Moreover, the importance of a comprehensive approach is increasingly recognised today, also driven by the push towards Mobility as a Service (MaaS) systems, whose development is becoming more and more topical, with significant initiatives also in the analysed context.

Last but not least, user information provision and raising awareness certainly constitute fundamental aspects that must be addressed in a coordinated manner as well.

8.5. SWOT analysis

The key outcomes from the carried out analysis can be summarised through a “SWOT analysis”. In fact, from a consolidated methodological approach, an important synopsis is provided by highlighting the strengths, the weaknesses, the opportunities and the threats with reference to the possibility of developing or improving PT services, addressing the mobility needs of the cross-border commuters.

Strengths	Weaknesses
<ul style="list-style-type: none">• The CB area is endowed with a relevant PT network on both sides of the border.• Cross-border public transport services have been identified by the FVG PRTPL as important priorities to be implemented as regards to bus, rail and maritime public transport thanks to the possibilities of carrying out CB public transport services.• A first core base of transport demand can be ascertained, especially across the Ferneti and Rabuiese border crossings.• Cross-border innovative transport solutions have been developed thanks to some specific	<ul style="list-style-type: none">• Limited Accessibility, considering the low population density, represents a problem to be faced when talking about a wide area of the CB area (with particular reference to rural and mountainous areas).• General lack of coordination and integration of services at CB level.• Existing gaps in road PT connectivity and the absence of full-fledged cross-border PT services (apart from commercial services and the international linking directly to the Trieste bus station from Rabuiese).



<p>EU projects implemented (MICOTRA, CROSSMOBY, SUSTANCE ...).</p> <ul style="list-style-type: none"> • The existence of ongoing best practice in developing a joint cross-border bus service represented by the international line Gorizia-Nova Gorica 	
Opportunities	Threats
<ul style="list-style-type: none"> • Possibility for the FVG Region to activate CB services within the already tendered regular PT services. • The presence of different ongoing initiatives aimed at the development of a sustainable multimodal transport according to a comprehensive approach (MaaS). • Funding opportunities to support the pilot testing and/or the start-up phase of new/improved services • Opportunity that could arise from exploiting advanced ICT tools as well as innovative paradigms in designing PT service, also including flexible Demand Responsive ones. 	<ul style="list-style-type: none"> • Economic sustainability is to be ensured. • Competitiveness and appeal of car-based solutions. • Regulatory aspects and limitations to be addressed • Interoperability to be ensured when deploying services at the CB level (e.g. with reference to ticketing).

Table 23 – SWOT analysis



9. Conclusions

Within the general framework of the GreenPATH project, this deliverable has presented an analysis by CEI-ES of commuting in the Trieste FUA, specifically focusing on cross-border trips from Slovenia to Italy. The key rationale of the analysis is providing some quantitative facts and technical elements that could pave the way to further detailed analyses, in case, leading to the implementation of extensions of public transport services tailored to address the identified demand and needs.

In particular, it implied addressing the particular context of the Trieste area, where the relationship between an urban core and its suburban/rural hinterland is interwoven with the cross-border dimension. In such a peculiar context, the presence of political borders and a peculiar historical background, together with the geomorphological characterisation, has influenced urban development and transport infrastructure, creating a sharp differentiation between the Trieste urban core and its hinterland. In order to provide a more comprehensive overview, the analysis addressed the cross-border dimension, going beyond the six municipalities of the former Trieste province to include the Slovenian Obalno-kraška region, highlighting their mutual functional relationships. In perspective, a growing cross-border integration and extension of the Functional Urban Area could also be facilitated by bilingualism due to the presence of Slovenian-speaking communities in the Italian portion of the Karst and Italian-speaking groups in Slovenian coastal municipalities. Additionally, recent demographic trends, notably Italians settling in Slovenian border municipalities, reflect suburbanization driven by real estate opportunities and reinforce cross-border socio-economic ties.

Given the typical lack of complete and harmonised data covering both sides of the border, deepening the analysis of cross-border transport demand is challenging. To address this, the present research leveraged different and heterogeneous data sources identified on both the Italian and Slovenian sides. Among others, it is worth mentioning the innovative use of mobile phone location data provided by the Friuli Venezia Giulia Autonomous Region, which allows a comprehensive and extensive data collection of transport demand by different user categories, including cross-border travellers.

The overall analysis allowed to the identification of commuting flows across key border crossings (Ferneti, Pesek, Rabuiese), which could provide a first basis for new or improved transport services. To this end, the study also examined public transport data available through the Italian and Slovenian National Access Points, revealing significant gaps in multimodal accessibility at the national border, especially at Ferneti and Rabuiese.

The preliminary assessment of missing public transport connections forms the basis for future planning, suggesting the need for improved cross-border connectivity, to be further examined and operationally planned, considering technical, economic, legal, and governance aspects.

More in general, the results underscore the importance of coordinated institutional dialogue and the integration of data and technical analysis for thorough planning to support seamless cross-border mobility. Ultimately, the Trieste FUA and its Slovenian neighbours offer a valuable laboratory for testing new models of cross-border urban integration, with the analysis of transport data playing a central role in identifying needs and guiding the design of more effective, sustainable, and inclusive mobility solutions.



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