Interreg

EUROPEAN UNION

Danube Transnational Programme

RADAR

Project co-funded by European Union funds (ERDF, IPA, ENI)

O.T.3.1.c Pilot Actions on 4 (6) Road Safety Thematic Areas

TA2 VRU'S - SLOVENIA

RADAR – Risk Assessment on Danube Area Roads

https://www.interreg-danube.eu/radar

Internal Report Hierarchy Level			
Activity Number	5.3	Activity Title	Pilot Action Provisions for Vulnerable Road Users
Work Package Number	*5*	Work Package Title	Road Safety Pilot Actions
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Status (F: final, D: draft, RD: revised draft):	F		
Version Number	2.1		
File Name	20210305_SLO_Pilot_action_RADAR_v2.1_KF		
Issue Date	03.05.2021		
Project start date and duration	June 1, 2018 – 36 months		

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Revision log

Version	Date	Reason	Name and Company
1.0	21/10/2021	Initial version	dr. Darja Šemrov, PTI
1.1	05/01/2021	Remarks from KfV	dr. Darja Šemrov, PTI
2.0	26/02/2021	Merge to template	Nina Petrič, AMZS
2.1	05/03/2021	Final minor corrections	Klemen Fiipič, AMZS

Abbreviation list

AADT	Annual Average Daily Traffic
AMZS	Avto-moto zveza Slovenije (Slovenian automobile club)
ASP	Associated Strategic Partner
DRSI	Direkcija Republike Slovenije za Infrastrukturo (Sloveninan Infrastructure Agency)
EU	European Union
HGV	Heavy Goods Vehicle
iRAP	International Road Assessment Programme
LED	Light Emitting Diodes
LRV	Light Reflectance Value
NACTO	National Association of City Transportation Officials
RADAR	Risk Assessment on Danube Area Roads
RSEG	Road Safety Expert Group
SRS	Star Rating Score
VRU	Vulnerable Road Users

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Executive summary

The evolution of road infrastructure has in many cases favoured motorised traffic and left pedestrians and cyclists behind.

As part of an EU funded project RADAR, this report describes steps taken to increase infrastructural road safety for vulnerable road users by providing solutions that are easily transferable and adaptable so they can be considered and used in other countries of Danube area and beyond.

Methodology of assessing the provisions for vulnerable road users as well as the list of countermeasures, available in the iRAP Toolkit are presented.

The Pilot action focuses on three selected locations that were suitable for an upgrade in terms of safety for vulnerable road users (pedestrians and cyclists) while considering the overall usage of space within the treated area.

The in-built level of safety for specific groups of road users (pedestrians and cyclists) is assessed and possible solutions are presented. General requirements for each solution are described and upon that the selected solution in elaborated and displayed at each location including provisional plans for installation.

1. Introduction

1.1. *About the RADAR project*

Large parts of the Danube road network have poor safety standards, especially for vulnerable road users, and death rates in many countries are above the EU average. In many countries, there is a lack of professional capacity and the approaches to solving the problem vary. (source: RADAR project Status Report)

RADAR aims to improve the safety of road infrastructure in the Danube region by increasing capacity and improving transnational cooperation for all road users, including vulnerable road users on Danube major, secondary, and tertiary road networks. One of RADAR's main tasks is to identify risks on the road networks and to provide plans to systematically reduce these risks by improving infrastructure and road layout. The project RADAR addresses the differences in the safety level of road infrastructure in the western and eastern EU countries. It will help to improve the knowledge and capacities of all stakeholders in the Danube Region to successfully address road infrastructure safety. The RADAR project will facilitate transnational processes for the exchange of knowledge and best practises and provide governments in the participating countries with ready-to-use tools for improvements in all national languages.

Training courses and study visits for road safety experts guide the project partners through the steps from analysing the safety on their road network to defining road safety solutions that are cost-effective and likely to achieve the highest reduction of accidents and fatalities.

With National Action Plans, the RADAR partnership will define clear steps for implementation and pilot actions will help local authorities to prioritise high-risk road sections. By developing Road Layout Concept Plans solutions ready for implementation, RADAR identifies specific needs at locations prior to crash countermeasure implementation.

The establishment of a transnational Road Safety Expert Group (RSEG) increases knowledge across the region and also draws on input from outside the region.

The RADAR consortium consists of partners from nine countries with the lead partner European Institute for Road Assessment - EuroRAP. EIRA - EuroRAP is an international not-for-profit organisation whose mission is to save lives and promote safer road infrastructure, using EuroRAP protocols that systematically assess the built-in safety attributes of roads.

The partners in the project are:

- European Institute for Road Assessment, Slovenia (lead partner),
- University of Zagreb, Faculty of Transport and Traffic Sciences, Croatia,
- General Automobile Club of the Czech Republic, Czech Republic,
- Austrian Road Safety Board, Austria,
- Automobile Club of Slovenia, Slovenia,
- KTI Institute for Transport Sciences Nonprofit Ltd, Hungary,
- Bulgarian Association for Road Safety, Bulgaria,
- Bosnia and Herzegovina Automobile Club, Bosnia and Hercegovina,
- Automobile Club of Moldova, Moldova.

The RADAR project also has associated strategic partners:

- Ministry of Infrastructure, Slovenian Infrastructure Agency, Slovenia,
- Croatian Roads, a limited liability company for management, construction and maintenance of state roads, Croatia,
- Public Company Roads of Federation of Bosnia and Herzegovina, Bosnia and Herzegovina,
- Ministry of Transport and Road Infrastructure, Moldova,
- The Road and Motorway Directorate of the Czech Republic, Czech Republic,
- European Union Strategy for Danube Region Priority Area 1b - Road, Rail and Air links, Slovenia,
- Ministry of Transport and Maritime Affairs, Montenegro,
- Road Infrastructure Agency (at the Bulgarian Ministry of Regional Development and Public Works), Bulgaria,
- National Company for Roads Infrastructure Administration, Romania,
- National Motorway Company, Ltd., Slovakia.

1.2. *RADAR's Thematic Area 2 – Vulnerable road users*

The pilot action on TA2 involves the assessment of locations where pedestrian or cyclist activity is relatively high but where the provision of pedestrian and/or cyclist facilities is poor – or poorly maintained – and where accidents have occurred or are likely to occur. The aim is to show how and where risk reduction measures can be implemented.

For vulnerable road users, either pedestrian or cyclist facilities or Shared Space, road design plans are prepared ready for implementation. The pilot actions will test the best practices and methodologies discussed and selected in the work done with RSEG and included in the Thematic Reports. They will make use of practical procedures and tools acknowledged through the training courses and benefit of the most relevant examples that study visits selected.

1.3. *iRAP Star rating procedures for vulnerable road users*

Star Ratings include an inspection of road infrastructure attributes that are known to influence the probability of an accident and its severity. Depending on the level of safety "built into" the road, between 1 and 5 stars are awarded.

The safest roads (4- and 5-star) have road safety attributes that are suitable for the prevailing traffic speeds. Road infrastructure attributes on a safe road may include separation of opposing traffic by a wide median or barrier, good lane marking and intersection design, wide lanes and sealed (paved) shoulders, roadsides without unprotected hazards such as poles, and good provision for cyclists and pedestrians such as footpaths, cycling infrastructure, and pedestrian crossings.

The least safe roads (1- and 2-star) do not have road safety attributes that are appropriate for the prevailing traffic speeds. These are often single-lane roads with frequent curves and intersections, narrow lanes, unpaved shoulders, poor lane markings, hidden intersections and unprotected roadside hazards such as trees, poles and steep embankments close to the roadside. They are also not sufficiently suitable for cyclists and pedestrians in terms of footpaths, cycle paths and crossings.

The star rating score can be calculated for 4 different groups of road users - vehicle occupants, motorcyclists, pedestrians, and cyclists. For each score, attributes that have a higher influence on each group are considered in the calculation.

1.4. *iRAP Road Safety Toolkit – a collection of countermeasures that can increase road safety of vulnerable road users*

The Road Safety Toolkit provides free information on the causes and prevention of serious road accidents. Building on decades of research in the field of road safety, the toolkit helps engineers, planners, and policymakers to develop safety plans for car occupants, motorcyclists, pedestrians, cyclists, heavy goods vehicle occupants and users of public transport.

The iRAP toolkit website (toolkit.irap.org) contains a comprehensive collection of measures that can be used to improve road safety for all road users. These countermeasures reduce the likelihood of an accident happening in the first place and reduce the consequences of an accident. The following is a brief description of those that contribute most to the safety of vulnerable road users.

Bicycle Facilities: Introduction of bicycle lanes and paths greatly increases cyclist's safety by separating them from motorized traffic. It also increases use of bicycles, reduces road congestion, and is associated with health and environmental benefits that come with increased bicycle use.

Central Hatching: Central hatching (painted medians) and wide centrelines can be used to narrow wide lanes and therefore encourage lower speeds which reduces the risk for vulnerable road users as well. In urban areas, it provides some protection to pedestrians crossing the road, and may be coupled with pedestrian crossing facilities, such as refuge islands to provide improved safety.

Delineation: Centre and edge delineation treatments help drivers judge their position on the road and provide advice about conditions ahead. It helps drivers to maintain a safe and consistent lateral vehicle position within the lane, which reduces the risk of hitting cyclists or motorcyclists.

Intersection - signalised: Traffic signals are a way to stop conflicting flows of traffic entering the intersection at the same time and can reduce crash risk. By regulating pedestrian and cyclists flow they can improve their safety as well.

Lane Widening: Widening traffic lanes can in certain circumstances reduce sideswipe crashes between motorised vehicles and vulnerable road users.

Parking Improvements: Adequate on-street parking can help to improve pedestrian mobility and safety through the removal of vehicles that are causing an obstruction by being parked on the footpath. Carefully designed on-street parking provision may reduce crashes, including those involving pedestrians.

Pedestrian Crossing - Unsignalised: Can help to reduce risk for pedestrians attempting to cross the road and leads to reduced pedestrian crashes if installed at appropriate locations, and if pedestrian priority is enforced. If combined with a raised platform type feature, crossings can help to slow approaching traffic speeds.

Pedestrian Crossing - Signalised: A signalised crossing reduces pedestrian crashes as it separates motorised and non-motorised flow. It is considered as an upgrade from an unsignalised crossing.

Pedestrian Crossing - Grade Separation: When adequately designed they completely remove the conflict between motorised vehicles and vulnerable road users at a road crossing. They enable unobstructed flow in all directions.

Pedestrian Fencing: Pedestrian fencing, or guard rail, may be used on the side of a road or within the median to restrict pedestrian access to the carriageway, reducing conflicts between motorised vehicles and pedestrians. It can also help to prevent motorists from parking on the footpath.

Pedestrian Footpath: Increased safety for pedestrians by separating vehicles and pedestrians. Improves facilities for pedestrians (improves accessibility) and may help to increase walking as a mode of transport (environmental benefits and reduced traffic congestion). Walking can also improve health and fitness.

Pedestrian Refuge Island: Pedestrian refuge islands are raised median islands that provide a location for pedestrians to safely wait for a gap in the traffic so they can finish crossing the road. This makes crossing the road easier for pedestrians by allowing them to cross in two stages and deal with one direction of traffic flow at a time.

Regulate Roadside Commercial Activity: Regulating roadside activity not only improves traffic flow and reduces "turning" crashes but also reduces vulnerable users crashes by improving visibility along the road by removing obstacles.

Restrict/Combine Direct Access Points: With reducing the number of potential conflict points and traffic friction it has potential to reduce pedestrian and bicyclist risks as well.

Road Surface Rehabilitation: By providing an even running surface free from major defects and hazards such as potholes, rutting, cracking, deformation, polishing or fretting, safety of bicyclists when using the same surfaces, is also improved.

School Zones: School zones and crossing supervisors can reduce pedestrian risk by helping to moderate traffic speeds which can reduce injury severity. It has also been shown that school zones can reduce crashes involving bicyclists.

Service Road: The presence of service road can reduce the number of conflict points (intersections) along a route and at the same time the number of crashes (including parking and pedestrian crashes).

Shoulder Sealing: Beside reducing run-off-road and head-on crashes, sealed (paved) shoulders can provide a safe cycling space and can be marked as bicycle lanes when they are of sufficient width.

Sight Distance (obstruction removal): Adequate sight distance provides time for drivers to identify hazards and take appropriate action to avoid them while good forward visibility at pedestrian crossing facilities will give drivers more time to react.

Skid Resistance: By maintaining a sufficient skid resistance, the road can provide adequate grip for all road users, including bicyclists. This is also important for road markings.

Speed Management: Lower speeds can reduce the severity of all crash types and also the likelihood of many crash types occurring in the first place. It improves safety for vulnerable road users such as pedestrians and cyclists.

Street Lighting: Street lighting helps to reduce night-time crashes by improving visibility. It can reduce pedestrian crashes by approximately 50%.

Traffic Calming: Traffic calming aims at reduced speeds and reduced crash severity while reducing traffic volumes on local roads. It can provide an improved environment for pedestrians and cyclists.

2. Locations

2.1. *Selecting locations*

The sites were selected in consultation with the AMZS's Associated Strategic Partner (ASP) in RADAR DRSI which proposed the following two locations:

- Rodica, as a location with a more complex traffic situation.
- Gabrovka, as a long- term puzzle due to its challenging cramped setting.

As a third location, Domžale has been selected jointly due to its high potential for the upgrade, especially with regard to the provisions for vulnerable road users in connection with the general traffic regulation as part of a complete redesign of the city for all users, but with a focus on pedestrians and cyclists.

All selected locations are presented in the figure below.

Figure 1 Locations of selected sites

2.2. *Assessment criteria*

Locations for this Pilot action were selected amongst the ones where pedestrian or cycling activity is relatively high but where provision of pedestrian and/or cycling facilities is low or poorly maintained and crashes occurred on will likely occur. Experts involved in the selection of suitable locations needed to have the following activities in mind when selecting locations as these were to be performed as a part of the actual Pilot action.

For pedestrians, these activities include:

- Examination of how the adjacent land use can be used to estimate the likely pedestrian activity and hence the demand for pedestrian paths or crossings, and assessment of existing pedestrian facilities and conditions; facilities often lack visibility for drivers, are badly worn or there is poor enforcement of nearby parking.
- Consideration of desirable pedestrian lines between different generators of activity.
- Warrants for the provision of facilities to be compared.
- Assessment what needs to be done to raise the standard of pedestrian provision to a generally accepted safety standard.
- What measures are required to achieve an adequate safety standard.

For cyclists, the following assessments are included:

- Cycling activity and desirable lines within settlements.
- The need to provide special cycling infrastructure on existing roads, separate lanes, green wave, special traffic lights or similar facilities.
- Other assessments similar to those described for pedestrians.

3. Rodica – reducing the barrier effect by installing a pedestrian underpass

3.1. *Location description*

The Rodica site, a village outside Ljubljana, is located at the junction of the regional state road R3-644, section 1358 Domžale - Duplica. It is an undivided two-way road with one lane in each direction. The section has an AADT of approximately 8,000, but very dense traffic during the morning peak hour (see figure 3). Outside of peak hours, speeds exceed the 50 km/h speed limit, as the road is almost straight and gives drivers a very good view far ahead along the road.

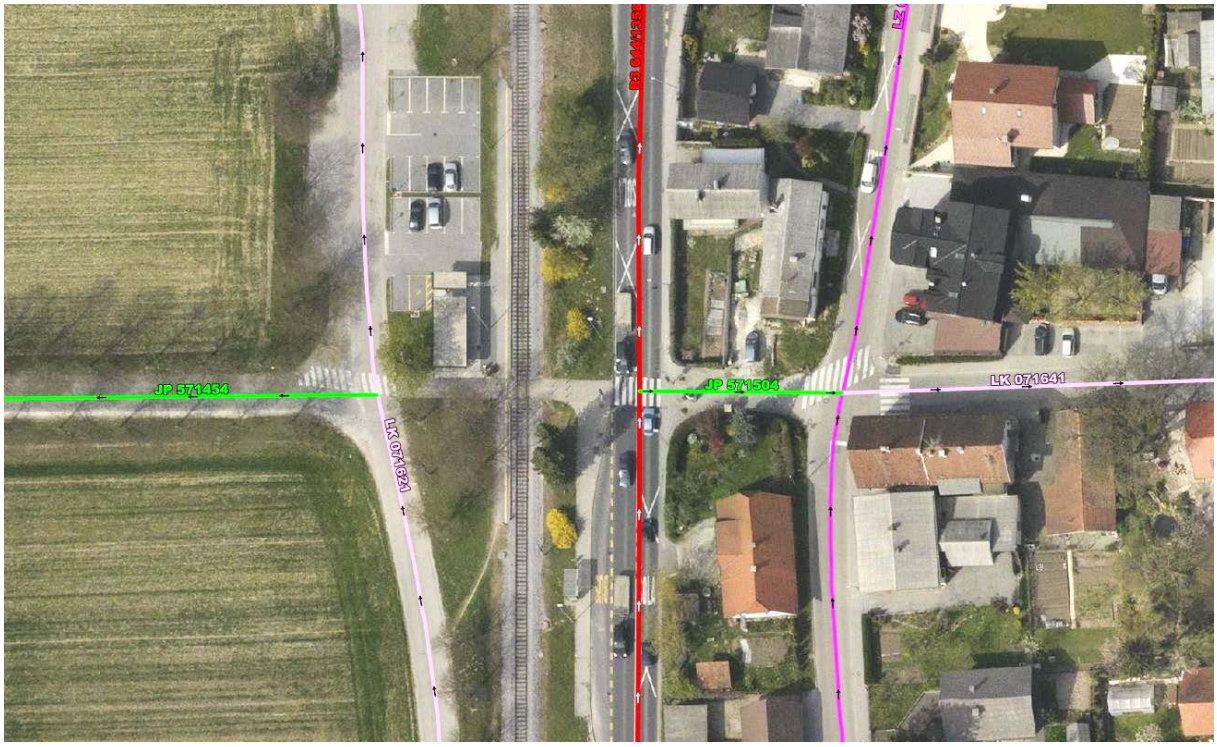


Figure 2 Overview of location 1 – Rodica

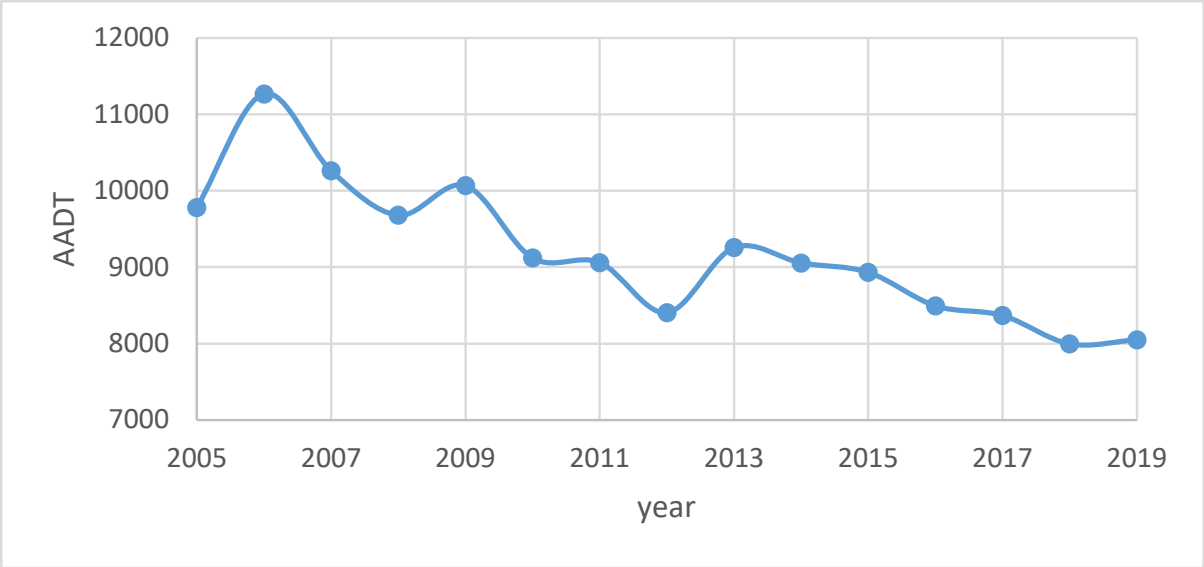


Figure 3 Average daily traffic in Rodica, road R3 644, section 1358

The complex crossing consists of crossing the road and railway track. The road crossing is signalised. The complex situation consists of two parallel roads and a parallel railway line, at the same time with a third parallel road nearby. All mentioned parallel roads are oriented in the north-south direction. The path that crosses them is oriented east-west and connects the village of Rodica with the recreational areas west of the village and a smaller part of the village of Groblje, which is located on the other (western) side of the road and railway line. It also provides access to the railway station and bus stop, both of which are located on the west side of the main road. There is a bus stop on the east side of the main road, after the crossing when driving north.

The layout of the settlement east of the road is such that houses and fences block access to the road and channelize all VRU traffic to this crossing. The east-west connection is therefore quite busy even outside of peak hours. During peak hours, it is very busy with train passengers coming to and from the train station, and bus users coming from the north or south. A significant proportion of users outside peak hours are older people, while during peak hours there are students travelling to school in Ljubljana, the capital of Slovenia, by train or bus. In the timetable there are 13 buses going to Domžale (and further to Ljubljana) between 5 and 9 AM, 6 of them between 5:48 and 6:48 in the morning. In the train timetable there are 6 trains going southbound from Rodica between 5 and 9 AM.

As regards the choice of transport mode, most users are pedestrians, followed by cyclists and e-scooter users. The intersection of the state road is equipped with a signalized and marked pedestrian crossing. There is a pedestrian call button to be pressed to give a green signal to pedestrians, which stops the flow of traffic on the road by showing them the red light. However, the green signal for pedestrians does not come immediately. After the desire to cross the road is expressed by pressing the button on either side of the road, users can see how long they have to wait for on a countdown display. The time can range from 5 to 90 seconds, depending on how much time has passed since the last pedestrian green signal. Green signal for pedestrians is 7 seconds long, followed by all-red signal for another 7 seconds. This covers even the slowest road users.

Figure 4 Pedestrian crossing with the pedestrian call button

The application of the iRAP methodology of risk mapping in relation to the calculation of the crash risk per kilometre travelled or »level of accidents« on Slovenian state roads is carried out every three years for a period of three consecutive years (latest available data for the period 2015-2017). For road R3-644, section 1358, the »level of accidents« is calculated to be 4, with 4 serious or fatal accidents occurring between 2015 and 2017. The section is 6.090 m long. A particularly tragic fatal accident occurred at this site in 2017, in which a 12-year-old girl crossing both, road and rail, riding a bicycle and was hit by a freight train. There were a few factors that contributed to this. Besides the poor visibility due to vegetation that was later removed and focusing on keeping up with two friends on a bicycle, the usual slow speed of passenger trains stopping at the station may have contributed to the girl crossing the railway without checking thoroughly enough to see if she could do so safely. At the time of the accident, the freight train was travelling through the station at about 60 km/h. Another factor that may have contributed to the accident is the false confidence that after correctly waiting for the green light at the road crossing, it is also safe to cross the railway tracks.

A similar accident happened in February 2020, this time the victim was a young woman in her twenties who was hit by a train and seriously injured. This prompted the responsible institutions to take "immediate action". After consultation with and at the suggestion of the AMZS, a pedestrian chicane was installed in April 2020. The fence replaced bollards that were supposed to warn level crossing users but did not prevent them from taking a direct path across the tracks. The fence causes users to make an S turn before entering the tracks and to turn (and hopefully look) in at least one direction along the tracks.

Figure 5 VRU protection at railway crossing before (left) and after (right) 2020 accident

The on-site inspection carried out in July 2020 gave additional insight into the potentially dangerous situations that can occur in the area of the intersection. The most basic and common scenario for VRUs (in off-peak hours) is simply not pressing the call button and crossing the road while the pedestrian signal is red.

Figure 6 Cyclist crossing the road at the red light without pressing the call button

If the call button is pressed and the countdown time is long (i.e., near or at maximum 90 s), there is a chance that the pedestrian (or other users) will not wait for the signal but cross the road after visually checking that there is no oncoming traffic.

On the drivers' side, even in a relatively short amount of time spent at the location, two offences were observed. The first was a driver not stopping when the signal for cars was red and no persons were waiting or crossing. The second was that after stopping and letting the pedestrian cross the road, a driver drove off while the car signal was still red, indicating that the driver might not have noticed the signal at all, just the pedestrian at the marked crossing.

Apart from access to the bus stations, there are no facilities for pedestrians or cyclists along the main road, but some demand was noted as there were clearly visible numerous cycle tracks leading from the road to the eastern part of the intersection, which means that some cyclists ride on the main road despite heavy traffic and narrow lanes.

The Rodica road is already equipped with safety devices at a fairly high level. There is still some room for improvement. In accordance with the iRAP star rating procedures, the marked and signalized pedestrian crossing is the third-best option, immediately after grade-separated facility, where there is no conflict with motorized traffic, and a signalized crossing with pedestrian refuge islands.

The Star Rating Score was calculated using the iRAP Demonstrator: the existing configuration achieves SRS 2.50, while the planned underpass as a grade-separated facility achieves SRS 0.80 and both receive 5 stars, whereby the underpass reduces the risk to pedestrians by a factor of 3.

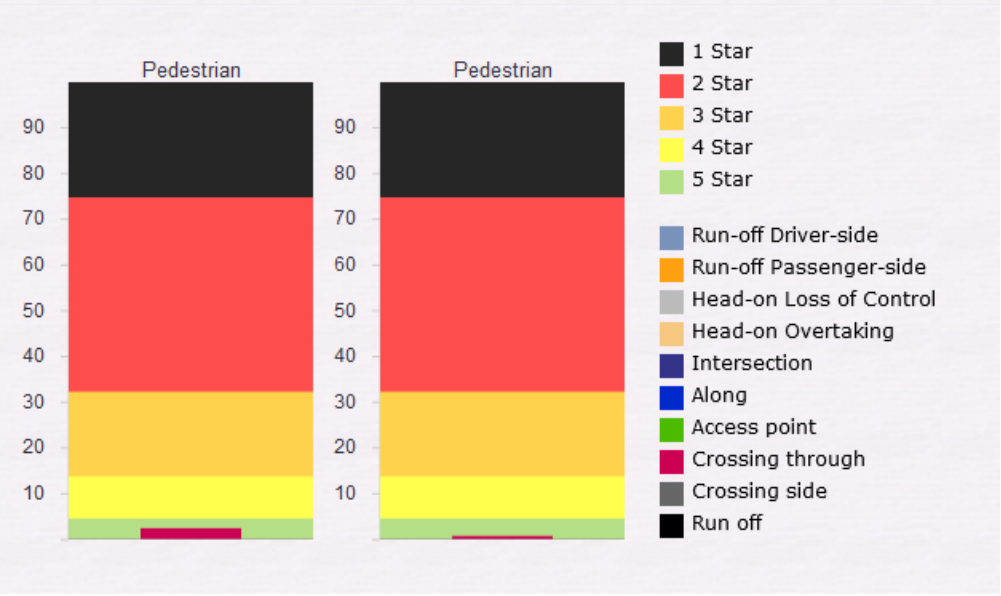


Figure 7 Risk charts for pedestrian safety at Rodica. Existing (left) and grade-separated facility (right)

Key safety problems detected at the location Rodica:

- road users do not follow road rules (e.g., crossing at the red signal – all, car drivers, pedestrians, cyclists);
- the complexity of the situation (in a short distance one must cross the main road, railway line, local road, and the vicinity of the bus and train stop) increases the potential danger for VRUs;
- also, the strong flow of pedestrians and cyclists in the east-west direction increases the number for potentially dangerous situations;
- absence of cycling infrastructure in the direction south north.

3.2. *Current situation*

Location

Municipality Domžale

Regional road R3-644, Domžale – Duplica

GPS: 46.14890, 14.59270

The pedestrian crossing is the main connection between the western and eastern part of Rodica and as such, it is an important element of the pedestrian infrastructure, providing access to public services on both sides of the built-up area. For example, 500 m to the east of the examined crossing a primary school and a school for persons with special needs are located, therefore the measures proposed by the RADAR project require special attention, considering different groups of vulnerable road users, while at the same time mobility, safety, and accessibility for all with the same importance. To this end, consideration should be given to proper navigation, signs, tactile markings, and barrier-free pedestrian surfaces to ensure that persons with disabilities have equal access to school, work, housing, shops, public facilities, and buildings and to public transport.

However, it is essential that the design of pedestrian facilities considers the abilities and challenges of all pedestrians. Mobility impairment is but one classification of disability, along with sensory deficits (the sight and hearing impaired) and cognitive impairments - those with diminished ability to process information including language barriers.

Due to the flow function of the road, which leads to high traffic volumes and high speeds, a signalized pedestrian crossing reduces road capacity. The pedestrian crossing is followed by a level crossing with the railway line, where pedestrians are rather poorly protected. To this end, the pedestrian underpass would address both identified problems, namely reducing traffic congestion, and increasing pedestrian safety at level crossings (road and rail), as well as increasing the capacity of the regional road. The designers of the pedestrian underpass should bear in mind that underpasses require special attention to assist people with disabilities, such as tactile warning strips and acoustic signals for visually impaired people and properly designed ramps or lifts for pedestrians with mobility problems.

3.3. *Pedestrian underpass – general requirements*

The conflict between pedestrian's and vehicle's requirements increases with the number of vehicles, the proportion of heavy vehicles and the speed of road traffic and is most evident at pedestrian crossings. In order to mitigate safety problems at pedestrian crossings, various measures are available, such as protection by traffic lights or the introduction of a level-free crossing (over- or under-pass). Underpasses aim to connect pedestrians from one side of a pedestrian obstacle to the other, and the level-free crossing is the safest way to cross the road/railway infrastructure. However, numerous factors prevent this type of essential connection from reaching its full potential, such as rundown appearance, the lack of adequate lighting and surveillance, the lack of pedestrian wayfinding, the lack of a definition of its 'usefulness' and the fact that underpasses are often perceived by people as unsafe, dark and dirty, making pedestrians feel unsafe when using them and trying to avoid them. Another con using a pedestrian underpass, and the same is true for the pedestrian overpass, is the extra effort and energy that pedestrians need to overcome the difference in height.

General recommendations to be applied when designing / constructing a new underpass (SIS ISO 21542:2012, Planning and designing for pedestrians):

1. Over and underpasses should be considered for crossing in zone 3 shown in the figure below.

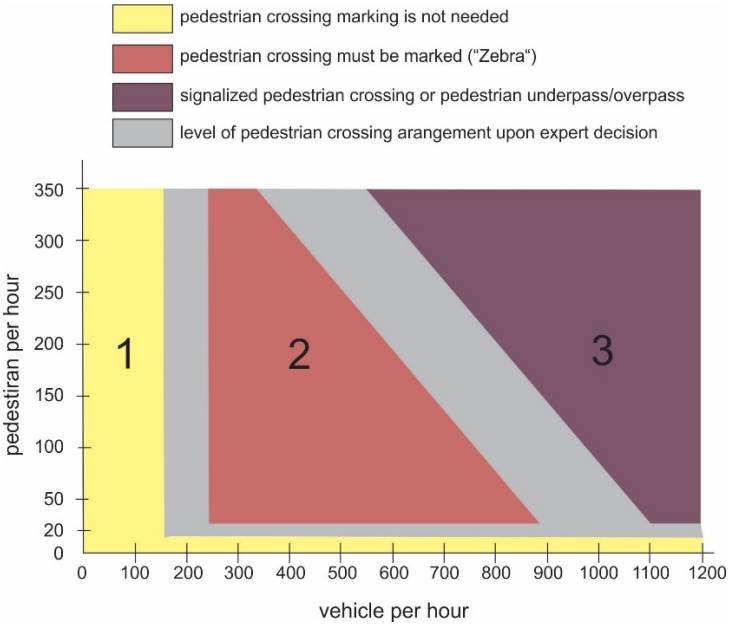


Figure 8 Level of required measures at the pedestrian crossing (source: Pedestrian crossings priority for pedestrian safety)

2. The minimum width for overpasses should follow the width of the sidewalk.
3. Underpasses should have a minimum illuminance of 110 lux during the day, which can be achieved by artificial and/or natural light provided through an open gap to the sky, and 45 lux illuminances at night.
4. Signage should be provided to indicate that stairs are a public facility. The signage should inform users where the stairs lead to, i.e., "BUS Stop in the direction of Domžale, Rodica West, Rodica East".
5. The placement of the stairway, the landscaping and the lighting all contribute to making the pedestrian feel safe and secure, as does visibility to and from the stairway to ensure "eyes on the path."
6. The riser height and tread width of each stair should be uniform, with the riser not exceeding 16 cm. The following formula can be used to determine the appropriate ratio of tread to riser: 2R + T = 60-66 cm, where R = riser and T = tread.
7. The minimum width for the stairs should not be less than 1.20 m.
8. Stairways should be designed to prevent the accumulation of water.
9. A continuous handrail should be provided which meets the requirements for persons with disabilities.
10. Narrow side ramps for bicycles and prams should be considered.
11. The minimum length of the landing should be at least 1.50 m or equal to the width of the stairs.
12. The proper lighting should be installed for better visibility and increased safety.
13. Surface materials should be durable, provide a non-slip walking surface, including a contrasting colour for visually impaired users, and be subject to regular inspection and maintenance.
14. Accessibility for all should be achieved by removing barriers for disabled people;
    - Stairs and underpass should be designed with handrails and rest areas to serve impaired and elderly users.
    - Correctly designed stairs with uniform risers and treads are also navigable for those with visual impairments.
    - Where possible, a ramp system or lift should be considered instead of a staircase system to ensure universal accessibility.

- Long, steep stairs should have level areas where pedestrians can stop and rest, e.g., every 15 stairs.
- Ramps are defined as places where the gradient is more than 5 %, but not more than 1:12 or 8.3 %.
- Where the gradient is more than 5 %, handrails are required.

15. In order to avoid the temptation of jaywalking, crossing possibilities should be offered at regular and appropriate intervals.
16. Pedestrian underpasses should be subject to regular inspection and maintenance.

Figure 9 Example of pleasant pedestrian underpass; wide and proper lightning[1]

[1] Source: https://twitter.com/urbanpastoral/status/487150366463913984

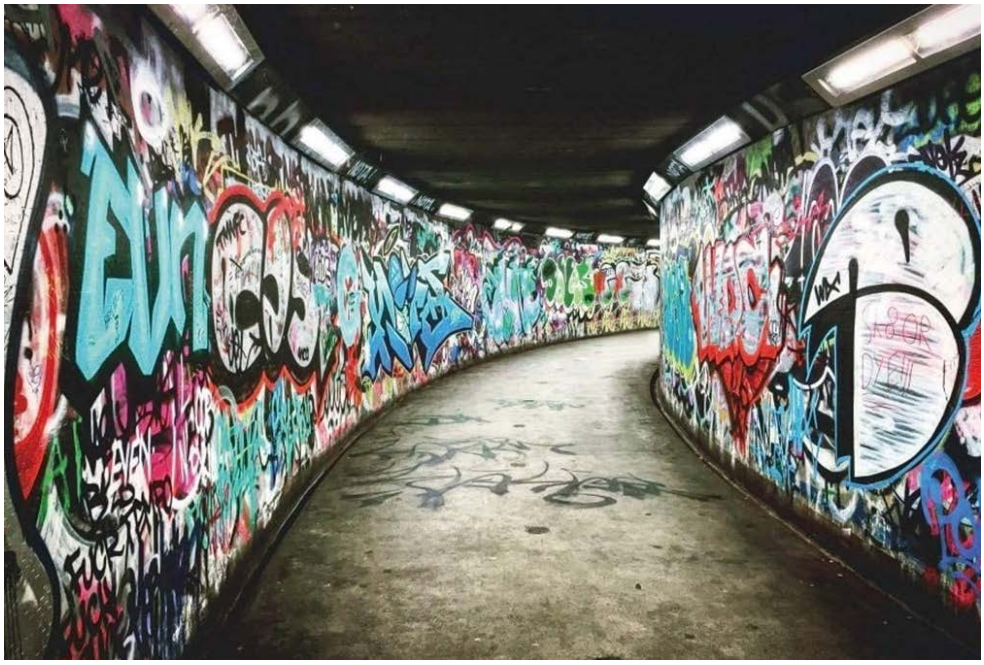


Figure 10 Example of unpleasant pedestrian underpass; aggressive graffiti, poor sightline[2]

3.4. *Rodica pedestrian underpass*

The »Rodica« underpass will provide direct, safe access for vulnerable road users, pedestrians and cyclists travelling between the western (residential area and concentration of public service facilities) and eastern (residential area) parts of Rodica, allowing travellers to cross the busy regional road and railway tracks easily and safely. The concept of the underpass has been designed with accessibility and cost efficiency in mind and meets the requirements of disabled people (tactile markings, disabled lift, adequate lighting ...).

The proposed pedestrian underpass is located at the location of the existing pedestrian crossings on the western and eastern side where substantial pedestrian crossing demand is already present, therefore lack in pedestrian wayfinding is not foreseen, as well the connectivity to the pedestrian infrastructure network/system is also already ensured. The underpass is designed in such a way that users can see and understand what is in front of them, that they have a clear sense of direction by designing the underpass in a straight line and without ambiguous spaces such as gaps and corners. The layout and cross-sections of the proposed Rodica pedestrian underpass are depicted in the figures below.

[2] Source: https://www.nultylighting.co.uk/project/leake-street-arches-waterloo/

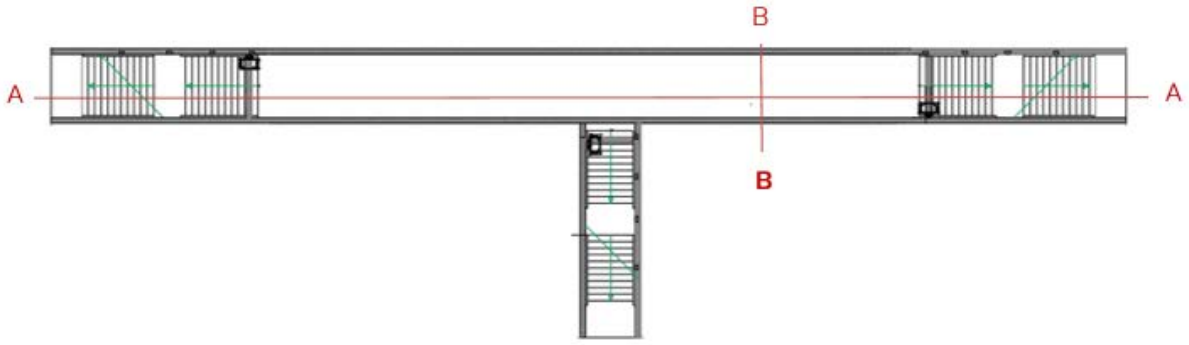


Figure 11 Rodica pedestrian underpass – layout

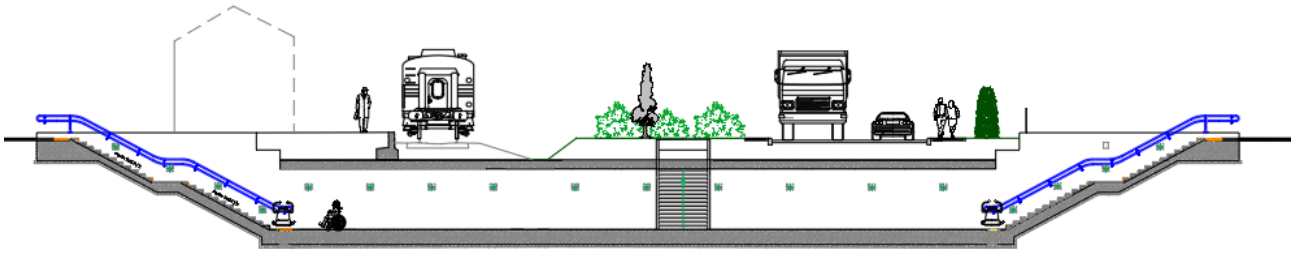


Figure 12 Rodica pedestrian underpass – cross-section A-A

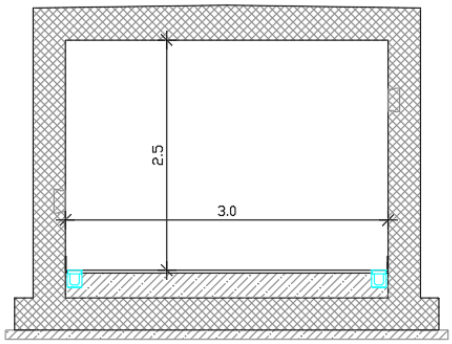


Figure 13 Rodica pedestrian underpass – cross-section B-B

Designing underpass, it is at most important to take special care in the design of pedestrian underpasses (and stairs), with special attention to accessibility and usability for people with disabilities.

Accessibility and usability for persons with disabilities

In order to meet the needs of disabled persons and reduce the above-mentioned risk, the design of the Rodica pedestrian underpass follows the requirements of the national standard SIS ISO 21542:2012 Building construction - Accessibility and usability of the built environment.

According to the standard SIS ISO 21542:2012 the accessibility of the pedestrian underpass is defined as the ability of all people, regardless of disability, age, or gender, can enter, use and leave the underpass, as well as the usability as the characteristic of the underpass that can be used by everyone in convenience and safety.

SIST

SLOVENSKI STANDARD
SIST ISO 21542:2012
01-november-2012

Nadomešča:
SIST ISO/TR 9527:2002

Gradnja stavb - Dostopnost in uporabnost grajenega okolja

Building construction - Accessibility and usability of the built environment

Construction immobilière - Accessibilité et facilité d'utilisation de l'environnement bâti

Ta slovenski standard je istoveten z: **ISO 21542:2011**

ICS:

11.180.01	Pripomočki za onesposobljene in hendikepirane osebe na splošno	Aids for disabled and handicapped persons in general
91.060.01	Stavbni elementi na splošno	Elements of buildings in general

SIST ISO 21542:2012 **en,fr**

Figure 14 Cover page of national standard SIS ISO 21542:2012 Building construction – Accessibility and usability of the built environment

To facilitate a better understanding the terms discussed below are depicted in the figures below.

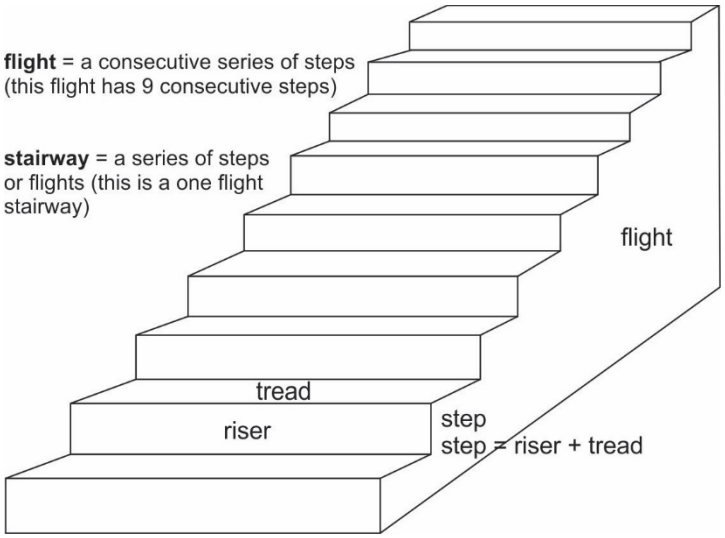


Figure 15 Definition of tread, riser, flight, and stairway[3]

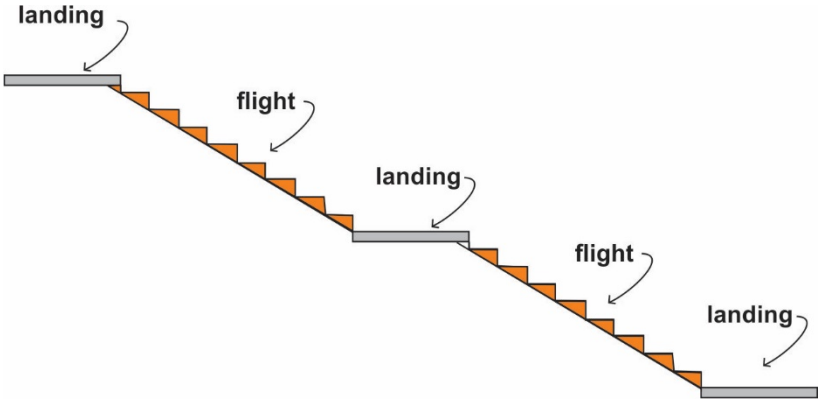


Figure 16 Definition flight vs. landing[4]

[3] Source: https://socalstairclimbers.com/2017/11/18/stairway-terminology/
[4] Source: https://socalstairclimbers.com/2017/11/18/stairway-terminology/

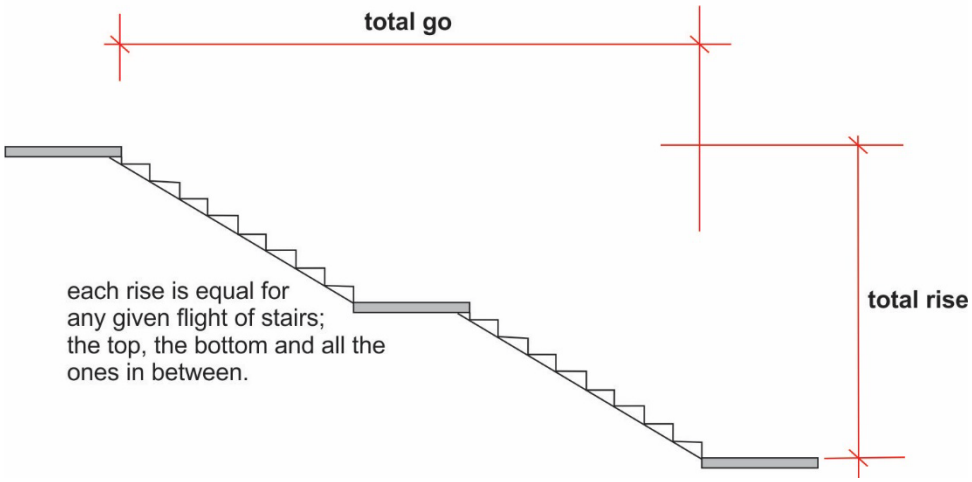


Figure 17 Definition of total go and total rise[5]

Below some aspects of accessibility and usability of the »Rodica« underpass considered in the design are highlighted below.

According to the Standard SIS ISO 21542:2012, the **minimum width of the stairs** shall be 1.2 m and 1.0 m between the handrails, where the designed width of the underpass of 3.0 m (2.8 m between the rails) at the main stairways and 2.30 m (2.1 m between the rails) at the exit to the BUS stop.

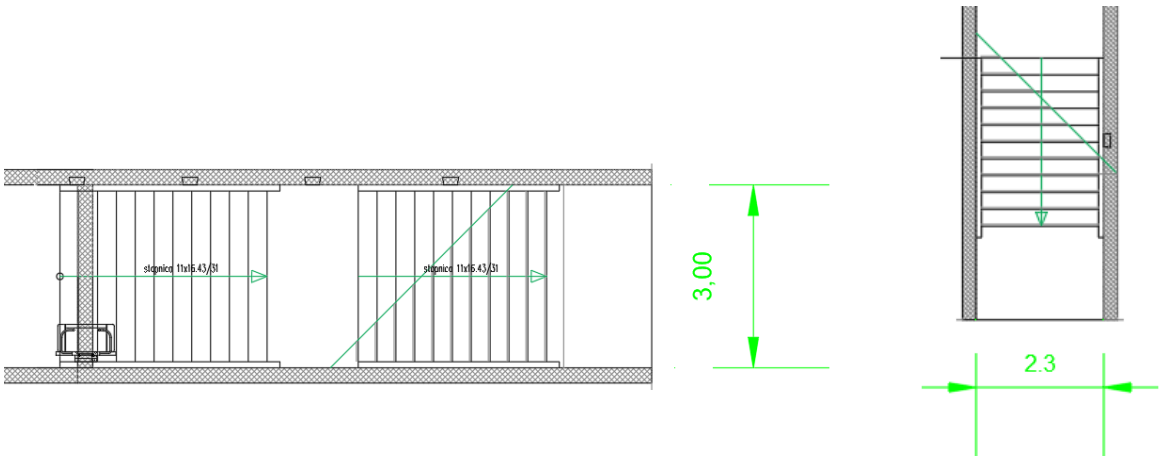


Figure 18 Dimension of stairways – main entrances, and exit to the BUS stop at Rodica pedestrian underpass

The rise and tread of steps within flights are uniform. The rise of a step shall be between 15 cm and 18 cm, and going of the tread is between 26 cm and 30 cm, whereby the sum of tread and twice rise of a step should not be less than 60 cm and more than 66 cm.

The Rodica pedestrian underpass is designed with the uniform rise (16 cm) and tread (31 cm), the appropriate ratio of tread to riser that is 2R +T = 63 cm. Since the total rise of given flight stairs exceeded 3,0 m a landing is provided. The edges of treads are equipped with non-skid strips that provide sufficient grip on the critical point of contact even in the most challenging weather circumstances.

[5] Source: http://www.builderbill-diy-help.com/stair-landings.html

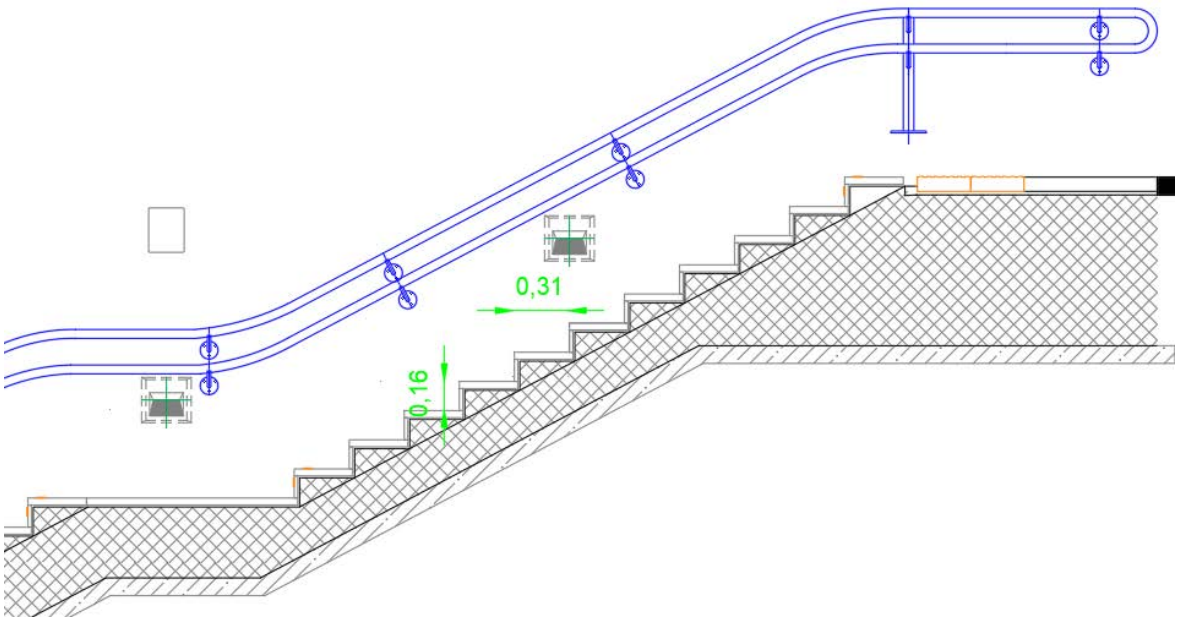


Figure 19 Dimensions of rise and tread at Rodica pedestrian underpass

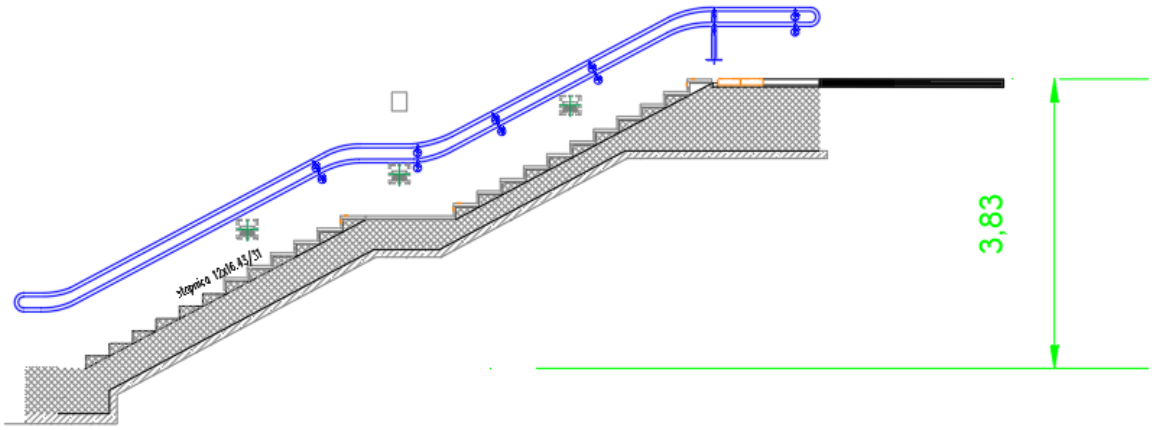


Figure 20 Total rise of Rodica pedestrian underpass

The unobstructed **width of the path** shall be not less than 1.8 m for constant two-way traffic, and at the same time, the area of landings shall be free of obstacles - the width of the path in the Rodica underpass follows the width of the main stairways, which is 3.0 m. As no urban furniture is foreseen, the landings and path are designed as free of obstacles.

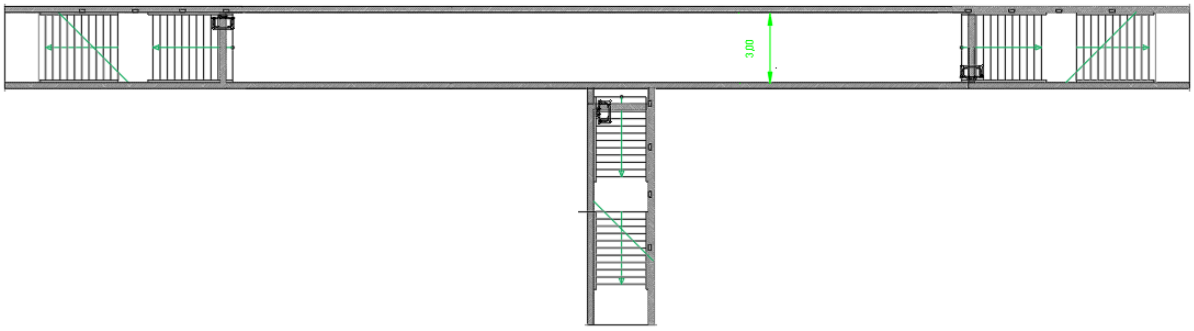


Figure 21 Obstacle free path in the Rodica pedestrian underpass

A handrail is a rail that is designed to be held to provide stability or support. Handrails are commonly used during ascent and descent of stairs to prevent injurious falls, as handrails help pedestrians keep their balance and provide leverage during ascent and descent. Stairs shall have handrails on each side. Some basic requirements for handrails (SIS ISO 21542:2012 Building construction – Accessibility and usability of the built environment and Planning and designing for pedestrians):

- handrails should have a rounded profile;
- should be located minimum 40 mm from a wall;
- should have a surface that is smooth but offers sufficient resistance to hand slippage;
- the height to the top edge of a handrail shall be between 850 mm and 1000 mm above the surface of a stair;
- the height to the top of the second handrail (with a lower profile than the first one) should be between 600 mm and 750 mm above the surface of a stair;
- the handrail should be continuous through the flight of a stair;
- the handrail should have a horizontal extension of not less than 300 mm beyond the first and last nosing of each flight.

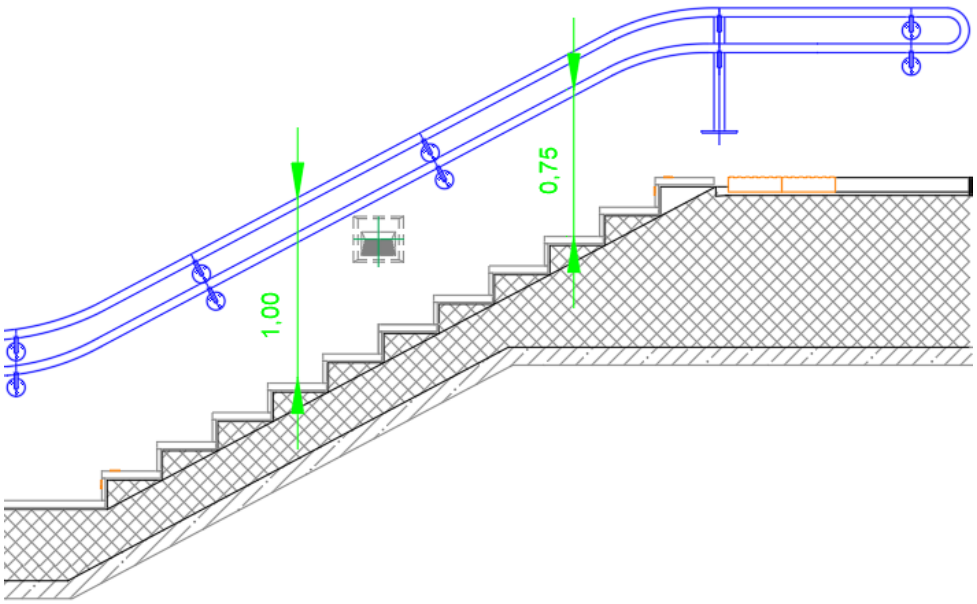


Figure 22 The design of the handrail in the Rodica pedestrian underpass

Tactile paving (also referred to as tactile warning signs, tactile tiles, tactile ground surface indicators, tactile walking surface indicators, or detectable warning surfaces) is a system of textured ground surface indicators found on footpaths, stairs and railway station platforms, to assist visually impaired pedestrians. There are two types of tactile indicators, one that warns the user of the potential danger and one that guides visually impaired persons. The tactile walking surface indicator is a profiled paving surface with visual contrast criteria that enables a person with visual impairment using a long cane, underfoot or by visual identification to detect a specific route (guiding pattern) or the presence of danger (attention pattern).

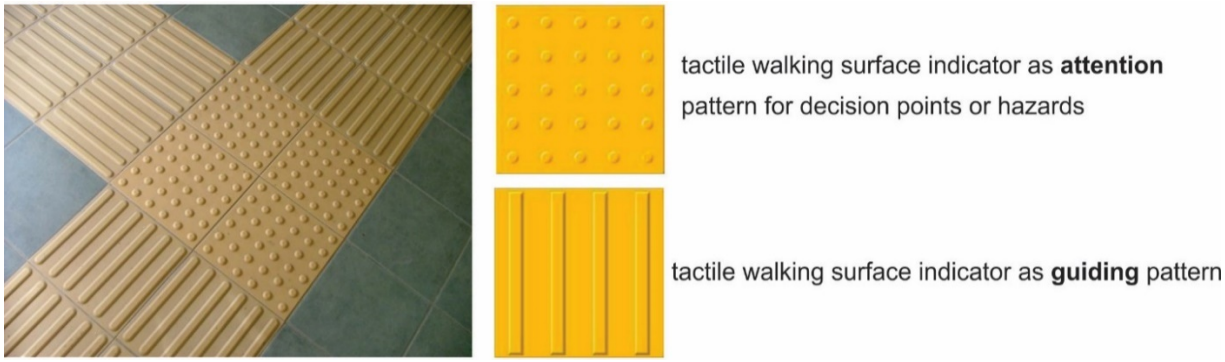


Figure 23 (Two) types of tactile walking surface indicator – attention and guiding pattern

The purpose of the warning tactile indicator is to warn visually impaired people of the presence of specific hazards: steps, level crossings, etc. It conveys the message "hazard, proceed with caution". The profile of the warning tactile surface consists of rounded bars running transversely across the direction of travel of the pedestrian. The bars are 6±0.5 mm high, 20 mm wide and have a distance of 50 mm from the centre of one bar to the centre of the next. The tactile paving units can be produced in any suitable paving material.

The surface is usually buff coloured, but can be any colour, other than red, which provides a good contrast with the surroundings to help the visually impaired. The warning tactile surface can be used in any situation (except pedestrian crossings) where visually impaired people need to be warned of a hazard, such as:

- the top or bottom of stairs;
- the foot of a ramp;
- a level crossing;
- where people may unintentionally walk directly onto the platform of a station;
- where a footpath meets a shared route.

At stairs, warning tactile indicators should start one tread depth back from the leading edge of the nosing at the top step and extend across the width of the stairs. The warning tactile surface alerts a person that there is a set of stairs ahead and that they should seek the assistance of a handrail for safe navigation.

The purpose of the guidance tactile indicator is to guide visually impaired people along a route when the traditional cues, such as a property line or kerb edge, are not available. It can also be used to guide people around obstacles, such as street furniture in a pedestrianized area. The surface has been designed so that people can be guided along the route either by walking on the tactile surface or by maintaining contact with a long white cane. The guidance tactile indicator comprises a series of raised, flat-topped bars running in the direction of pedestrian travel. The bars are 5.5±0.5 mm high, 35 mm wide and have a spacing of 45 mm. It is recommended that the guidance tactile indicator is in a contrasting colour to the surrounding area, to assist partially sighted people. It is recommended for use in the following circumstances:

- where the traditional guidance given by a standard footway between the property line and carriageway does not exist;
- where pedestrians need to be guided around obstacles;
- where several visually impaired people need to find a specific location and in transport terminals to guide people between facilities.

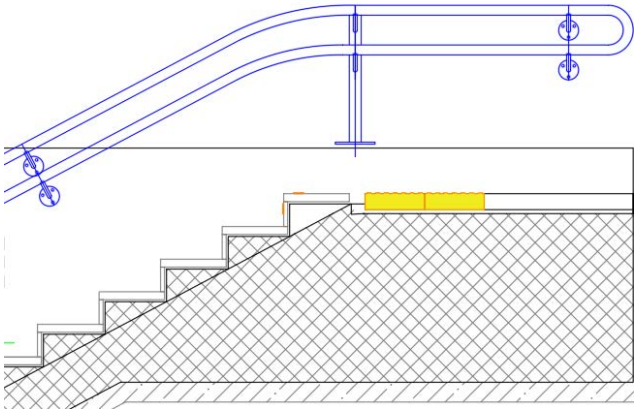


Figure 24 Warning tactile indicators at the top of the stairs in the Rodica pedestrian underpass[6]

In order to facilitate orientation and ensure the safe use of an environment, information on adjacent surfaces and potential hazards shall provide a discernible **visual contrast**.

A minimum difference in Light **Reflectance** Value (LRV) shall be provided, surfaces should have an LRV value of minimum 30 points for door furniture, 40 points for large area surfaces and 70 points for potential hazards and text information. The minimum LRV shall be achieved and maintained throughout the lifetime of the building elements. There shall be a visual contrast between landings and the top and bottom step of a stair. Preferably, a visual warning line with a single strip of 40 to 50 mm without brake shall be provided in the front edge of the going of each step with a minimum difference in RLV of 60 points.

The minimum **illumination** at the top and bottom of the flight should be 200 lux and 150 lux in between. The side exit to the bus station also provides additional natural lighting. However, to minimise the dreariness, especially at night, additional luminaires are foreseen.

[6] Tactile warning indicators are located at both the top and bottom of stairways, at all 3 stairways

A well-lit (white) and brightly coloured underpass can put it in a perceived "spotlight" and discourage crime because of the fear of being seen and caught, while weak or unpleasantly coloured lighting (yellow) can be unattractive. In order to ensure proper lighting of the Rodica pedestrian underpass, several luminaires are foreseen, namely one every 2.6 m (2.1 on stairs).

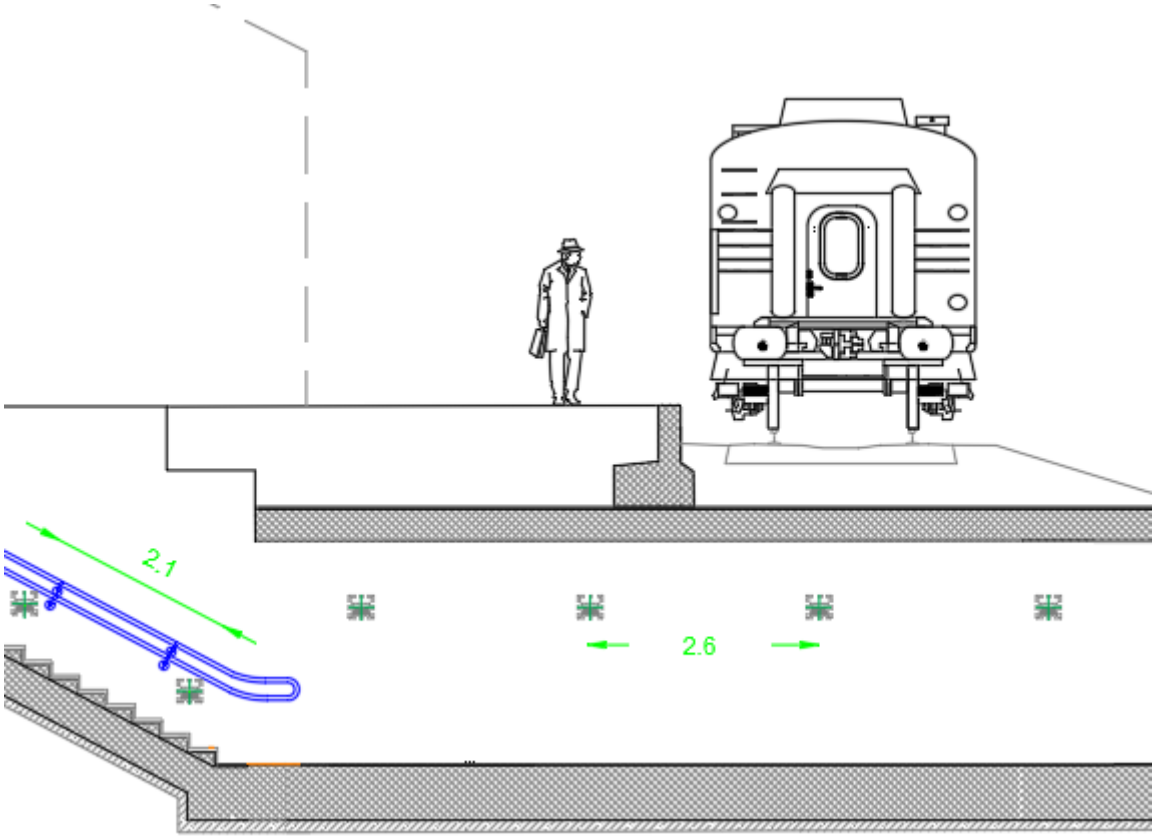


Figure 25 Distance between the foreseen fight in the Rodica pedestrian underpass

To assist persons using a wheelchair, the **platform stairlift** (the stairlift has a platform that can accommodate a wheelchair) is designed to provide comfortable, easy and reliable access for wheelchair users, in and out of a pedestrian underpass. The economical and space-saving platform stairlift is a very popular and versatile access solution for wheelchair users. The platform stairlift can be designed with straight through access or can be adapted to different landing floor access requirements.

New models of platform stairlifts allow wheelchair users to operate them independently. This means that a wheelchair user no longer needs to change seats to go up the stairs, reducing risk and inconvenience while maintaining the wheelchair user's independence. With this in mind, the design focuses on usability and safety. Built-in safety features ensure that the lift cannot be operated before the barrier arms and ramps are folded and in place. The lift stops automatically at the top and lower landings and constant pressure controls allow the user to stop the lift at any time. It also stops automatically if it meets an obstacle on the staircase.

The platform stairlift is foldable, so it can be stored when not in use, minimising obstructions.

Figure 26 Platform stairlifts

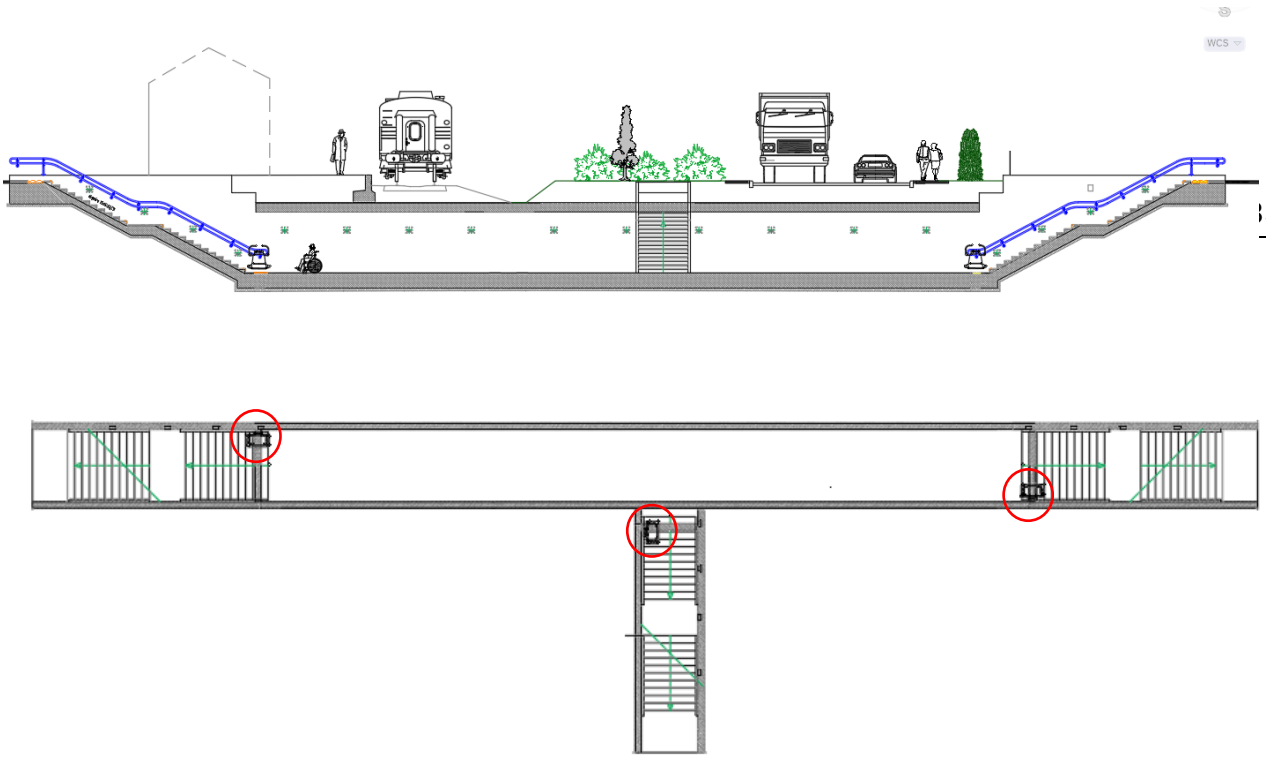


Figure 27 Locations of platform stairlifts in the Rodica pedestrian underpass

To support cyclist and persons with prams, following solution could be implemted at the Rodica underpass – ramps with the stairs inbetween:

Figure 28 Pram / bicycle ramps[7]

Knowing that the closure of the existing pedestrian crossing does not mean that pedestrians will not continue to try to cross a road, a physical obstacle, e.g., hedge on the right side of the Rodica underpass (marked in green) and new access from the bus BUS stop to Perkova ulica (red arrow) are foreseen and marked in the picture below. Other than that, access to the road is already blocked by either hedge or fence in both directions for more than 200 m along the road. Additionally, all attractions on the west side of the road are on the same spot; bus and train station as well as the road going further west. Follow up in terms of periodical check is nevertheless foreseen to confirm the effectiveness of the measures.

[7] Source: https://brianmjohnson.wordpress.com/2009/04/06/the-road-ahead/

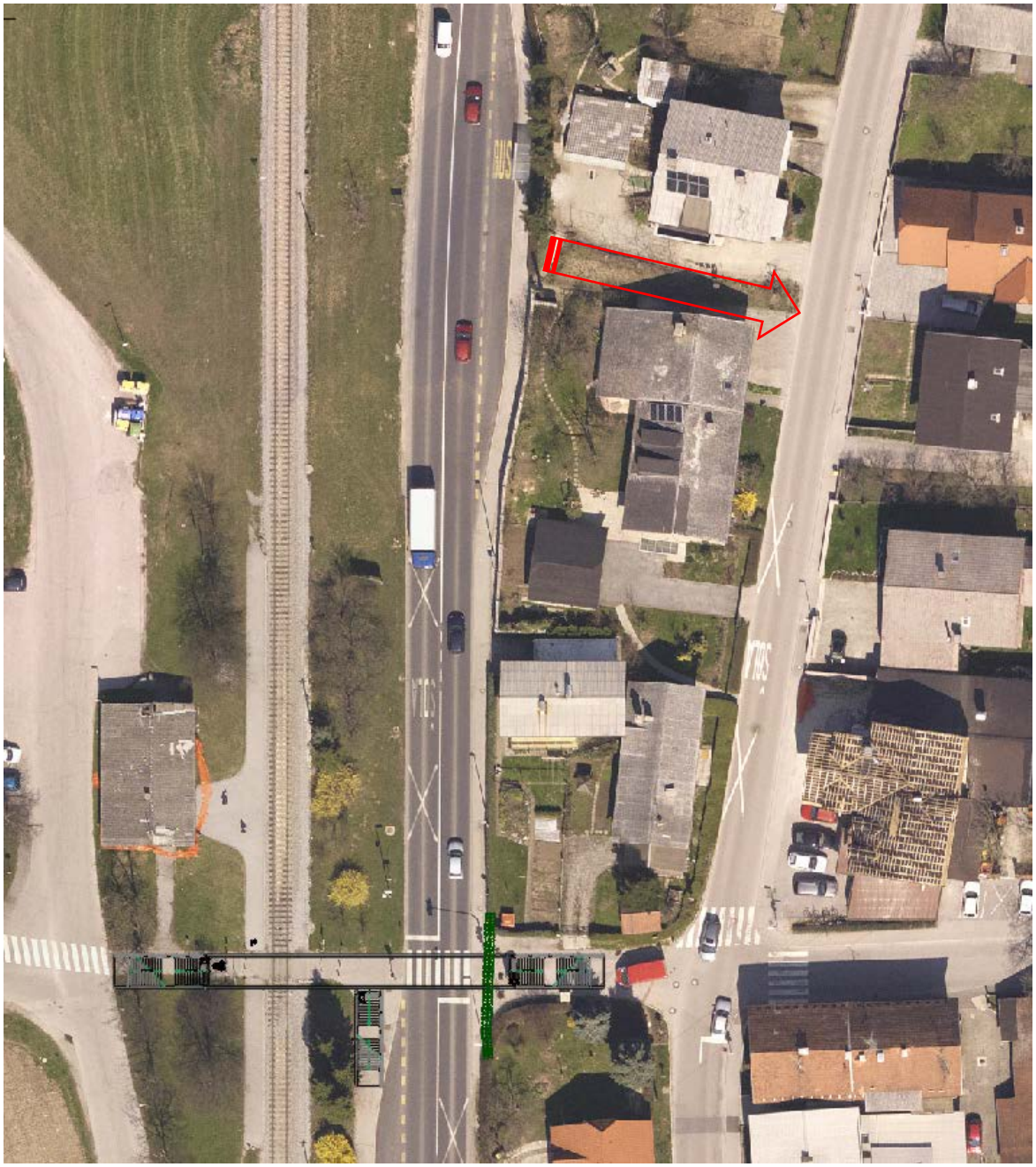


Figure 29Hedgerow at the location of existing pedestrian crossing and location of new access to Perova ulica

3.5. *Key safety improvements for VRUs at the location Rodica*

- new pedestrian underpass (with the grade separation of motorized and non-motorized modes of transport increases road safety by reducing the conflicts), where proposed design of the underpass meets requirements for the impaired users (sufficient width (3.0 m), tactile indicators, platform stairlifts, illumination …).

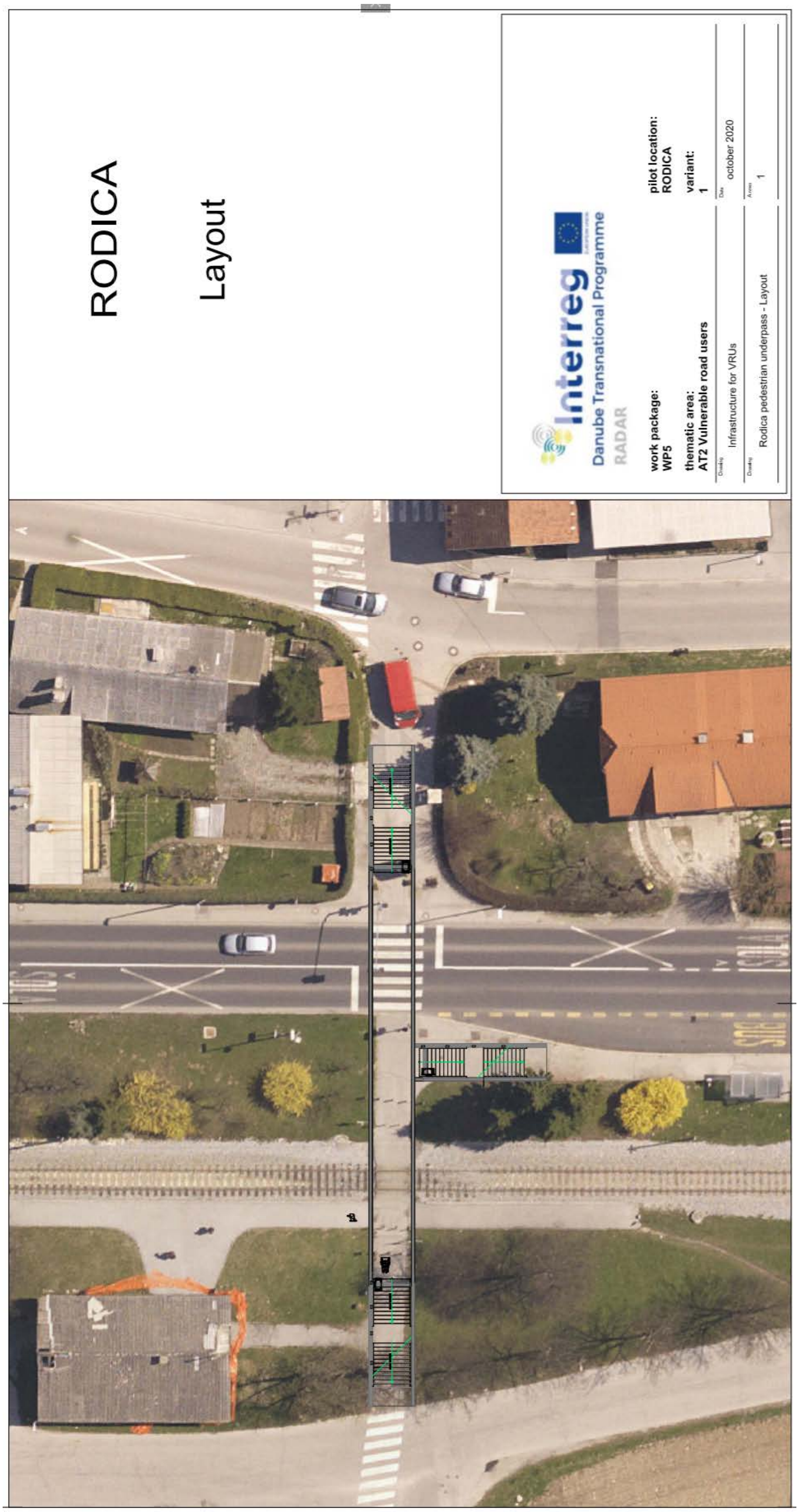
Key remarks:

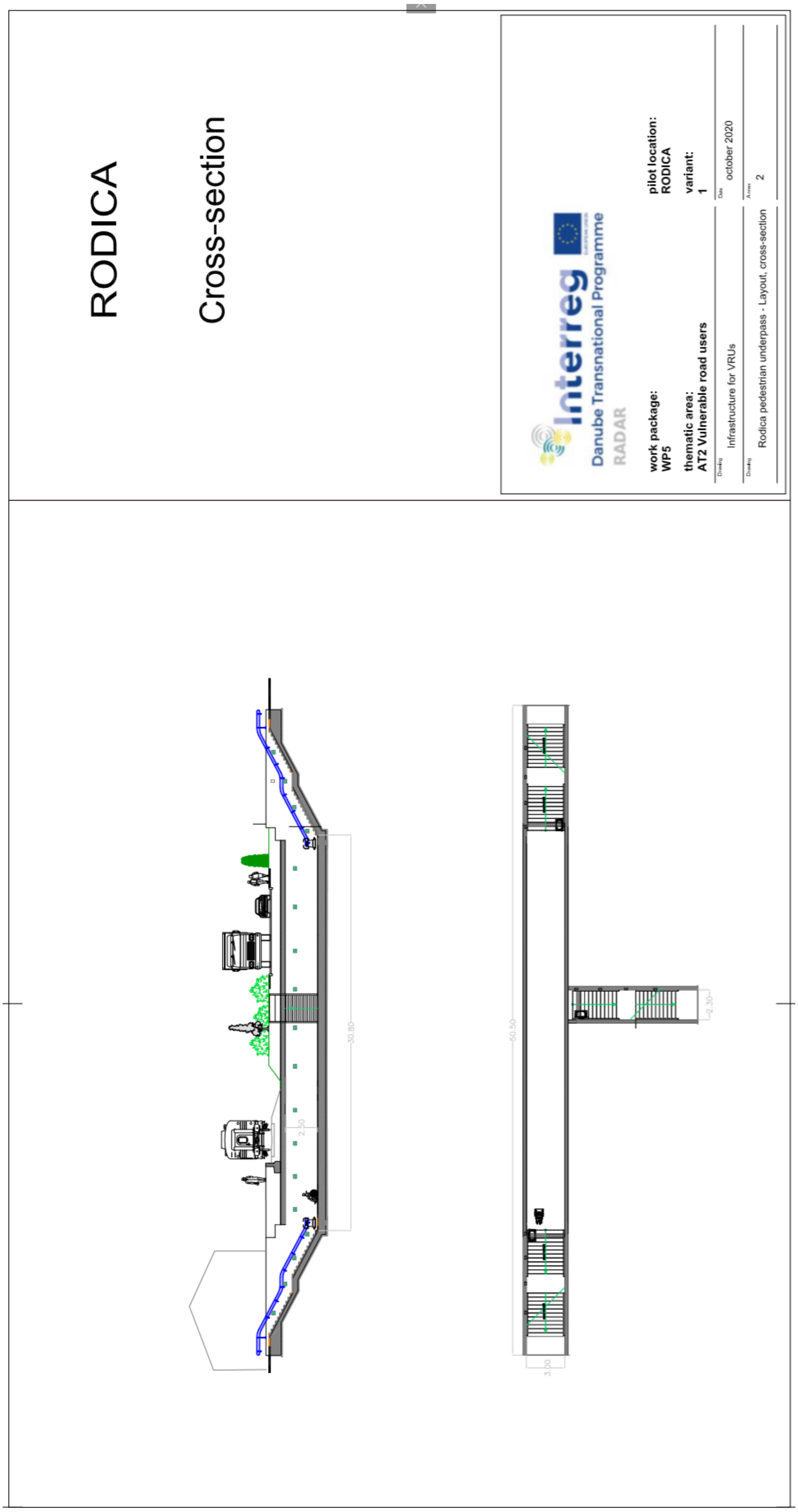
- International experience (from both in- and outside Europe) shows that many over- and underpasses are **avoided** by substantial shares of pedestrians and cyclists if there are less energy-consuming alternatives available. In order for the Rodica underpass to function the way it is designed, i.e. *all* VRUs use it without exception, and to ensure a positive impact (and avoid adverse effects!) on safety, a thorough **follow-up** should be foreseen (and described in this report): e.g. a survey, once construction is completed, of a) the then-illegal road crossings by pedestrians and cyclists at road level or b) a potential migration of crossing activities to other potentially unsafe locations. On this basis, implementation of appropriate *additional* (e.g. constructional) measures should be considered, where needed. This could well require a stepwise approach and you may end up e.g. with a long 2 m high fence in the median and / or fencing of the railway line. Would be great to have some thoughts on this in the report.
    - Added/explained in the text two pages back.

- It is said and shown in the report that there are cyclists using the crosswalk. Although it is mentioned in the general list of requirements, no rails for **bicycles** could be identified on the stair sketches. Please clarify in the report.

- The same is true for **pram** rails/ramps. Please clarify in the report.
    - Ramps for cyclists and prams are foreseen and mentioned in the text. But they are not included in graphics as this is design plan only and are to be included in the next phases of design where more detailed drawings will be produced.

- The underpass will require increased **maintenance** efforts. In addition to what a municipal road operation centre usually can contribute, the chairlifts require regular service and quick reaction (from whom?) in case somebody is locked down there e,g. due to technical failure. Have issues like these been discussed with stakeholders / the municipality in the course of the stakeholder consultation? Would be great to have a para on this in the report.
    - In general, municipal road authority is in charge of maintenance of public roads including existing underpasses, pedestrian pathways, other transport communications, traffic lights and street lighting, so there is no concern about that. In regard to more advanced/special equipment there is a technical support included in case of emergencies, similar to the one in residential buildings elevators where one service centre covers multiple devices.


RODICA
Layout
Interreg
Danube Transnational Programme
RADAR
work package:
WP5
thematic area:
AT2 Vulnerable road users
pilot location:
RODICA
variant:
1
october 2020
Infrastructure for VRUs
Rodica pedestrian underpass - Layout
1


RODICA
Cross-section
Interreg
Danube Transnational Programme
RADAR
work package:
WP5
pilot location:
RODICA
thematic area:
AT2 Vulnerable road users
variant:
1
Infrastructure for VRUs
october 2020
Rodica pedestrian underpass - Layout, cross-section
2

4. Domžale – VRUs-oriented design

4.1. *Location description*

The second site in this pilot project covers an area in the city centre of the small Slovenian city of Domžale on the northern outskirts of Ljubljana. The city centre is crossed by an important state road that connects the capital Ljubljana with the city of Kamnik. The section 1357 Šentjakob - Domžale on the R3-644 road, which runs in a south-north direction, has about 9,000 AADT (see figure 9). The part of the section discussed here is a section of the Ljubljanska cesta between the intersection with the Karantanska cesta to the south and the intersection Masljeva/Kamniška/Ljubljanska to the north (marked in red in the figure below).

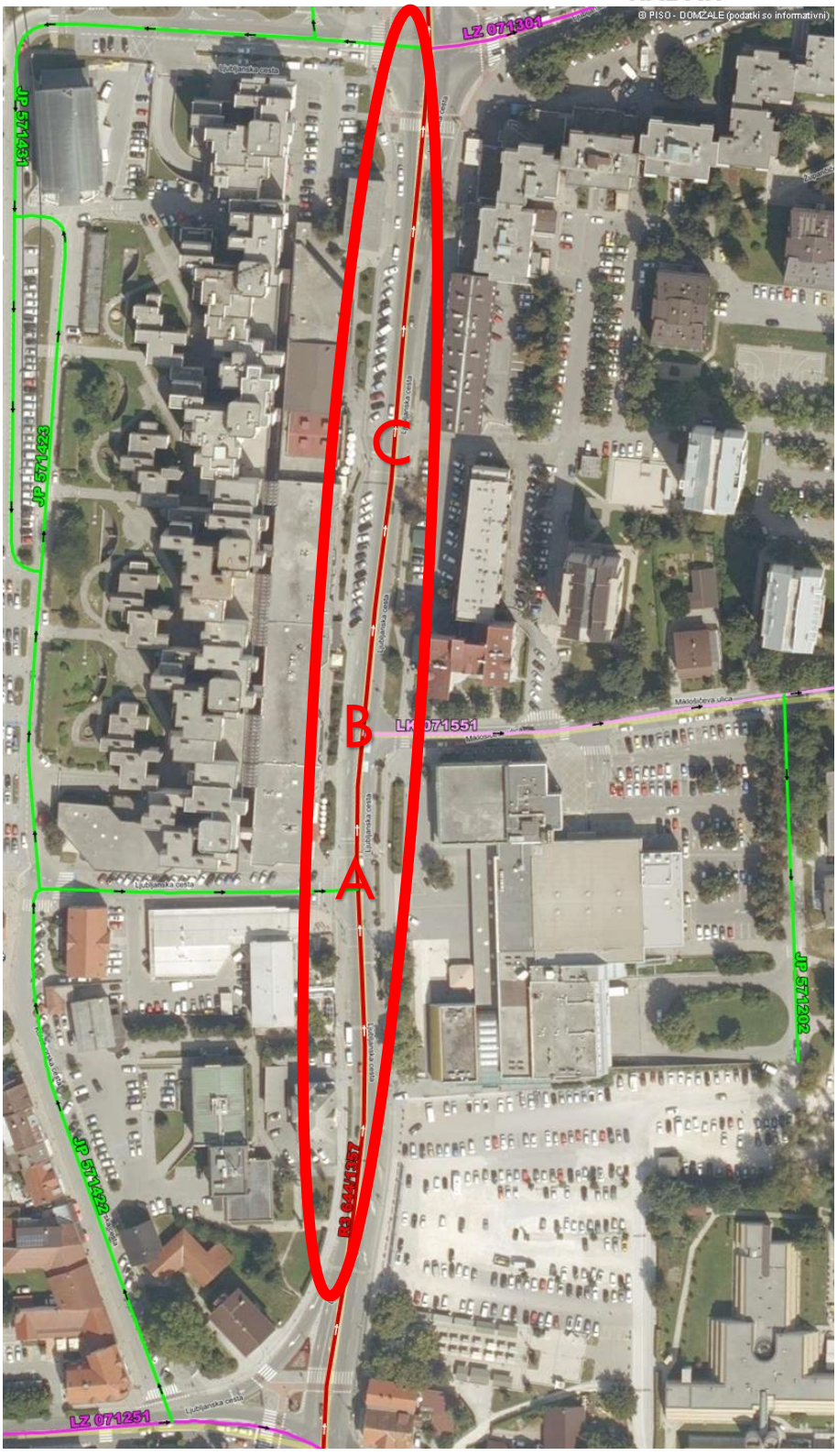


Figure 30 Overview of location 2 – Domžale

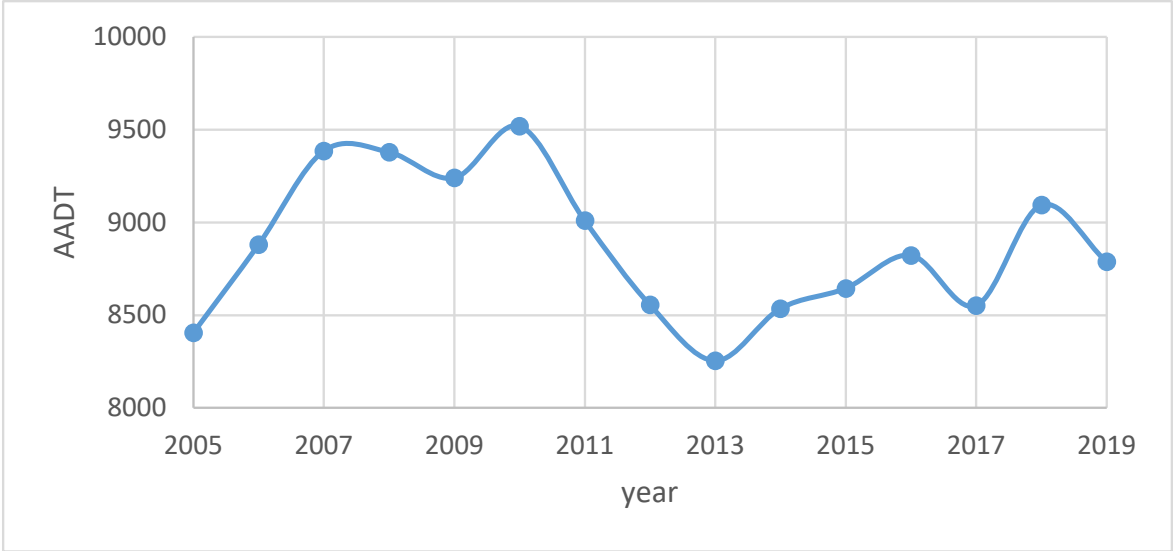


Figure 31 Average daily traffic in Domžale, road R3-644, section 1357

The area generally represents the heart of the city of Domžale and is, therefore, the liveliest part of the city, which is also reflected in the volume of traffic. The street is busy with pedestrians, cyclists, cars, delivery vans and buses that run on regular lines.

The road configuration on this stretch is an undivided two-lane road with one lane in each direction, which runs through the urban environment. There are two 3 leg intersections with local one-way roads and one commercial access point, marked A, B and C on the aerial image.

The southern intersection (A) connects a local one-way road directed towards the main road. Both turns are possible. The intersection is equipped with traffic signals and is combined with a pedestrian crossing on both the main and the side road.

The side road has been recently renovated and is designed as a Shared Space street. The speed is limited to 10 km/h, the single driving lane is level with areas dedicated for vulnerable road users, relatively narrow and there are small, round steel humps reminding drivers to drive slowly and to concentrate on other road users.

Figure 32 Renovated street and south intersection

The tactile markings present at the intersection are not correctly designed, as they guide the user across the main road at an angle rather than orthogonally. In addition, turning left onto the main road is somewhat difficult, as the space in front of the pedestrian crossing is limited when waiting at the intersection. Besides, due to a presence of a turning lane for the next intersection on the main road, which is already present within this intersection, there may be some confusion when traffic is heavy.

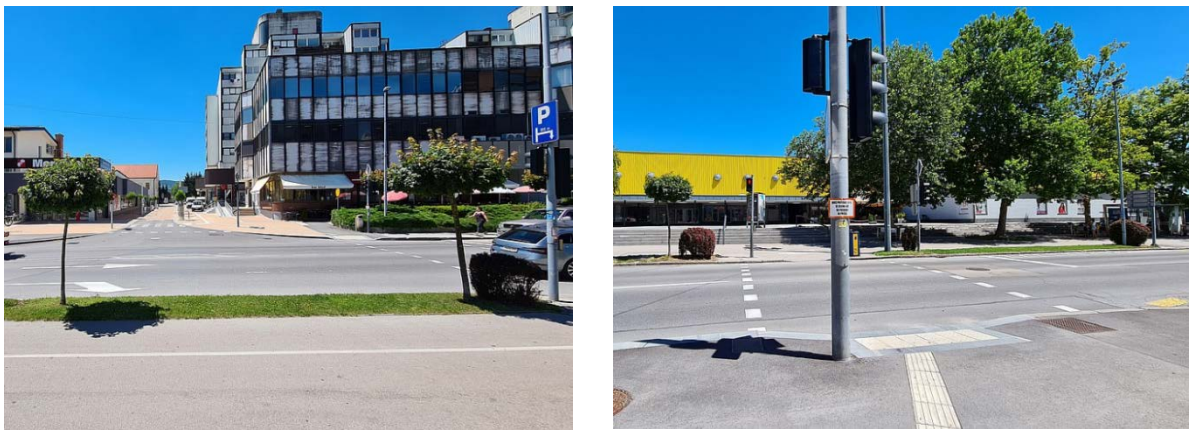


Figure 33Tactile markings and south intersection

The next intersection (B) is located 50 m to the north. Access to the side road is possible from both directions, and both have a turning lane. The intersection is not signalized, and a pedestrian crossing is located only on the side road.

Another 100 m further north there is an access point (C) on the east side of the main road. It provides access to the parking lots of the neighbouring residential buildings, which also have some shops on the ground floor.

At the access point, the main road's driving lanes are separated by a continuous centre line, so that traffic can only enter the parking lots from the south and exit from them from the north.

On the south side of the access point, there is a pedestrian crossing on the main road, which is signalized. However, there is no traffic signal for the access point, neither a yield or stop sign when entering the main road. The presence of a pedestrian crossing so close to the access point is a point of conflict, in addition to the one on the sidewalk, where there is no pedestrian or bicycle crossing over the driving path on the access point. Both conflict points pose a safety risk to pedestrians and cyclists.

Two on-street parking areas are currently available on the west side of the main road, the first on the part north of the access point and the second on the one to the south, located between the access point and the north intersection. Both are about 50 m long and have marked parallel parking spaces for cars. In reality, all cars park at an angle as the lane to the south is wide enough to leave enough space to drive by. Due to the much bigger width that is needed for angled parking, the problem occurs at the end of the southern parking area, shortly before the northern intersection (B). Vehicles heading south must do an S-curve, as their lane is no longer straight. If not, they are on the left-hand turn lane at the intersection.

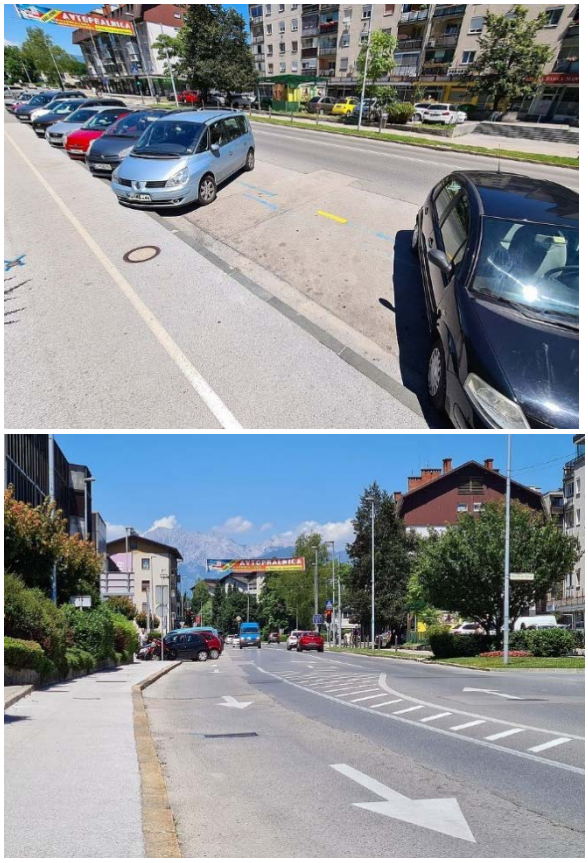


Figure 34 Parking situation and north intersection lanes

South of the southern intersection there are two bus stops, one on each side of the road. The one on the east side is on the right lane because from the crossing with Karantanska cesta two lanes are coming from the south for about 50 m, before the right lane becomes a bus stop and then further north joins the adjacent left lane. The bus stop on the west side is located in a dedicated lay-by.

The provisions for pedestrians on the treated section are mostly in the form of sidewalks, in some places as a separate facility. They are present along both sides of the road, the same applies to cycle paths. Markings are poorly visible and in some places are even completely missing.

The cycle path for bicycles is not optimal, especially in the northern direction on the east side of the road, as it makes quite a lot of deviations to follow green areas and other elements along the road.

The results of the risk mapping show that road R3-644, section 1357 for the last available three-year period has »level of accidents« 3, with 3 serious or fatal accidents between 2015 and 2017. The section is 6.180 m long.

Star rating was not conducted for this location as the star rating model does not yet take into account this specific shared space arrangement and processing of any adapted road element data would result in at least misleading if not wrong outcome.

Key safety problems detected at the location Domžale:

- due to the left turning lanes, the driving lanes on the main road are not straight and therefore confusing for road users;
- poor road marking for the delineation of different road users as motorized vehicles and cyclists;
- on-street parking.

4.2. *Current situation*

Location

Municipality Domžale

Regional road R3-644, Šemtjakob - Domžale

GPS: 46.14043, 14.59420

The city centre of Domžale is an area with different services, such as bar, shops, public services (pharmacy, bank, notary, Health Insurance Institute of Slovenia office etc.). The city centre has a strong relationship with the regional transport network and as such is accessible to a wide cross-section of the community and the car is used as the main means of transport. By understanding the weaknesses of car-dependency and at the same time by increasing awareness of the positive effects of sustainable transport modes on individuals, society and the environment, new concepts of urban planning and transport policies have recently been introduced. In contrast to the car-dependence movement, the car-free movement refers to sustainable urban design and transport policies that encourage residents to use environmentally friendly means of transport instead of their own car.

The main objective of car-free development is to improve sustainable and energy-efficient mobility by greatly reducing or eliminating or converting road and parking space for other public uses and to rebuild compact urban environments where destinations can be easily reached on foot, by bicycle or by public transport. So-called walkable cities keep people without a car from becoming isolated and allows people to drive and park once for several errands. To this end, pedestrian activity and public transport services are two of the many factors that should be considered in the design of pedestrian-orientated areas and streets. Putting pedestrians in the first place, however, does not mean that motorized trips are completely forbidden; existing accessibility should not be overlooked, but the level of service can be reduced.

In Domžale, urban development in recent decades seems to have focused on providing space available only for vehicles, so that today most of the space is dedicated to roads and parking, while the infrastructure for pedestrians and cyclists is poor. This has led to the city suffocating in traffic, noise, and polluted air, which is certainly not a synonym for a pleasant and sustainable environment for people. The main road, Ljubljanska cesta, where the majority of public services are located, including bus stops and the railway station, offers remarkable opportunities to change travel habits in Domal.

The Ljubljanska cesta cuts the built-up area of Domžale in half, and most residential buildings on both sides are within walking distance. The attractive and pedestrian-oriented city centre can have a positive impact not only from an environmental point of view (reduction of pollution and noise), but also from a human point of view, as this district becomes a place of meeting and social exchange, the safety of vulnerable road users is increased and accessibility for all can be achieved.

4.3. *General requirements for pedestrian-oriented roads*

People use urban roads for mobility or stationary activities, for leisure or work, out of necessity or by choice. People of all ages and abilities experience roads in different ways and have many different needs. Whether they sit, walk, cycle, use collective or personal transport, move goods, provide urban services, or do business, the various activities that the roads host and facilitate shape the accessibility and vibrancy of the city. The type of users and the total volume of people on a given street depend on many variables, such as the time of day, the size of the street, the urban context, and the local weather. Each user moves at a different speed and takes up a different amount of space within the limited geometry of the street. Therefore, the total capacity of the road is determined by the mix of transport modes allowed by the road design. Roads should be designed to balance the needs of different users to create an enticing environment that ensures access, safety, comfort, and pleasure for all.

The pedestrian and road network should be integrated wherever possible. The identification of the prevailing conditions is necessary for the selection of design and planning strategies that can be used to create a pedestrian-friendly environment. The main challenge of an effective/frequently used pedestrian-friendly road is how to maintain pedestrian interest and a supporting density of use. Low land use intensities translate to great walking distances, where distances over 500 m are usually driven rather than walked. Gaps or obstacles between uses can also create unfriendly zones that disturb pedestrian interest. The specific objectives of pedestrian-oriented roads, that is an area in the community where pedestrian access is a priority, are:

- encourage people to walk, cycle or use public transport;
- allow for a mix of uses to create an environment that engages people at the pedestrian scale;
- achieve a compact pattern of uses within the area that is more conducive to walking and bicycling;
- provide a high level of services that create a comfortable environment for pedestrians;
- maintain an adequate level of parking and access for cars and service vehicles, but minimize parking lots along the primary corridor;
- create fine-grained detail in an architectural and urban form that provides interest and complexity at the level of the pedestrian.

General recommendations to be applied when designing/establishing pedestrian areas (Planning and designing for pedestrians):

1. On pedestrian-oriented streets, buildings should front onto the majority of the street.
2. Primary building entrances (e.g. the front door to a home, the entry to a store, or the lobby entry to an office building) should front onto adjacent public streets or entry plazas.
3. The perceived level of security has bearing on the level of investment made in a community. Physical maintenance of buildings and quality of building materials signals to the pedestrian whether the area is being cared for and if it is safe to be there.
4. Designing a safe and attractive pedestrian realm with development fronting the streets fosters an increased sense of security;
   - blank facades and mirrored or darkly tinted glass should be avoided as they give nothing back to the pedestrian and make for an uncomfortable walk.
   - empty store windows should be kept clean and should be leased out to adjacent businesses for advertising, or non-profits could use the space for notices and announcements.
5. The increased activity and visual interest associated with continuous building frontage can give the perception of shorter distances as opposed to crossing expanses of empty land, stretches of blank facades, long stretches of car-dependent roads. This helps to make walking a more attractive mode of transportation.
6. An effective means of maintaining visual interest for a pedestrian is achieving a sense of "transparency" and connection between the pedestrian and the uses along the street.
7. Long stretches of walls, fences, and berms should be avoided, and a more creative solution to sound reduction should be explored, e.g. breaking up the walls into sections and alternating with landscape features.
8. The issue of speed along pedestrian-oriented streets should be aggressively addressed by physically narrowing the streets using bulb-outs, landscaped medians, bicycle lanes and/or widened sidewalks or creating pedestrian zones.
9. Accessibility for all should be achieved by eliminating barriers for disabled;
   - In order to assure equal mobility for vision-impaired pedestrians, audible signals and braille instructions at pushbuttons should be considered.
   - Tactile cues should be used where crossings occur in an unexpected location. Wayfinding strips should extend between the expected and actual crossing location, while tactile bumps or grooves should be placed at either side of the crossing itself.

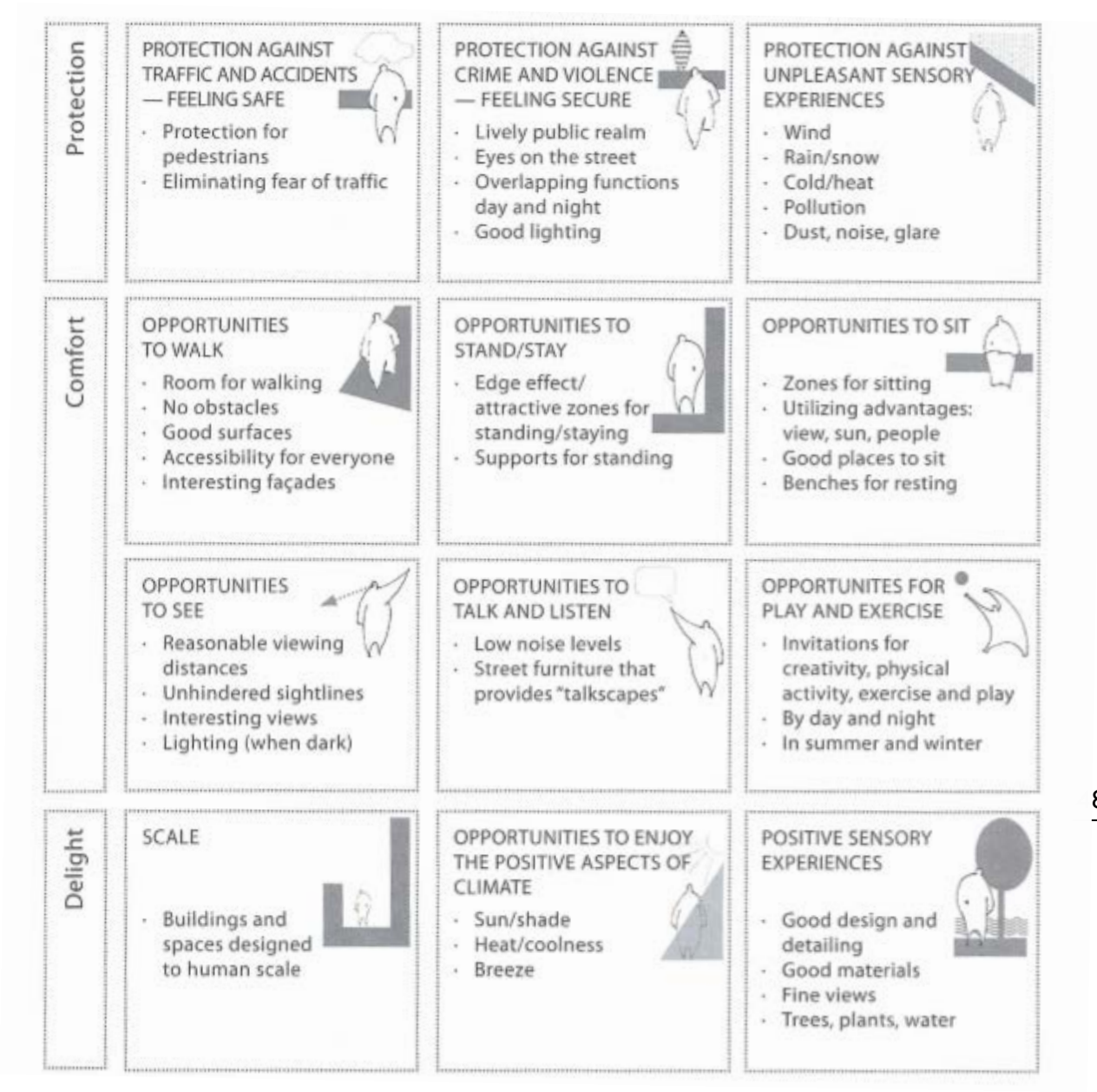


Figure 35 12 quality criteria concerning the pedestrian landscape[8]

Below one can find a visual checklist to ensure a comprehensive approach to prioritizing pedestrians and providing universal accessibility (Global Street Design Guide – Pedestrian Toolbox):

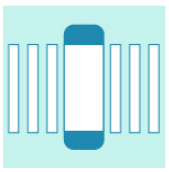
[8] Gehl, 2010

Sidewalks

Sidewalks should be continuous and provide a clear path consistent with pedestrian volumes, but always wide enough to allow two people using wheelchairs to pass one another. Allocate space for building entrances and commercial activity outside the clear path. Street furniture, trees, and utilities should serve as a buffer between the clear path and moving traffic.

Pedestrian Crossings

Safe and frequent pedestrian crossings support a walkable urban environment. Pedestrian crossings should be located at all intersections in addition to mid-block points where pedestrian traffic is anticipated or desire lines are observed. Support marked crossings with signals and stop controls, raised elements, refuge islands, and narrow corner radii. Slow vehicular traffic approaching pedestrian crossings.



Pedestrian Refuges

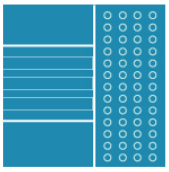
Pedestrian refuges reduce crossing distance and provide waiting areas for people who cannot cross the full width of the street in the pedestrian interval. Use pedestrian refuge islands whenever speeds and vehicle volumes make single-stage crossings dangerous for some users, and in most streets of three or more lanes of traffic.

Sidewalk Extensions

Sidewalk extensions are an extension of the sidewalk, usually at the point of the intersection, visually and physically narrowing the roadway and shortening crossing distances. They make pedestrians waiting to cross the street more visible to drivers, calm traffic speeds, and increase the available curb space for people waiting to cross. Large sidewalk extensions can accommodate street furniture, benches, vendors, transit stops, snow storage, planters, and trees.

Pedestrian Ramps

Install pedestrian ramps at every pedestrian crossing and change of level. They should be built of non-slip materials and have a maximum slope of **1:10 (10%)**, ideally **1:12 (8%)**. These ramps are critical for people pushing strollers or carts, or using wheelchairs. They should be aligned perpendicularly to the pedestrian crossing.



Guidance for the Visually Impaired

Employ strategies such as accessible pedestrian signals at intersections, tactile paving strips on sidewalks, station edges, and pedestrian ramps to facilitate accessibility for people with vision impairment. These elements provide guidance to assist blind people and the visually impaired in navigating the city.

Signage and Wayfinding

Provide consistent pedestrian signage in a clear visual language that can be universally understood. Provide information to allow users to switch between mobility modes and navigate local street networks. Illustrate walking and cycling times and distances in wayfinding signs and maps.

Pedestrian Countdown Signals

Install pedestrian signals at intersections to allow pedestrians to cross the street safely. Display crossing time duration with a numerical timer during the clearance interval. The clearance time is generally based on a 1-m/s walking speeds applied to the total crossing distance. Since many pedestrians walk below this speed, provide frequent refuge or time the walk signal to allow for a 0.5-m/s speed.

Lighting

Well-lit spaces are critical to pedestrian safety, creating lively, inviting spaces at night and preventing crime. Place pedestrian-scaled lighting along all streets, ensuring appropriate illumination levels and spacing to avoid dark spots between light sources. Brightness levels should be greater along commercial streets and softer in residential areas. Poles and fixtures should never obstruct walking paths. *See: Lighting Design Guidance.*

Seating

Provide frequent opportunities for people to pause and rest. Seating should have comfortable backs, offering a mix of shaded and unshaded seats suited to the local climate. Placement should allow legroom that does not block the clear path. In larger pedestrian areas, provide movable chairs and a variety of seating arrangements to invite conversation and social activity.

Water Fountains

Provide drinking fountains with fresh, potable water to offer sustainable alternatives to bottled water and ensure an essential water source in many communities. Use creative designs to encourage use, and ensure that fountains are maintained to clean and safe standards. Provide access for children and people in wheelchairs with varied heights.

Weather Protection

Incorporate awnings and canopies into building facades where possible to add shelter and character to the street, and offer protection from the weather during snow, rain, or extreme heat. Install stand-alone shade structures in larger pedestrian-only areas if shade trees are not present or are immature.

Curbs

Provide curbs to create a structural edge between the sidewalk and adjacent cycle or travel lanes. Curbs discourage vehicles from entering or blocking pedestrian areas, and many are integrated with a gutter to assist in channeling water. Curbs should not be more than be 15 cm high. They should incorporate ramps at pedestrian crossings to facilitate safe access.

Waste Receptacles

Provide conveniently available receptacles for waste to help maintain a clean and enjoyable pedestrian environment. Place waste receptacles near corners, vendors, crossings, and parklets, adjacent to clear paths. Receptacles should be sized in accordance with expected use and local collection and maintenance plans. Solar–powered compactors can increase collecting capacity in high volume areas.

Active Building Edges

Building frontage design plays a critical role in shaping the overall pedestrian experience. The design of the ground floor influences the character of the street and the level of pedestrian engagement. Frequent entrances, appropriate transparency levels, visual variation, and textures all contribute to shaping an enticing street environment.

Trees and Landscaping

Include landscaping where possible to create a pleasant walking environment, contribute to the character of a neighborhood and encourage active transportation choices. Landscaping improves microclimatic conditions, cleans the air, filters water, and increases the biodiversity of a city, offering physical and mental health benefits.

4.4. *Domžale VRUs-orientated design of the city centre*

A VRUs-oriented design is planned for the city centre of Domžale. By creating an environment that encourages walking and cycling can be achieved the following:

- that most trips start and end on foot (not only in the vicinity of the Ljubljanska cesta, but also in the neighbourhood; even if major trips are done by car, short trips (up to 500 m) can be made on foot;
- increased access to local services, entertainment and retailing;
- better services/accessibility for an ageing and disabled population;
- safer walking and cycling;
- improved physical health in the community supported.

At this pilot site 4 variants were tested, namely:

- Grade separation of motorized and non-motorized traffic, where motorized traffic is at level -1 (tunnel), non-motorized users at level 0;
- Shared Space concept;
- Prioritisation of public transport, walking and cycling;
- Pedestrian zone.

Variant 1: Grade separation of motorized and non-motorized traffic

As can be seen in the picture below, Kamniška cesta ('prolongation' of Ljubljanska cesta to the north) gives the impression that the level on which the road is situated in the area of the underpass is low enough that it could be continued through the city in the south direction below the ground level. Therefore the first idea was to use the opportunity and continue with that level and to divert motorized traffic on the level -1. The main advantage of the tunnels is truly separating motorists from cyclists and pedestrians - a holy grail for many cities and an answer to the problem of the congestions, noise emissions and has a great impact on the safety of pedestrians and cyclists.

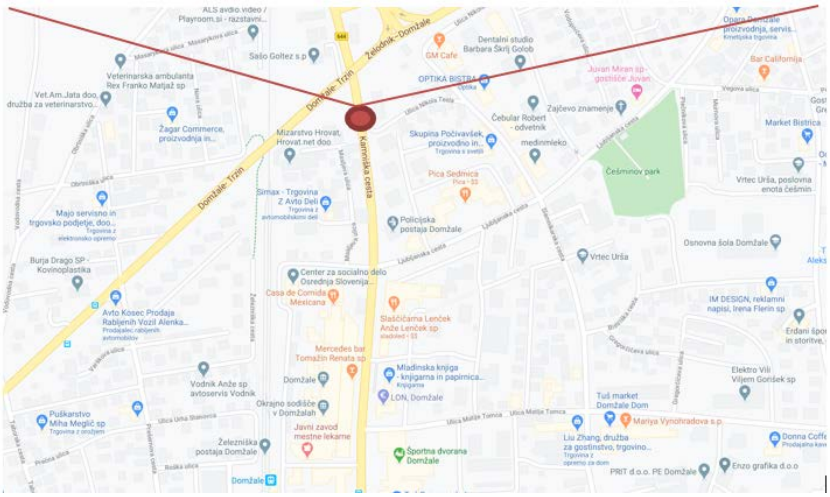


Figure 36 North from Ljubljanska cesta

Unfortunately, the change in the gradient is not sufficient to design a tunnel in the city centre. The small difference in the height of the road on this section (less than 2 m), the short length of the section (750 m), and the needed clearance of the tunnel (4.5 m) on one side, and the maximal longitudinal tilt regulated by the national law (Rules for road design; Pravilnik o projektiranju cest (Uradni list RS, št. 91/05, 26/06, 109/10 - ZCes-1 in 36/18) on the other side, make the design of the tunnel unfeasible.

Variant 2: Shared Space concept

In the Domžale city centre, more specifically on part of Ljubljanska cesta, we propose a Shared Space concept, which is still a relatively new way of thinking and acting in Slovenia. Main objectives of the Shared Space concept are a more sustainable development of the city, and improvement of the quality of life due to the cleaner and more energy-efficient transport system. The basic idea of the Shared Space concept is that the road and its surrounding are not filled with diverse traffic signals that segregate different road users (pedestrians, cyclists, motorized vehicles). Instead of markings that determine where a motorized vehicle can drive, where a cyclist can go, and where a pedestrian can walk, everyone has a free choice where they want to move – and movement is subject to social protocol and informal regulation, not traffic rules. Thus, all road users must follow 3 main rights i.e., equality, freedom and respect - which lead to a higher quality of life in the urban environment, greater safety and an improvement in driving culture of all participants. De Haan (https://www.dnevnik.si/1042719406) argues that users of Shared Space areas may feel threatened since there are road signs, traffic signals, roundabouts, crossing points and curbs are done away with and replaced by flat, smooth roads without markings, on which cars and people interact regularly, but they behave more safely. Road users under the current regulation (traffic signs, road markings and other signals) feel safer, but behave dangerously - because they feel dominance in 'their' area, with which they are trying to overpower the weaker road user.

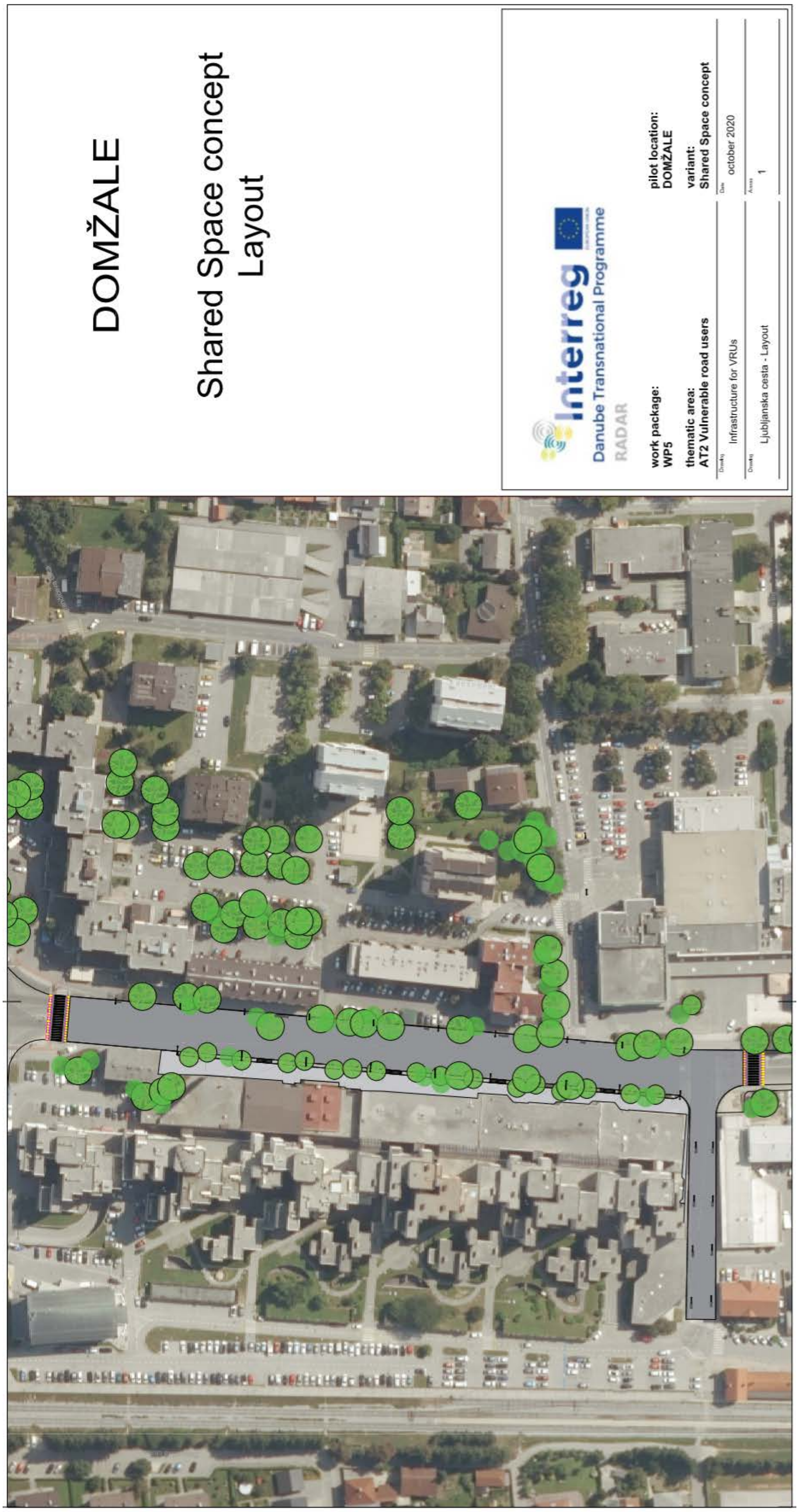
The figure below depicts a cross-section of the Ljubljanska cesta with the proposed Shared Space concept.

Figure 37 Shared Space concept in Domžale centre

The existing situation on the Ljubljanska cesta is chaotic (deviation of the main road axis, on-street parking, left-turn lanes, lack of cycling infrastructure ...). The core principle of the Shared Space concept is that all road users should not be separated from each other, but integrated, with everyone having the same rights of way. Such a drastic change requires both physically division and visual contrasts with the rest of the road network. This is why we propose traffic calming measures on both sides of the proposed Shared Space zone and distinctive road surface. Recently the Kolodvorska cesta was reconstructed and we propose to use similar paving and street furniture on the Ljubljanska cesta.

Figure 38: Example of the paving and urban furniture that is proposed to be used in Shared Space in Domžale centre – Kolodvorska cesta

The Shared Space concept should only be introduced if the volume and speeds of motor vehicles are so low that most people who walk and cycle have little or no interaction with passing motor vehicles. When designing Shared Space, it should be considered whether a high volume at peak hours creates a highly stressful cycling environment; nevertheless, this can be tackled through volume management (motor vehicle volumes can be reduced by building diversions, banning through traffic or removing parking spaces, with delivery only possible during off-peak hours ...). If the comfort and safety of cyclists are still not acceptable, cycling facilities should be separated (see variant 3, Prioritisation of public transport, walking and cycling).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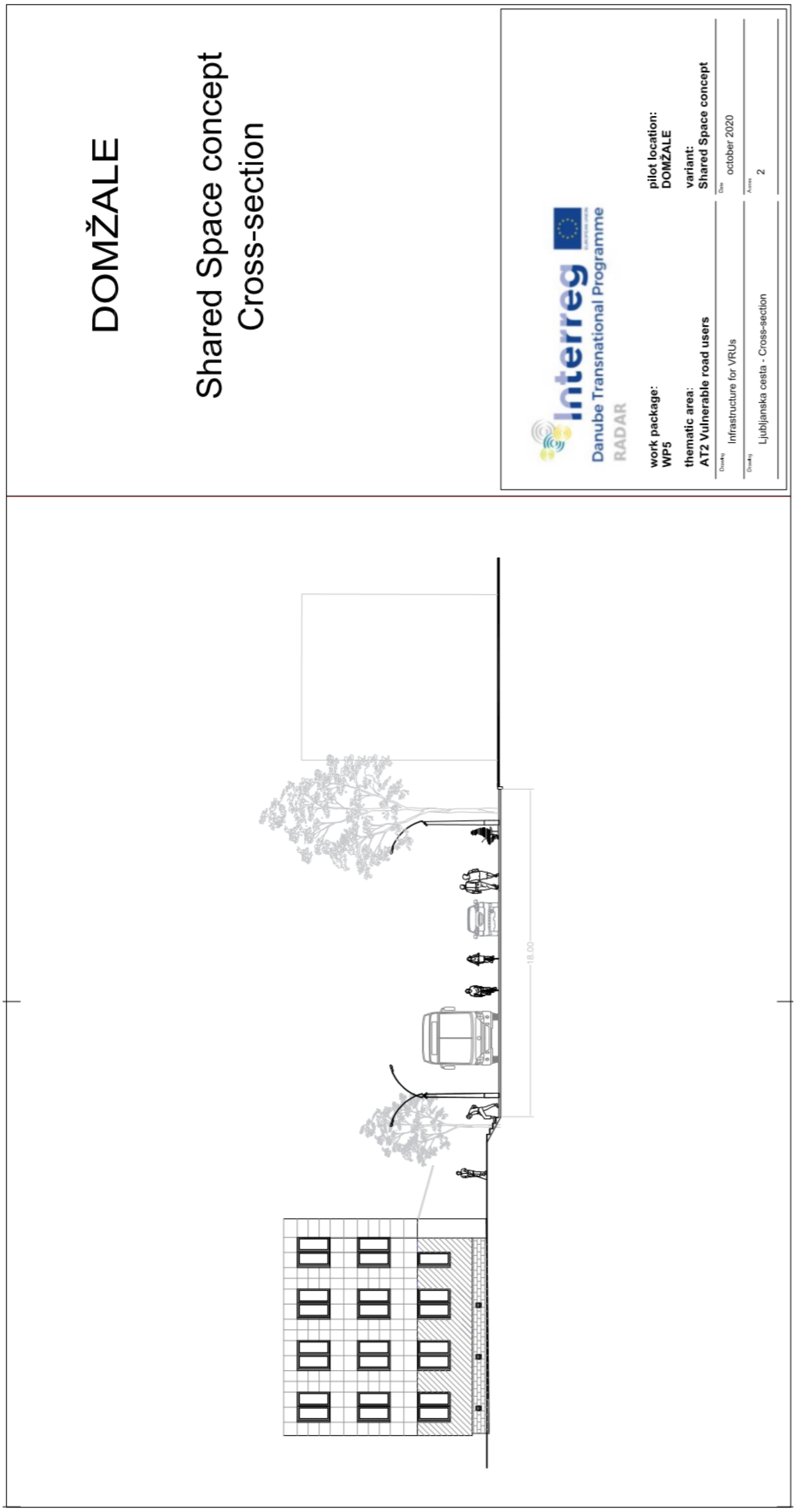
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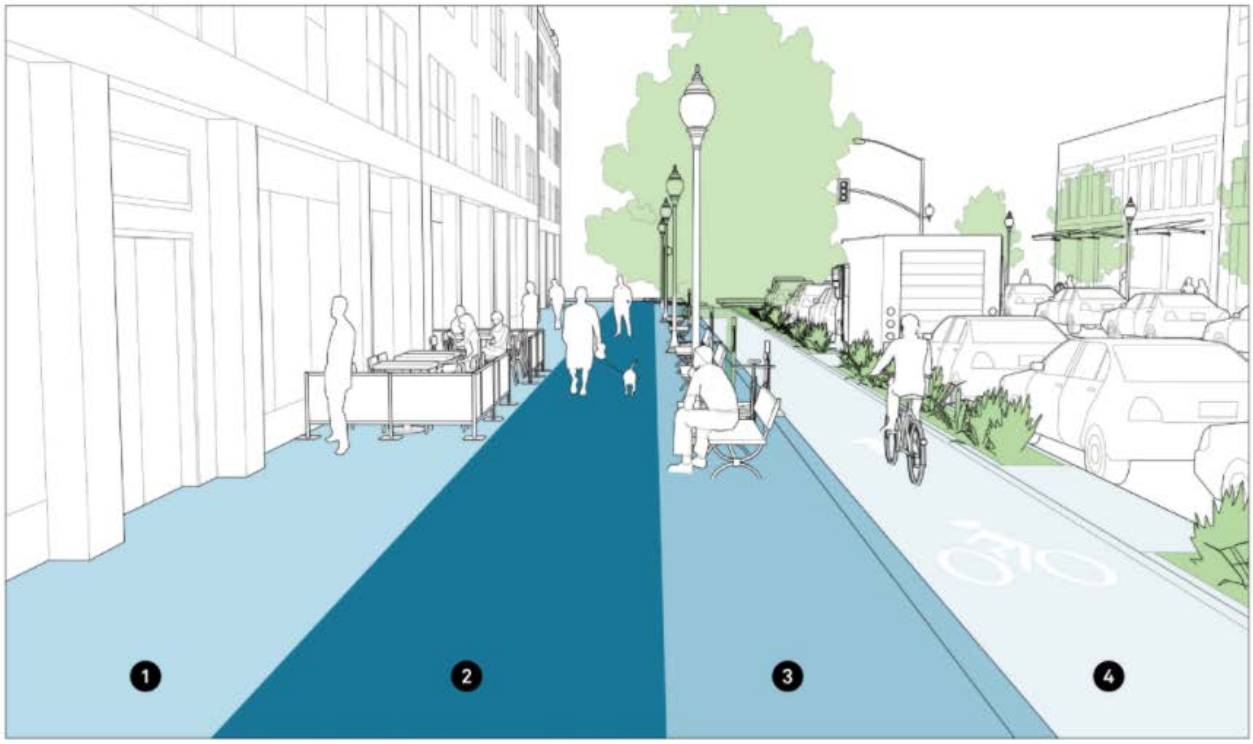
Variant 3: Prioritisation of public transport, walking and cycling

In Variant 3 we propose the introduction of a prioritisation of public transport, walking and cycling, in which only public transport vehicles, emergency vehicles, delivery vehicles and residents may use this section of the Ljubljanska cesta with protected cycling lanes and a separate pedestrian zone. In this way, the different means of transport are separated, and the risk of accidents is minimized. Zone entrances and exits are designated with traffic calming treatment (e.g. speed bumps) to make all road users aware when they are entering or exiting the road section with prioritisation of public transport, walking and cycling.

An example of good practice in Slovenia is Slovenska cesta in Ljubljana and provides a convincing lesson that a carefully designed road that prioritizes public transport, walking and cycling (combined with an effective detour for motorized vehicles, adequate parking facilities and attractive accessibility of the pedestrian-oriented part of the road from the neighbourhood) can be a base to the liveability of life and is well used except in all but the worst weather.

Figure 39 Prioritisation of public transport, walking and cycling best practice (source: Designing Streets for kids)

The basic concept of separating transport modes, that was also considered in the proposed solution, is depicted below.



Frontage Zone

1 The frontage zone defines the section of the sidewalk that functions as an extension of the building, whether through entryways and doors or sidewalk cafés and sandwich boards. The frontage zone consists of both the facade of the building fronting the street and the space immediately adjacent to the building.

Clear Path

2 The pedestrian clear path defines the primary, dedicated, and accessible pathway that runs parallel to the street. The clear path ensures that pedestrians have a safe and adequate place to walk and should be **1.8–2.4 m** wide in residential settings and **2.4–4.5 m** wide in downtown or commercial areas with heavy pedestrian volumes.

Street Furniture Zone

3 The street furniture zone is defined as the section of the sidewalk between the curb and the clear path, in which street furniture and amenities such as lighting, benches, newspaper kiosks, transit facilities, utility poles, tree pits, and cycle parking are provided. The street furniture zone may also contain green infrastructure elements such as rain gardens, trees, or flow-through planters.

Buffer Zone

4 The enhancement or buffer zone is defined as the space immediately next to the sidewalk, and may consist of a variety of different elements. These include curb extensions, parklets, stormwater management features, parking, cycle racks, cycle share stations, and curbside cycle tracks.

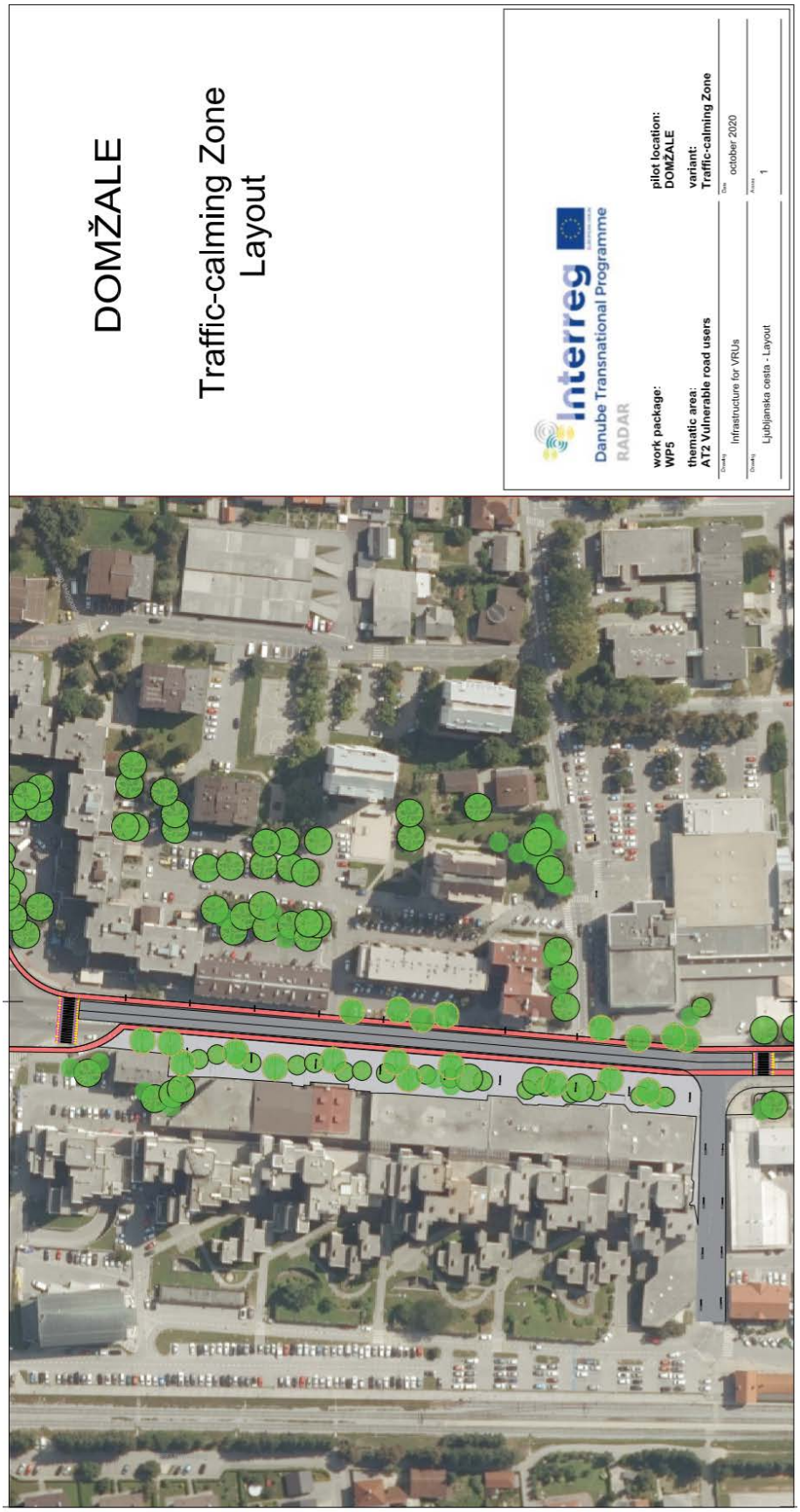
Figure 40 Types of Zones where transport modes/activities are separated (source: Global Street Design Guide – Sidewalks)

The figure below depicts a cross-section of the Ljubljanska cesta with proposed prioritisation of public transport, walking and cycling.

Figure 41 Prioritisation of public transport, walking and cycling in Domžale centre

The proposed design, 2 lanes, one in each direction, with a width of 3.5 m, which may only be used by public transport vehicles, emergency vehicles, delivery vehicles and residents are foreseen. The bicycle lane is located next to the driving lane and is physically separated from the motorized vehicles. The cycling lanes are 2.0 m wide. Experiences showed that the installation of protected cycle lanes on the roads reduced the number of accidents with injuries for all road users by 40% within four years. Furthermore, among adults only 6-10% of people feel comfortable in mixed traffic or on painted cycle lanes and almost two-thirds of the adult population may be interested in riding more often because there are better places to ride, and up to 81% of them would ride on protected cycle lanes. Cycle lanes that remove stress will attract traditionally underrepresented cyclists, including women, children, and senior citizens. Protected cycle lanes improve the overall organization of the road and increase safety for people walking, cycling and driving in motor vehicles, even at higher speeds and/or higher levels of motorized traffic or in unpredictable conditions. According to the National Association of City Transportation Officials (Urban Bikeway Design Guide) indicators for the construction of protected cycle lanes are where vehicle speeds are continuously above 40 km/h, where the daily vehicle volume is higher than about 6,000 vehicles per day, where curb conflicts are expected or where there is more than one lane per direction.

With the speed limit of 30 km/h and access restrictions (transit traffic would not be allowed on this section of the Ljubljanska cesta), the volume of motorized traffic will decrease significantly, and consequently (it is estimated that the volume of traffic would be less than 6,000 vehicles per day) we still propose the introduction of protected bicycle lanes. As mentioned above, this type of measure increases the awareness of cyclists for the safe cycling infrastructure and also deals with "all ages & abilities" and VRUs.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Ljubljanska cesta - Layout

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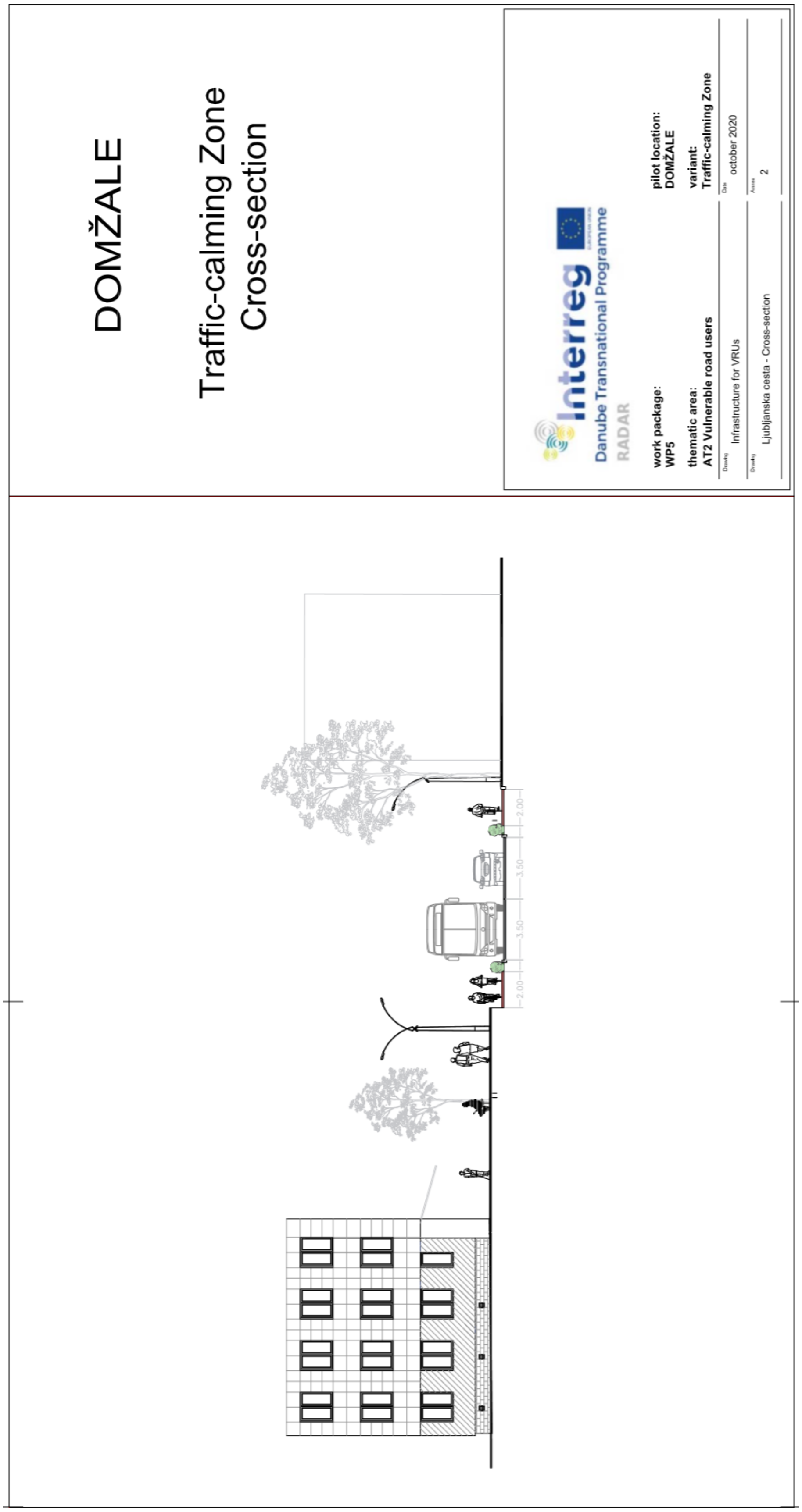


Variant 4: Pedestrian Zone

Ljubljanska cesta is categorized as a regional road and as such cannot be closed to the motorized vehicles unless the category of the road changes. Closing the road to motorized traffic may seem at first sight to be the simplest and most cost-effective solution, but it requires a comprehensive traffic study. If the road or part of the road is closed, traffic will be diverted, and adjustments/measures would be needed in other parts of the road network. One of the challenges would be also how to ensure access for all residents, emergency vehicles, vans ... As can be seen in the picture below, some adjustments would be necessary, but with a system of uni- and bidirectional roads, access to all buildings can be achieved.

The implementation of a pedestrian zone does not mean that the work is finished when the road is closed to motorized vehicles. The area must be redesigned so that it becomes a well-accepted VRUs-oriented zone (see chapter 4.4).

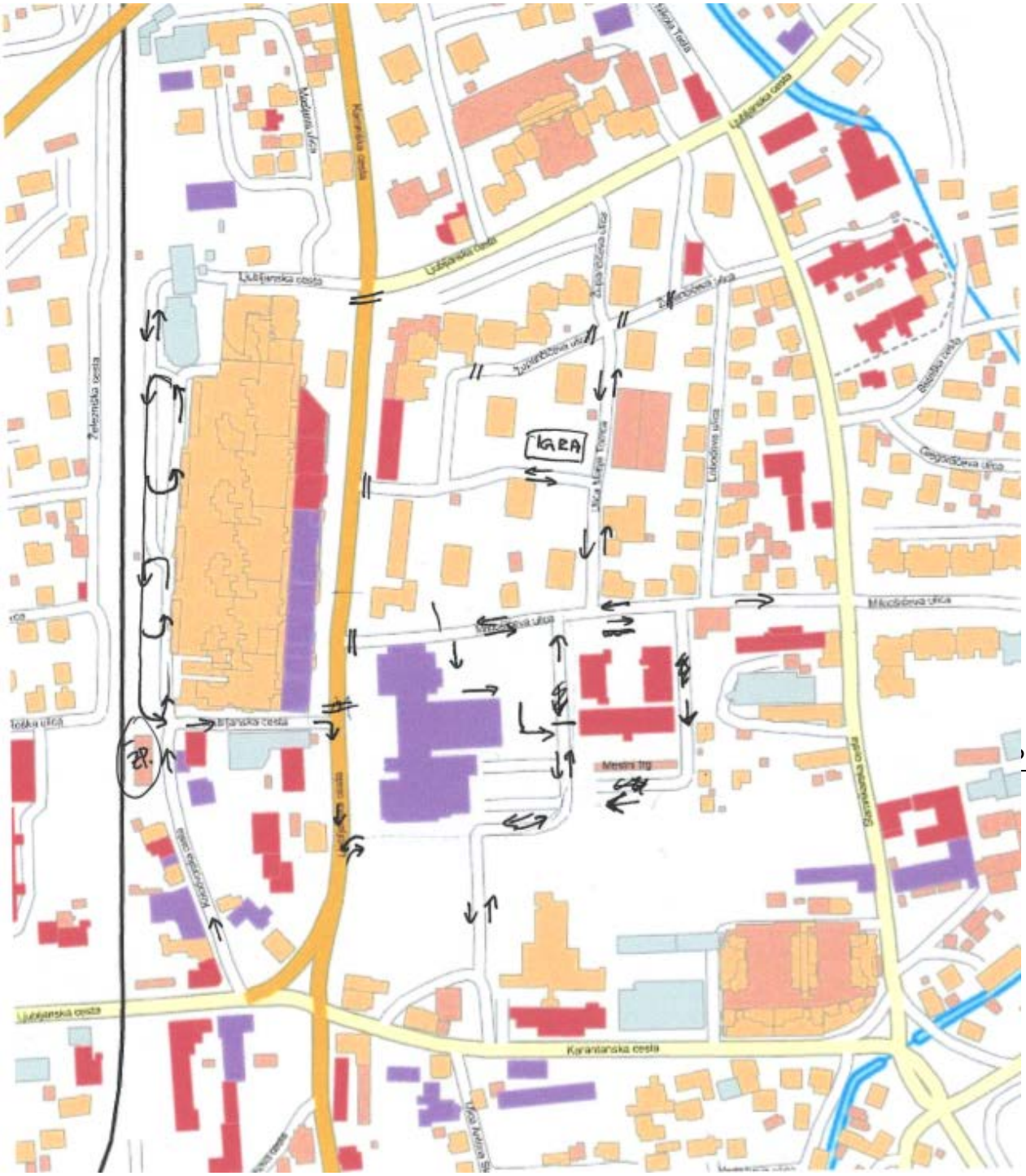


Figure 42 Accessibility study in Domžale if part of Ljubljanska cesta is closed for motorized traffic

4.5. *Recommendations for VRUs-orientated design*

Within the framework of RADAR pilot activities, several different variants were investigated at the Domžale site in order to achieve the main objective of the project, namely, to increase road safety for VRUs. At this location, it is important to give the highest priority to pedestrians and cyclists, but at the same time, motorized traffic must not be neglected.

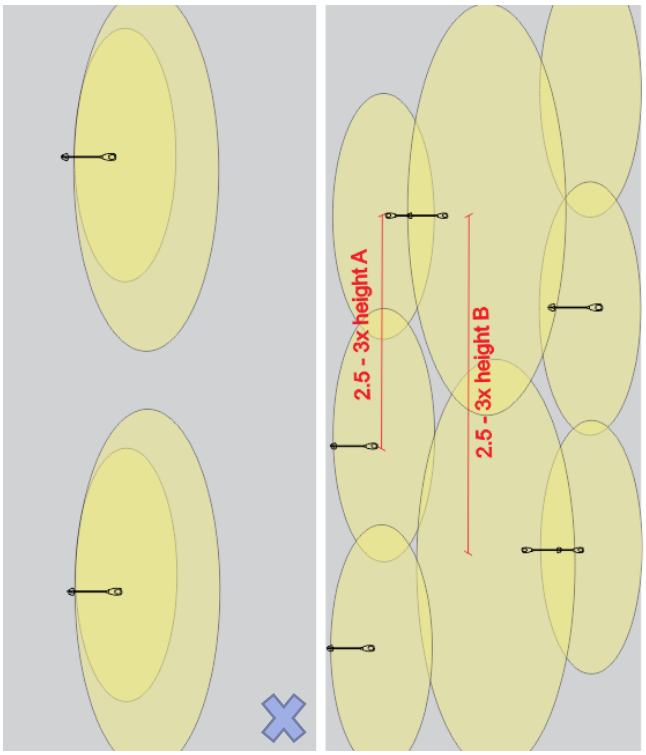
The Shared Space concept and prioritisation of public transport, walking and cycling should be designed with a lot of knowledge and sensibility because innovations as such can create (at least in the first months after the reconstruction) many unsafe and therefore dangerous situations, where proper urban planning can be a key factor for success, in order to turn a chaotic street into a city centre with character and charm, which is attractive for the citizens and at the same time increases safety for VRUs. With careful design, using the power of street furniture, planting, special paving, etc., the Ljubljanska cesta (the part in the city centre) can become the centre of social life with high social, environmental, and economic benefits. To this end, basic information/guidelines on proper street furniture and planting are discussed below.

Planting plays an important role in the design of pedestrian-oriented areas/streets, as plants create the desired microclimate and contribute to the psychological and visual comfort of the users. Trees and vegetation contribute to the cooling of the urban climate through shading and evapotranspiration. Planting materials should be selected to be visually interesting, support local ecology, require little or no irrigation or maintenance and make the experience more pleasant for pedestrians. Care should be taken to select plants whose growth does not create obstacles for pedestrians or damage the pavement (as may be the case with certain tree roots) and at the same time and should not be too low, so that even HGV drivers have a good view on pedestrians from some distance, bushes should be (kept at) less than 80 cm in height, so that children remain visible Trees can improve the aesthetics of street space by encouraging walking, increasing the chance of social encounters and providing health benefits. Trees soften the rough edges of urban structures, help to heal and satisfy the need to recognize seasonal differences. Trees can improve the local microclimate and reduce the "urban heat island effect", where air and surface temperatures in urban areas are much higher than in the surrounding rural or forest areas. Trees naturally clean the air by diluting and absorbing pollution and collecting airborne particles on their leaves. Trees also reduce carbon dioxide gas in the atmosphere by directly absorbing and producing oxygen gas. In addition, providing a pleasant road environment will encourage more walking, thereby reducing the number of car journeys and the pollution caused. Trees can provide seasonal shade for pedestrians, cyclists and motorists and reduce light reflection or glare from buildings and other surfaces. Trees help reduce extreme temperatures by trapping heat in winter and filtering heat and increasing humidity in summer. Trees are ideal for reducing wind speed on roads.

The next important measure in pedestrian-oriented roads is **lighting**, which should meet the requirements of the SIST EN 13201:2014 standard. It is important to ensure even distribution and illumination of lanes and pavements, considering the position of obstacles such as trees or billboards. There is a wide range of light sources that contribute to the overall lighting of public spaces. Well-designed solutions include different types of light sources such as conventional and decorative luminaires, pole-mounted luminaires, suspended overhead line luminaires, sign and advertising lighting. Borrowed light emitted from the shop window front or interiors of private homes, luminaires mounted on the outside of buildings such as hanging lights and façade lighting, and lights from cars can contribute to street lighting at certain times of the day. Borrowed light, however, is not always consistent, evenly distributed or designed for human comfort.

Low energy solutions such as Light Emitting Diodes (LED) minimize energy consumption and light pollution. LEDs have a long lifetime of 50,000-70,000 hours if not operated at high temperatures.

The standard height of light poles for sidewalks and bicycle lanes is 4.5-6 m, standard heights for narrow roads in residential, commercial, and historical contexts are between 8-10 m, and between 10 m and 12 m for wider roads in commercial or industrial areas. The distance between the light poles is typically 2.5 to 3 times the height of the luminaire. A single row of lighting columns may be sufficient for a narrow road, while wider roads may require several rows. Shorter light poles should be placed at closer distances. The density, driving speed and type of light source along a corridor also determine the ideal height and distance. The cone of light has approximately the same diameter as the height of the light from the ground.



Measure the width of the street and the height of the proposed light poles to determine the required spacing of light for even coverage. Light poles that are spaced too far apart result in dark areas that leave street users feeling unsafe.

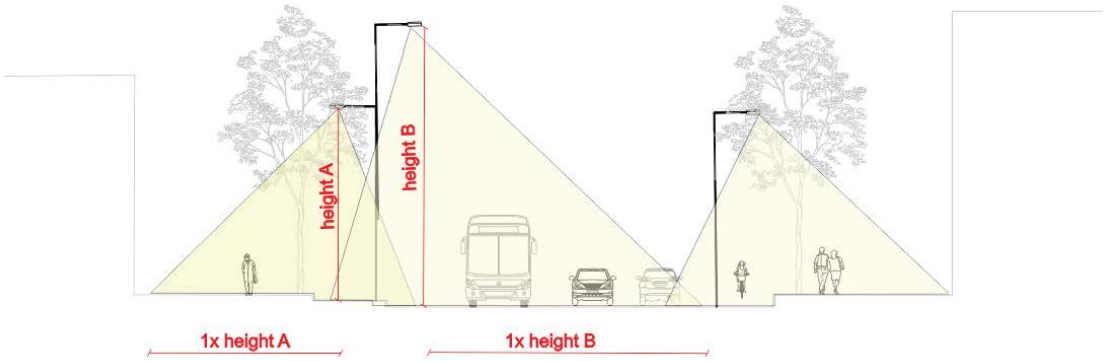


Figure 43 Dimensions and spacing of the light fixtures (source: Global Street Design Guide – Lightning Design Guidance)

Best practices suggest lighting columns with luminaires running parallel to the ground, also known as full-cut-off luminaires (a). If they are rotated slightly, the lights should be fully shielded (b). Avoid luminaires that are not properly shielded (c) and upright light poles (d) that emit light into the sky.

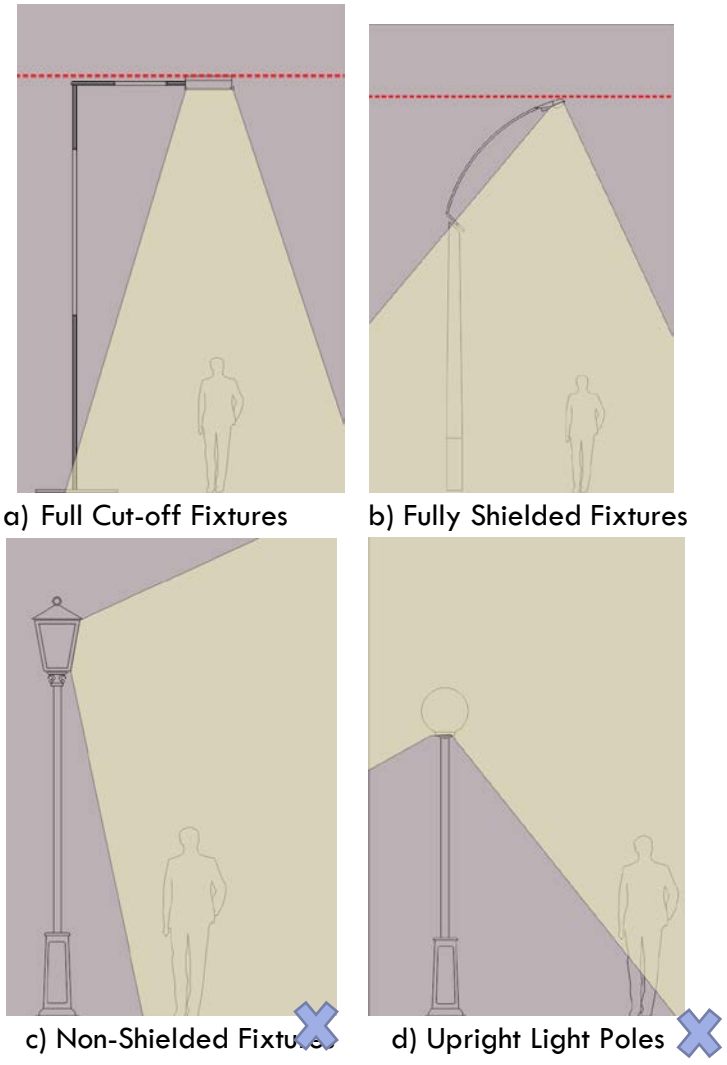


Figure 44 Light pollution[9]

The provision of **seating** and street furniture offers the opportunity to rest, to wait for transit or friends or to take a break on a journey. The placement of benches and seating furniture can also promote conviviality and provide opportunities to meet or chat with others.

To make sitting comfortable and accessible, seats should be 0.5 m high and have armrests and backrests at an angle of 10 to 15 degrees. Where possible, child-friendly elements and benches longer than 3 m should be installed to provide seating and encourage social interaction. It is important to meet the standards and needs of disabled people, so space should be provided for wheelchairs, pushchairs or nearby flexible seating that can be raised alongside the fixed seats.

Ideally, seating should be installed every 50 to 100 meters along a road, providing a mix of seating in both sun and shade, considering the proximity of major destinations, playgrounds, and street corners.

It is important to ensure that seating and legroom do not obstruct the path, are not too close to the road and are well lit.

[9] Source: Global Street Design Guide – Lightning Design Guidance

Seating and other street furniture should be designed and manufactured from materials that are easy to maintain or repair and adapt to the local climate; consideration should be given to water drainage, wear and tear and metal temperatures in very hot or cold climates.

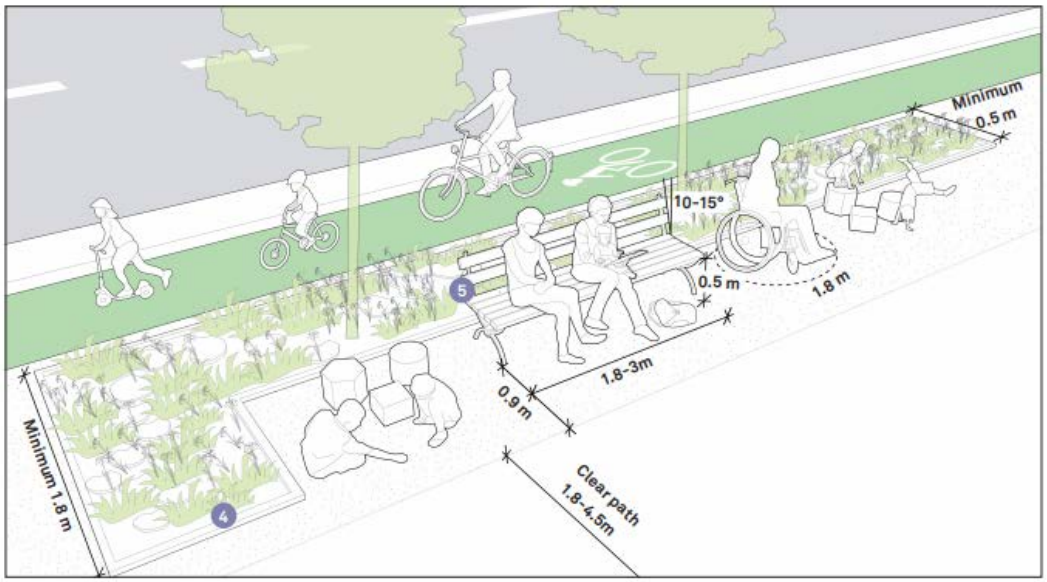


Figure 45 Dimensions and spacing of the sitting[10]

[10] Source: Designing Streets for Kids

4.6. *Key safety improvements for VRUs at the location Domžale*

- to increase road safety 4 variants of separation of motorized and non-motorized traffic are considered: tunnel; Shared Space concept; Prioritisation of public transport, walking and cycling; pedestrian zone.
  - tunnel is not feasible due to the needed clearance for vehicles;
  - pedestrian zone on the main road is not allowed, therefore the road should be re-categorized and detailed study of the pedestrian zone on the surrounding should be conducted;
  - Shared Space concept is a novelty and (at least in first weeks/months) from the implementation might have a negative impact on road safety, but later, when people get used to it, might be very beneficiary for the city Domžale and citizens;
  - Prioritisation of public transport, walking and cycling where left-turning lanes are not necessary the existing road width can be used for cycling infrastructure.
- in all variants, on-street parking is not foreseen since the main goal is to make the city centre comfortable and walkable for the VRUs and in the vicinity sufficient number of parking places already exists.

5. Gabrovka – providing infrastructure for VRUs

5.1. *Location description*

The third location is a small village Gabrovka near Litija, about 45 km southeast of Ljubljana. There is a very limited area around the local primary school, which is almost surrounded by the state road R2-417, section 4326 Moravče-Mirna, that connects towns of Šmartno pri Litiji and Mirna, with AADT < 1,000 (see figure 14).

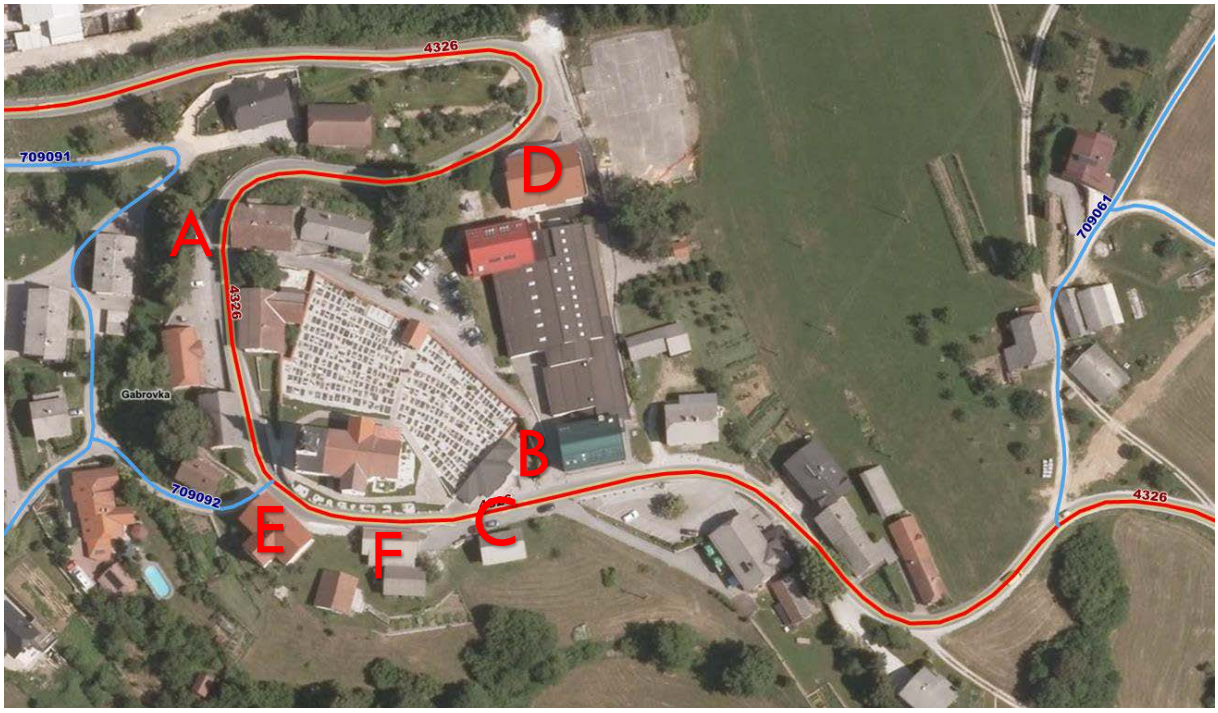


Figure 46 Overview of location 3 – Gabrovka

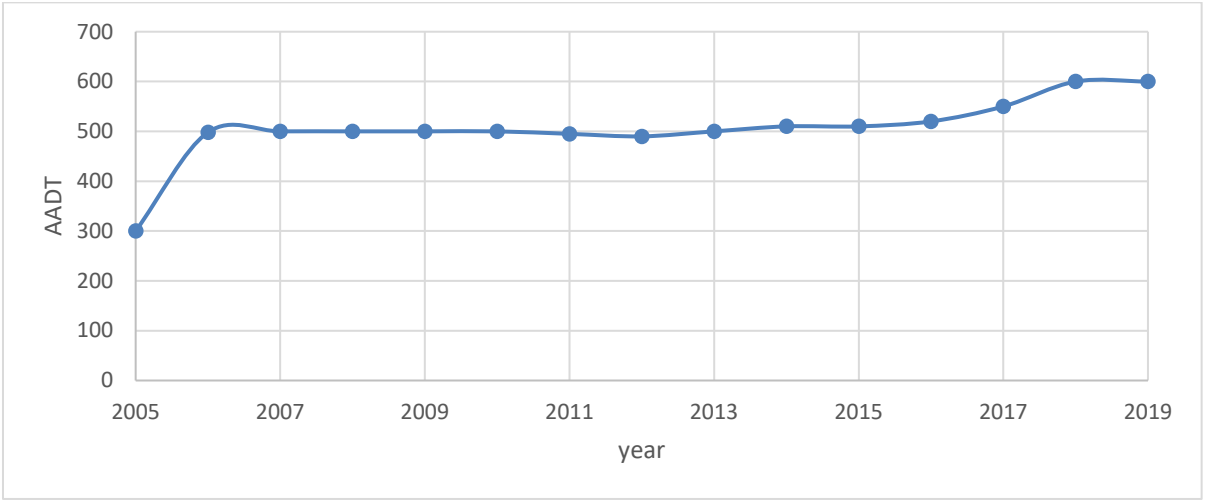


Figure 47 Average daily traffic in Gabrovka, road R2-417, section 4326

The focus is on the span of the road that is curving through the village centre. Gabrovka is located on a small hilltop and historically built around the church and cemetery. In the course of time, the winding path became a road. As the size and flow of vehicles increased, it became too narrow to adequately serve all road users. Today there are no provisions for pedestrians or cyclists, although there are a primary school and kindergarten in the immediate vicinity. The speed limit in the entire village is 40 km/h, and because of the narrow design, the actual driving speeds do not exceed it.

Although the road is very narrow, it is used by numerous trucks and delivery vans. According to latest available counting data from 2019, HGV represent approx. 5% of all vehicle and delivery vans approx. 7%. In the morning peak hour, when the road around the school is busiest, they are even more numerous.

Before classes begin, in the morning peak hour, children are either driven there by their parents by car, or they come by an organised bus or van, depending on their route. Some of the children also come on foot, as the town is cosy enough. The school car park offers a relatively safe drop-off point for children brought by car. The car park is accessible from two sides via an uncategorised driveway, which is extremely narrow and does not provide enough space to meet another car with also challenging vertical alignment.

Figure 48 Truck near the school, occupying the road

Visibility is an additional problem on the driveway's both, western (A) and southern (B) links to the main road. On the western link, the buildings block the view of drivers trying to drive onto the main road. On the southern link, there is the school building on the left and some cypress trees on the right, blocking the view of drivers trying to join the main road.

Due to this configuration, two drop off points were set up on the main road. The first one is located on the opposite side of the street on the south side of the school. The unmarked parking area (C) can accommodate 4 vehicles at the same time. From there, the children have to cross the main road and enter the school grounds in the same area as the cars using the south connection.

Figure 49 Parking along the road

The second drop off point is more formal but is overburdened. It is located on the north side of the school, next to the kindergarten (D). The main road here is in a very sharp curve, and a manipulation area for buses, vans and cars is only a wide gravel-covered outer bank of the road. A pedestrian fence has been installed to give the children a sign and protection when they walk from the bus along the road to the school. The bus or van stops at the side of the road, while the cars tend to do so everywhere in all possible directions. This creates disorder but is strongly tolerated and everyone seems at peace with it. The situation in a sharp curve is a plus point here because the speeds are low, but the risk of a collision still exists.

After classes, a considerable number of children take part in catechesis in the presbytery (E) located opposite to the church. To access the presbytery from the school area one has to cross the road and walk along the street for about 80 metres. Since there are no provisions for pedestrians they must walk along the main road. The place where there is a building (F) on the south side of the road in their path is the narrowest point along the road through the town and therefore represents an even higher risk for pedestrians to be hit by a vehicle.

To preserve the historical appearance of the town configuration, a bypass road north of the school is being considered. A new road would carry transit traffic and reduce potentially dangerous situations with VRUs.

The Star Rating Score was calculated using the iRAP Demonstrator: the existing configuration received a score of SRS 65.14 with 2 stars for pedestrians and SRS 44.68 with 2 stars for cyclists. If pedestrians were provided with a sidewalk and a marked intersection in front of the school, combined with an effective speed limit of 30 km/h, this would result in SRS 7.40 with very firm 4 stars for pedestrians and SRS 10.25 with again very firm 3 stars for cyclists, which is a huge improvement. The change in the safety level can be even greater if the bypass is implemented, as it further reduces the number of transit vehicles.

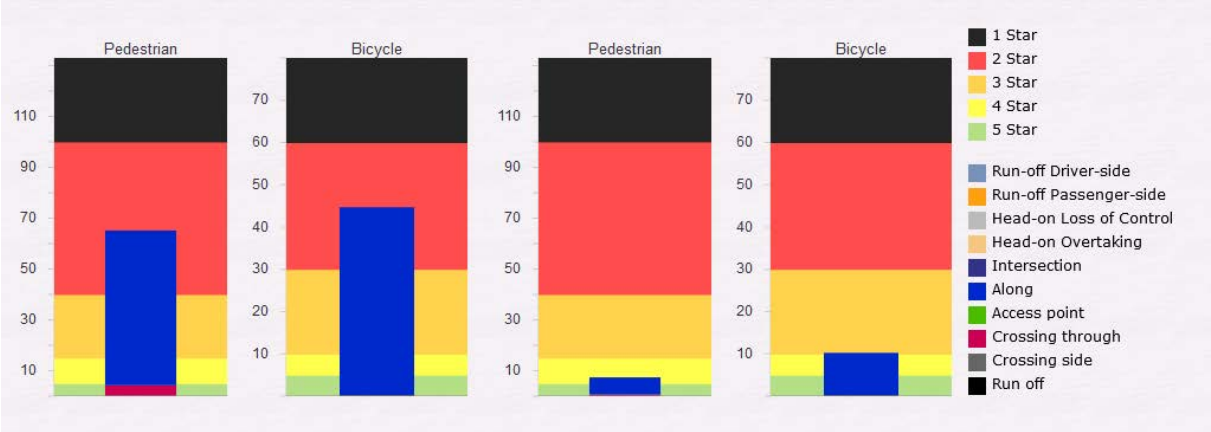


Figure 50 Risk charts for pedestrian and cyclist safety at Gabrovka. Existing (left) and after treatment (right).

Key safety problems detected at the location Gabrovka:

- no provisions for pedestrians or cyclists;
- absence of proper and safe (school) bus stop;
- narrow and winding road;
- no alternative road for the transit.

5.2. *Current situation*

Location

Municipality Litija

Regional road R2-417, Moravče-Tihaboj-Mirna

GPS: 46.00000, 14.98773

Schools often serve as the focal point of the community and provide open spaces, playgrounds, and meeting places for community events. As such, due consideration should be given to their location and their connection to the community. Wherever possible, schools should be easily accessible - for pedestrians, cyclists, and vehicles. Their location should physically reflect their role as community centres and be within 1.5 km of the pupils being served. Sidewalks and cycle paths should be connected to the school and effective traffic control facilities & measures should be available in the vicinity.

The challenging topography in Gabrovka dictates the development of the rural area. The kindergarten, primary school and church with the cemetery are in the immediate vicinity and form the centre of the traffic jams in the morning hours during services and funerals. Unfortunately, the streets and neighbourhoods around the school lack the most basic pedestrian facilities (no pavement, no traffic calming measures, poor visibility), so that parents feel obliged to drive their children to school by car even if the distances are short.

This, in fact, creates a vicious circle where the school generates a high volume of traffic, which only makes the pedestrian environment less safe and forces more parents to drive.

Main safety challenges in Gabrovka are marked in the figure below and are reinforced with the morning peak hour images.

Figure 51 Entrance to the school parking place – poor sight distance on the right-hand side at Location 1

Figure 52 Absence of pedestrian infrastructure on the way to the church and school at Location 2

Figure 53 Intersection - poor sight distance on both sides at Location 3

Figure 54 Absence of proper bus stop at Location 4

Figure 55 Vehicle/vehicle and vehicle/pedestrian conflict at Location 4

5.3. *Safe VRUs infrastructure general requirements*

Children cannot be considered as "small adults". They are more vulnerable, their movements are more unpredictable, and their judgement of distance and speed is not yet well developed. Special care is therefore essential to create a safe environment for children, and nowhere is this more necessary than in school zones. Senior citizens have similar concerns about pedestrian safety. Although they have more experience of crossing roads etc., many of them have lower walking speeds and impaired vision, which must be considered when designing pedestrian crossings. Older people and school children are less able to assess appropriate traffic gaps due to developmental and visual impairments. Young children have a typical eye height of only one meter and their peripheral vision is not yet developed, their movements are less predictable and less easily seen by drivers, they have shorter attention spans and are more impatient when crossing pedestrian crossings. Since children do not drive motor vehicles, they lack understanding of a driver's intentions at a crossroads or intersection, and at the same time, adults often overestimate the child's ability to deal with traffic.

General recommendations and applicable guidelines that should be applied when planning/establishing safe routes for VRUs (Planning and designing for pedestrians):[11] [12]

1. At bus stops, there must be a sufficient area away from the road to allow a group of children to gather and wait;
2. intersections along school routes should achieve maximum visibility by providing an unobstructed field of vision between motorized traffic and pedestrians;
3. all the following traffic control techniques should be considered:
   - reduced speed zones,
   - traffic calming techniques,
   - marked zebra crossings,
   - intersection guards and student escorted crossings,
   - signalized intersections with pedestrian activators,
   - islands of refuge for pedestrians at intersections,
   - technological devices at signalized intersections, such as countdown pedestrian signals, audible signals and passive pedestrian detectors should be used close to senior citizens' or school activities where appropriate,
   - special zebra crossings - "School Crossing", "Senior Crossing".
4. The following elements should be considered when designing a school area:
   - the buildings are accessible to pedestrians from all sides;
   - safe bicycle parking is located near the building entrances;
   - bus drop-off zones are separated from car drop-off zones to minimize conflict;
   - pedestrian routes, pavements and paths are separated from other means of transport.
5. There should be sufficient waiting space at school bus stops and crossings of the road.
6. Accessibility for all should be achieved by removing barriers for disabled people:
   - as regards young children, cars parked near road junctions may be a danger to wheelchair users.
   - the accessibility needs of disabled young children, which may not be compatible with the needs of disabled adults, should be taken into account. For example, pedestrian buttons may be too high for children in wheelchairs.

[11] Technical specifications: https://www.gov.si/assets/organi-v-sestavi/DRSI/Dokumenti-DRSI/Tehnicne-specifikacije/TSC_02_401_2010_Oznacbe_na_voziscu_Oblika_in_mere.pdf

[12] Rules on road design: http://www.pisrs.si/Pis.web/pregledPredpisa?id=PRAV5811

5.4. *VRUs infrastructure in Gabrovka*

Pedestrian networks must be safe, comfortable, and enjoyable. Compared to other users, pedestrians cover less ground in the same amount of time and experience the street the most intensely. Unfortunately, there is no pedestrian infrastructure in Gabrovka, not even sidewalks and consequently no pedestrian crossing. Moving without the protection of an enclosed vehicle, pedestrians engage all senses and are the most vulnerable users. At least at the location of the main point of interest in the Gabrovka (school, daycare, library, presbytery) the pedestrian infrastructure should be connected & permeable, accessible & comfortable, safe, and relevant to context (Global Street Design Guide – Pedestrian networks).
Connected: To be useful, sidewalks and pedestrian crossings must offer a continuous clear path. Even short stretches of sidewalk that are unpaved, uneven, obstructed, or that end abruptly disincentivizes walking and creates serious barriers for wheelchair users.

Permeable: pedestrian links should be created in order to shorten walking routes when possible. Paths and streets that end in cul-de-sacs should be extended to connect to nearby streets.

Accessibility: All streets should be universally accessible, accommodate different walking speeds, and be legible for all users. Pay particular attention to the needs of children, the elderly, and people with disabilities.

Capacity and Comfort: Ensure that sidewalk networks, hierarchy, and width relate to their context. Sidewalks should not require people to walk in single file, but allow pairs and groups to comfortably walk past each other. Downtown areas need wide sidewalks and clear paths for higher pedestrian volumes at peak periods. Neighbourhood streets should allow space for outdoor uses and commercial activities, while residential streets with narrower clear paths should include additional landscaping.

Safe: Pedestrian spaces must be safe for all users at different times of the day. They should be well-lit, provide accessible slopes and gradients, be free of obstructions, and offer eyes on the street for natural surveillance and crime prevention. Intersections are critical nodes in a network in which pedestrians are exposed to the highest risk of fatality and injury. Provide visible, clear, short, and direct crossings at intersections. Install curb extensions and refuge islands to shorten crossing distance and provide protected areas for pedestrians waiting to cross. Crossings should always be marked, and when possible raised, for increased safety.
Relevant to Context: Design facades and edges of buildings or spaces that define the pedestrian network to be engaging and interesting. Support varied building heights, architectural details, signage, entrance spacing, transparency levels, and landscaping to break down the scale and rhythm of the block and make walking distances feel shorter. Include a variety of shading and lighting devices on building facades to provide a comfortable walk.

Sidewalks by separation from moving traffic provide adequate buffer space and a sense of safety for pedestrians, and as such are among the main elements of safe routes to school. In Gabrovka there is no sidewalk, so the safety of children should be addressed first by designing a sidewalk.

The sidewalk is necessary at least from the school to a staircase in the southern part, which also crosses other two important places of interests, namely the presbytery and the library, and from the school to the residential house in the east. The total length of the proposed sidewalk is 450 m.

While rural roads require less capacity than busy city centres, sidewalks must always maintain a comfortable and accessible clear path. Particularly on safe routes to school, the design of the sidewalks should go beyond the minimum both in width and in amenities. Unfortunately, in Gabrovka, due to the existing urbanism and due to terrain elevation in the proposed solution a one-sided, bidirectional sidewalk with minimum width is foreseen (according to national legislation, the minimum width of the sidewalk in an urban area is 1.20 m).

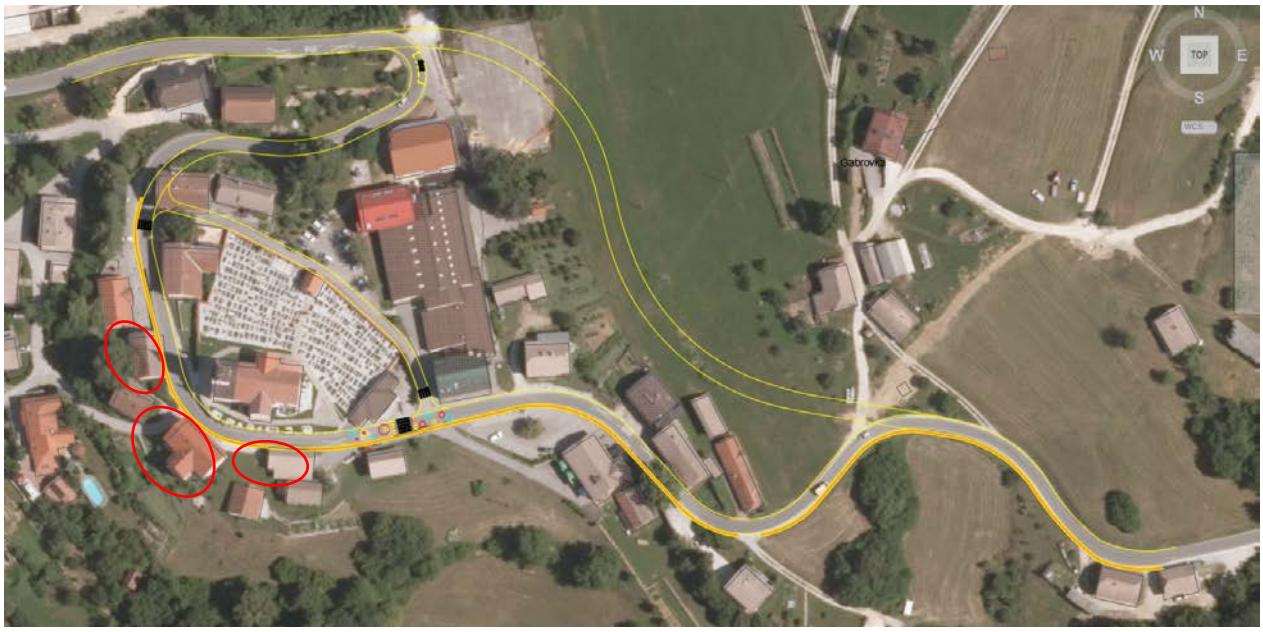


Figure 56 Proposed alignment of sidewalk in Gabrovka (1.20 m width, 450 m long)

In the marked area, the houses are located next to the road (see pictures below), therefore it is a challenge to design/build a sidewalk.

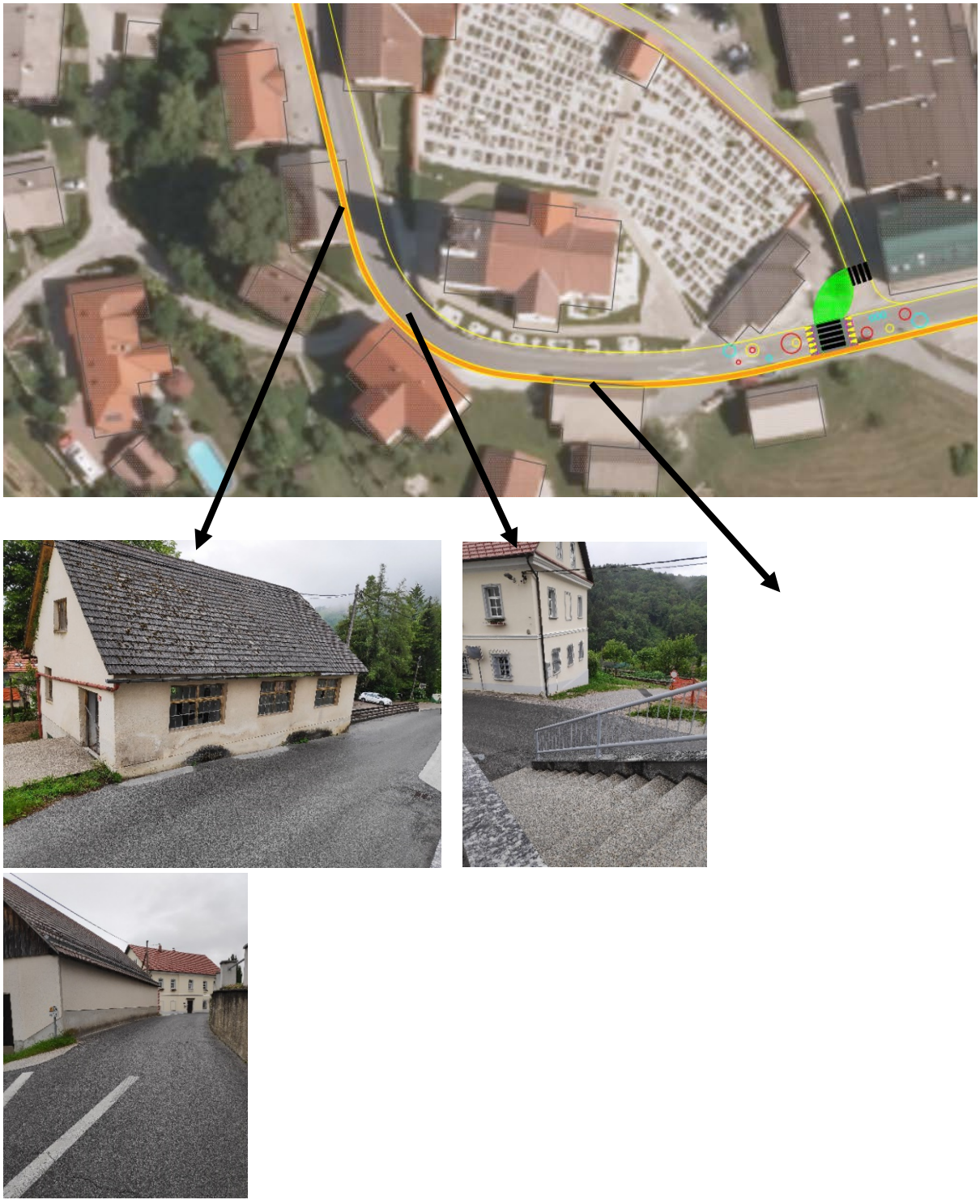


Figure 57 Narrow section of the road in Gabrovka

The house on the left (see first picture above) is planned to be demolished, to make a room for the safe and comfortable sidewalk.

At the location (opposite) of the other two buildings there already exists a walking path next to the church (see picture below).

Figure 58 Walking path next to the church

However, the existing walking path is actually the entrance to the cemetery and as such not suitable for the general public use. At the same time, it is not comfortable (pedestrians have to use stairs) and the requirements and needs of people with disabilities are not met. Therefore, a new solution should be found. Based on the national legislation, as a temporary solution, marking the pedestrian lane on the road is allowed on the roads with low traffic volume.

The pedestrian lane is not delineated from the motorized traffic, but the pedestrian and vehicle zones are visually separated by using blue colour and white continuous line as shown in the figure below.

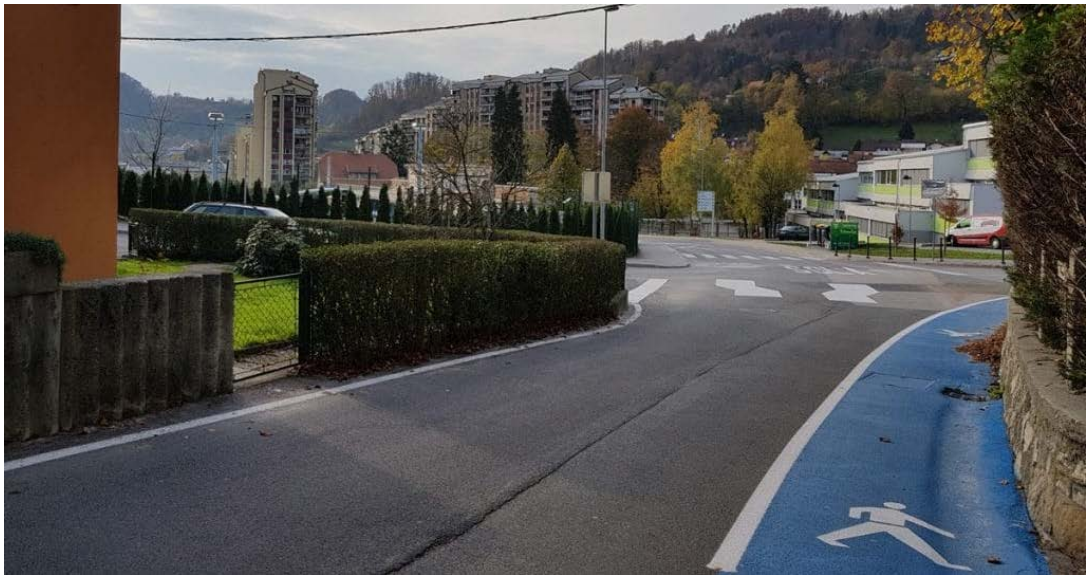


Figure 59 Walking line on one-way street in Trbovlje[13]

We would advise against this solution on the safe route to school, therefore a new road in the northern part of Gabrovka is proposed. The new road would take over the majority of the traffic on the existing road, and the existing road would be used primarily for access to the school, church, and residents. The new road would make it possible to narrow the existing road and its transformation into a one-way road would create conditions for the installation of sidewalk.

*New sidewalks (pedestrian infrastructure in general) should also be designed to be **accessible to the disabled**, so pedestrian ramps and detectable surfaces (tactile markings) should be implemented. Pedestrian ramps are inclined planes facilitating the access of sidewalks for people using wheelchairs and other personal mobility devices, as well as those pushing strollers, or heavy luggage, while tactile paving provides a distinctive texture intended to have a uniform meaning in alerting people with visual impairments to the approach of conflict zones.*

Reaching points of interest in Gabrovka often implies crossing the road, so **pedestrian crossings** should also be designed. Safe and frequent pedestrian crossings support a walkable environment. The design of pedestrian crossings has the potential to influence the behaviour of pedestrians and at the same time guide people to the safest way and is therefore an important element of a safe route to school. Pedestrian crossing should be installed where there are significant pedestrian desire lines, so it is important to know the pedestrian movements. Based on the observations made for this project, three crossings are proposed, all of which are located at three-legged junctions (see picture below).

[13] Source: https://www.zon.si/ne-gre-za-trboveljski-unikum/

Figure 60 Locations of proposed crossings (with blue line pedestrian flow is presented)

Pedestrian crossings can be located at an intersection or mid-block. It should be noted that a pedestrian crossing at the mid-block is not feasible due to the one-sided sidewalk, although in urban areas a pedestrian crossing should be provided every 80-100 m.

The pedestrian crossing should always be marked, regardless of the paving pattern or material. Highly visible zebra markings are preferable to parallel or dashed pavement markings, as zebra markings are more visible to approaching vehicles and have been shown to improve yielding behaviour by drivers. In addition to zebra markings in the vicinity of schools, experimental marking is proposed based on national Slovenian Guidelines for the installation and implementation of urban equipment and architectural design of traffic areas to improve road safety for children - school children. Examples of experimental markings near the school are shown in the following pictures.

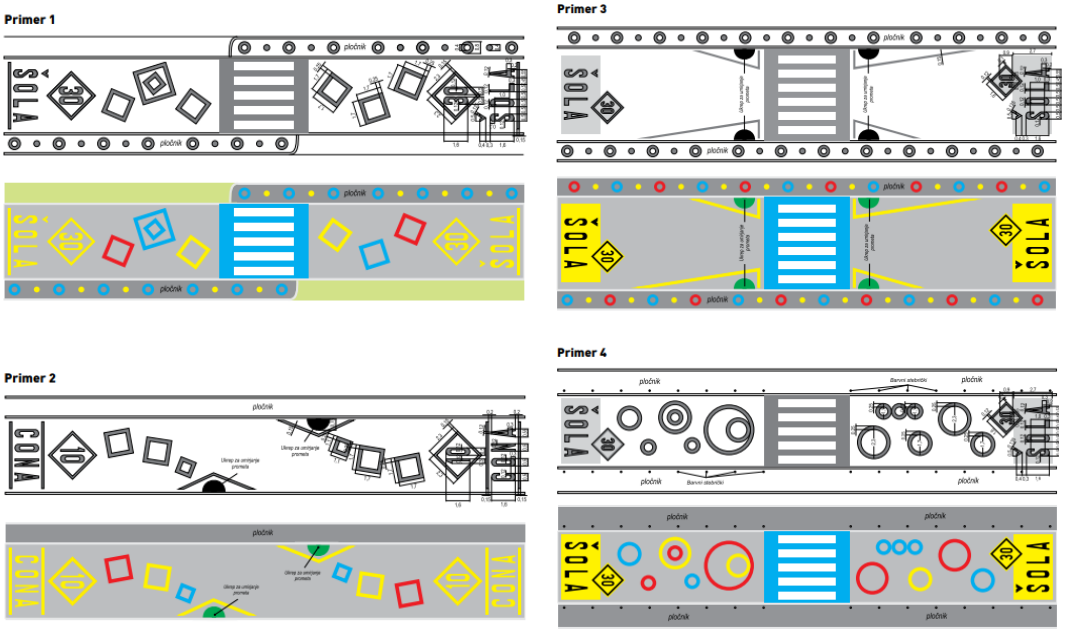


Figure 61: Contemporary road markings in the vicinity of schools according to the national guidelines[14]

[14] Source: Safer school path

The guidelines determine the pattern, colours and size of the markings. Note that coloured markings are suggested not only on the road but also on the sidewalk to enhance the safe behaviour of children.

Non-signalized crossings are generally safe on roads with low traffic volumes, and speeds below 30 km/h. Non-signalized crossings at intersections and mid-block can be raised by extending the level of the sidewalk across the street. This helps to calm traffic, improve accessibility and increase visibility between drivers and pedestrians, and it is therefore proposed to raise the level of the crossing next to the school.

A pedestrian crossing should be at least as wide as the sidewalks to which it is connected and not less than 3 m wide. The pedestrian crossings designed in Gabrovka are 3 m and 4 m wide, as shown in the figure below.

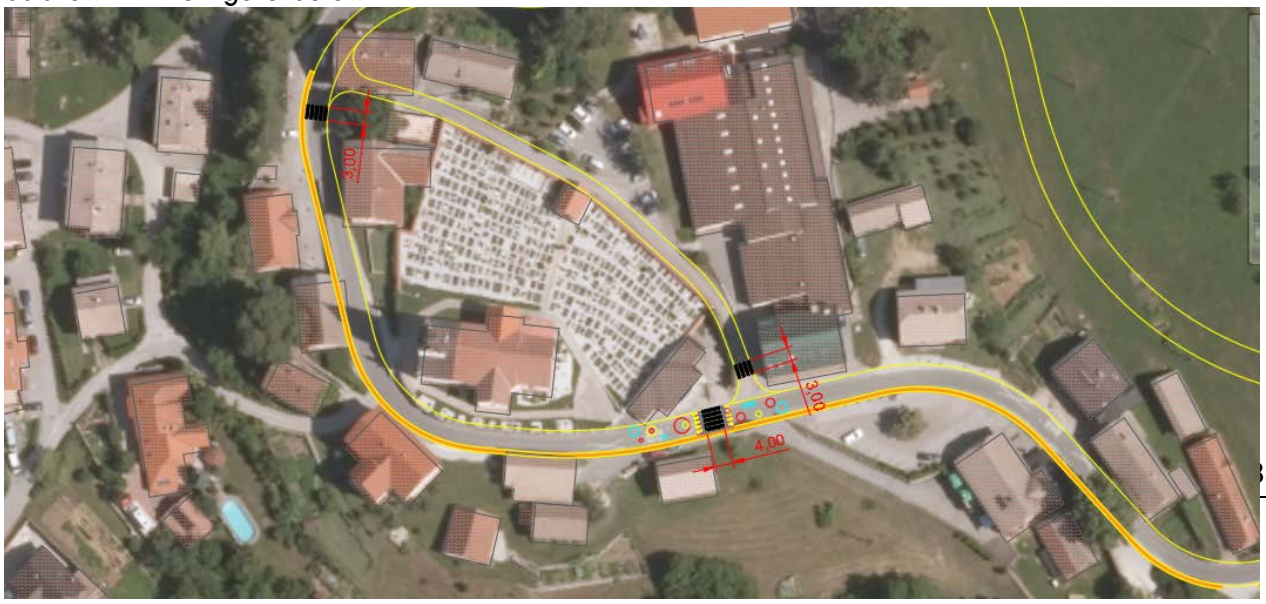


Figure 62: Dimensions of the proposed pedestrian crossings in Gabrovka

Adequate waiting areas for pedestrians with adequate lightning should be provided at the location of non-signalized crossings to see oncoming traffic, and at the same time sight distances at horizontal curves should be assured.

At the north-western location of the proposed crossing, the sight distance is poor as it can be seen from the pictures below.

Figure 63: Poor sight distance

The house next to the »STOP« traffic sign is planned to be demolished which will enable to reconstruct the road alignment in this section and assure adequate sight distance.

Figure 64: New horizontal road alignment

At the other location, the sight distance is adequate, but there is no waiting area for pedestrians.

Figure 65: Existing situation – no waiting area for the pedestrians

We propose to cut a few trees and evening of the levels to creat safe waiting place for the pedestrians (mainly schoolchildren). Two parking places in front of graveyard should be cancelled.

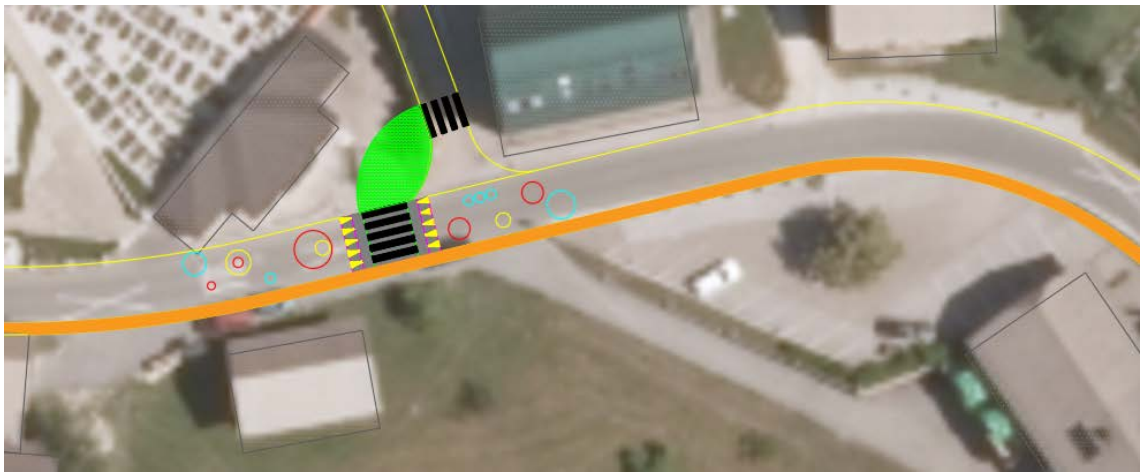


Figure 66: Waiting area at the pedestrian crossing

The width of the side road next to the school is very narrow and as it can be seen from the picture below.

Figure 67: Narrow side road

Within the RADAR project we have investigated the possibilities of closing or partially closing this road, as the access to the house should be guaranteed, but this would not solve the problem of the required road width for two-way traffic. For this purpose we propose to change the traffic regime on this road to one-way traffic, as shown in the picture below. Poor horizontal elements of the road in combination with the poor sight distances would most likely prevent speeding; if not, speed-reducing measures e.g. speed humbs should be considered.

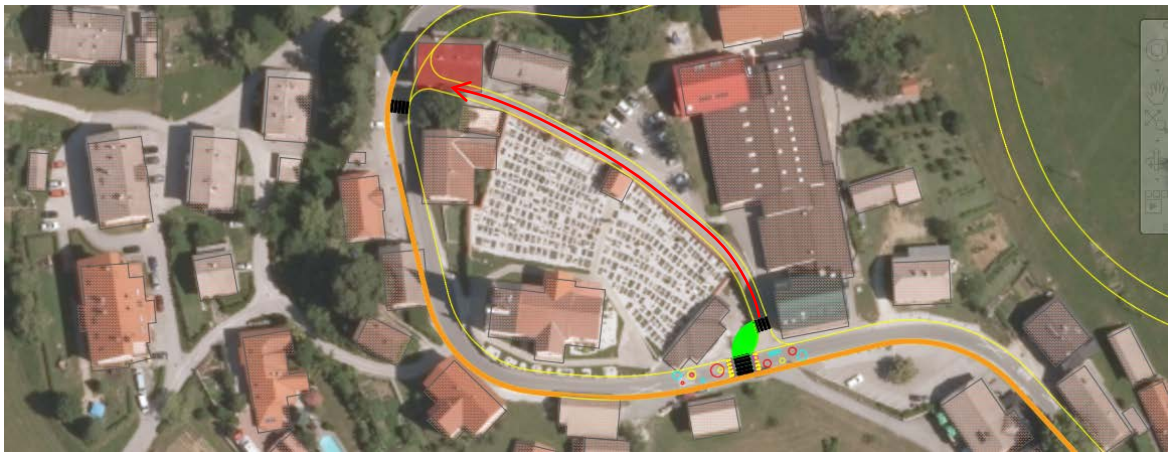


Figure 68: Proposed traffic regime on the side road

Road safety in Gabrovka would be greatly improved by a new road that bypasses the school path and takes over transit traffic. The idea of the proposed alignment of the new road is shown in the following figure.

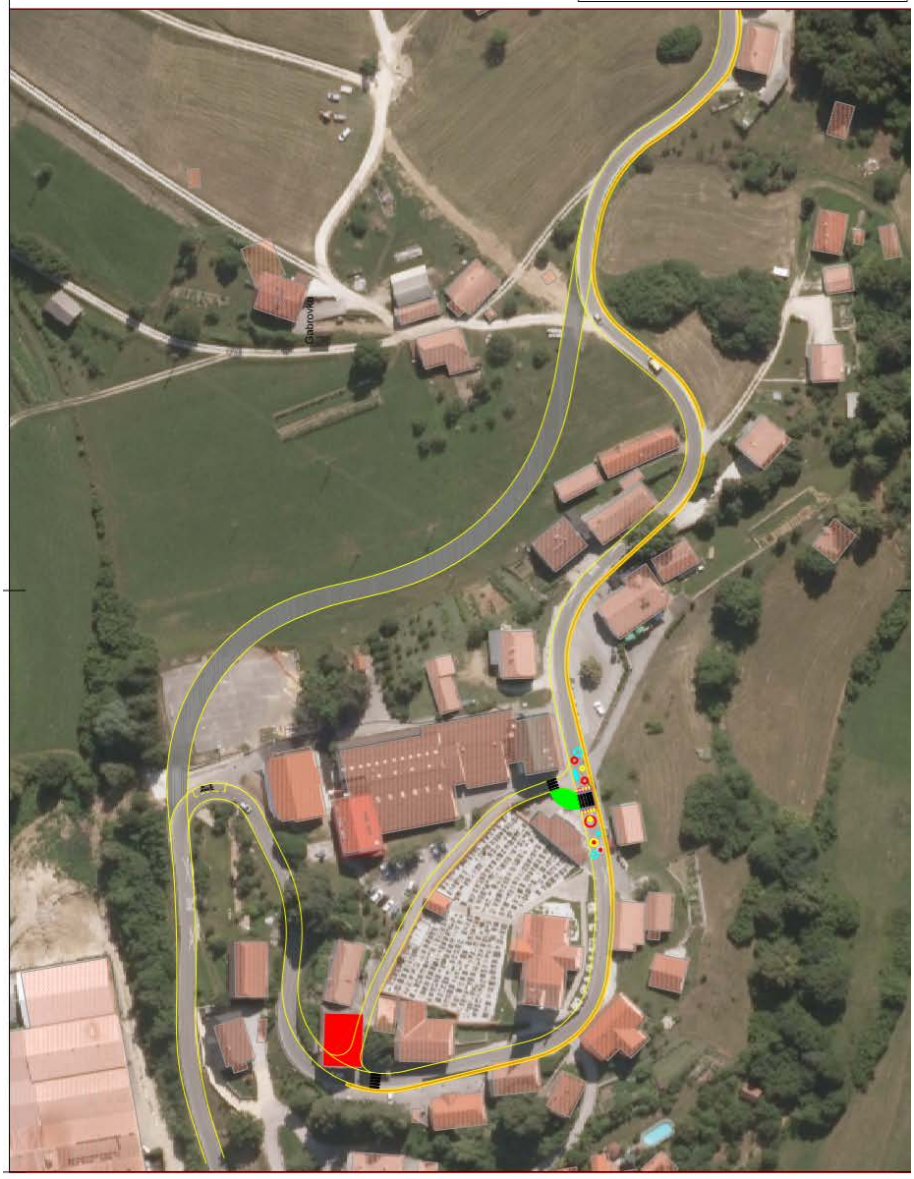
Figure 69: Proposed new (bypass) road in Gabrovka

5.5. *Key safety improvements for VRUs at the location Gabrovka*

- Sidewalk in total length of 450 m connecting two pedestrian crossings, one marked also with the experimental road marking emphasizing the vicinity of school and VRUs presence;
- Demolition of a house to ensure better road alignment and adequate sight distance;
- New (bypass) road to deviate the transit traffic.

GABROVKA

Layout



Interreg
Danube Transnational Programme
RADAR

work package:
WP5

thematic area:
AT2 Vulnerable road users

pilot location:
GABROVKA

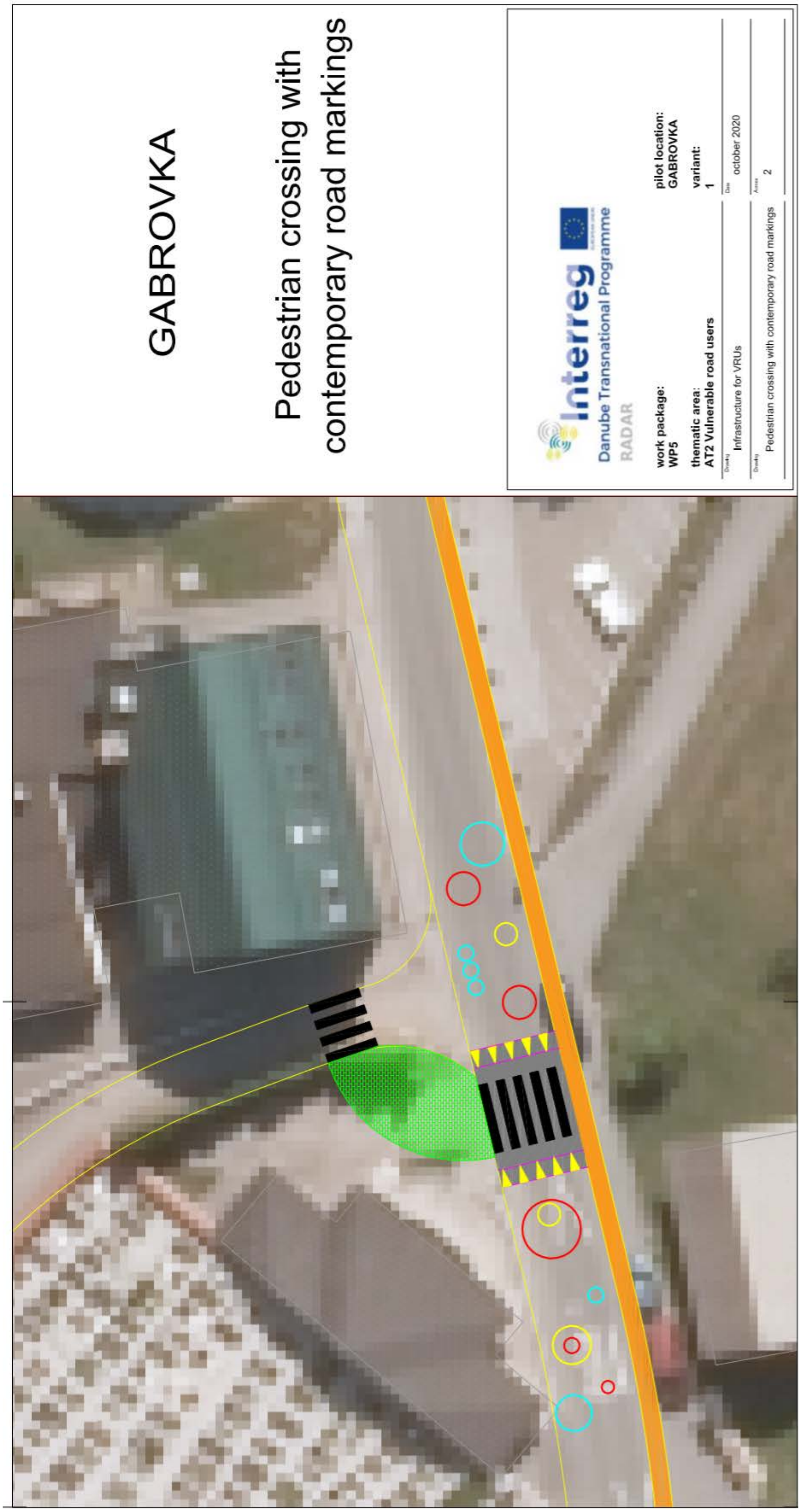
variant:
1

Date: october 2020

Drawing: Infrastructure for VRUs

Drawing: Gabrovka - Layout

Annex: 1


GABROVKA
Pedestrian crossing with contemporary road markings
Interreg
Danube Transnational Programme
RADAR
work package:
WP5
thematic area:
AT2 Vulnerable road users
pilot location:
GABROVKA
variant:
1
Infrastructure for VRUs
october 2020
Pedestrian crossing with contemporary road markings
2


GABROVKA
Road deviation
&
pedestrian crossing
work package:
WP5
thematic area:
AT2 Vulnerable road users
Infrastructure for VRUs
Road deviation, pedestrian crossing
pilot location:
GABROVKA
variant:
1
october 2020
3

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