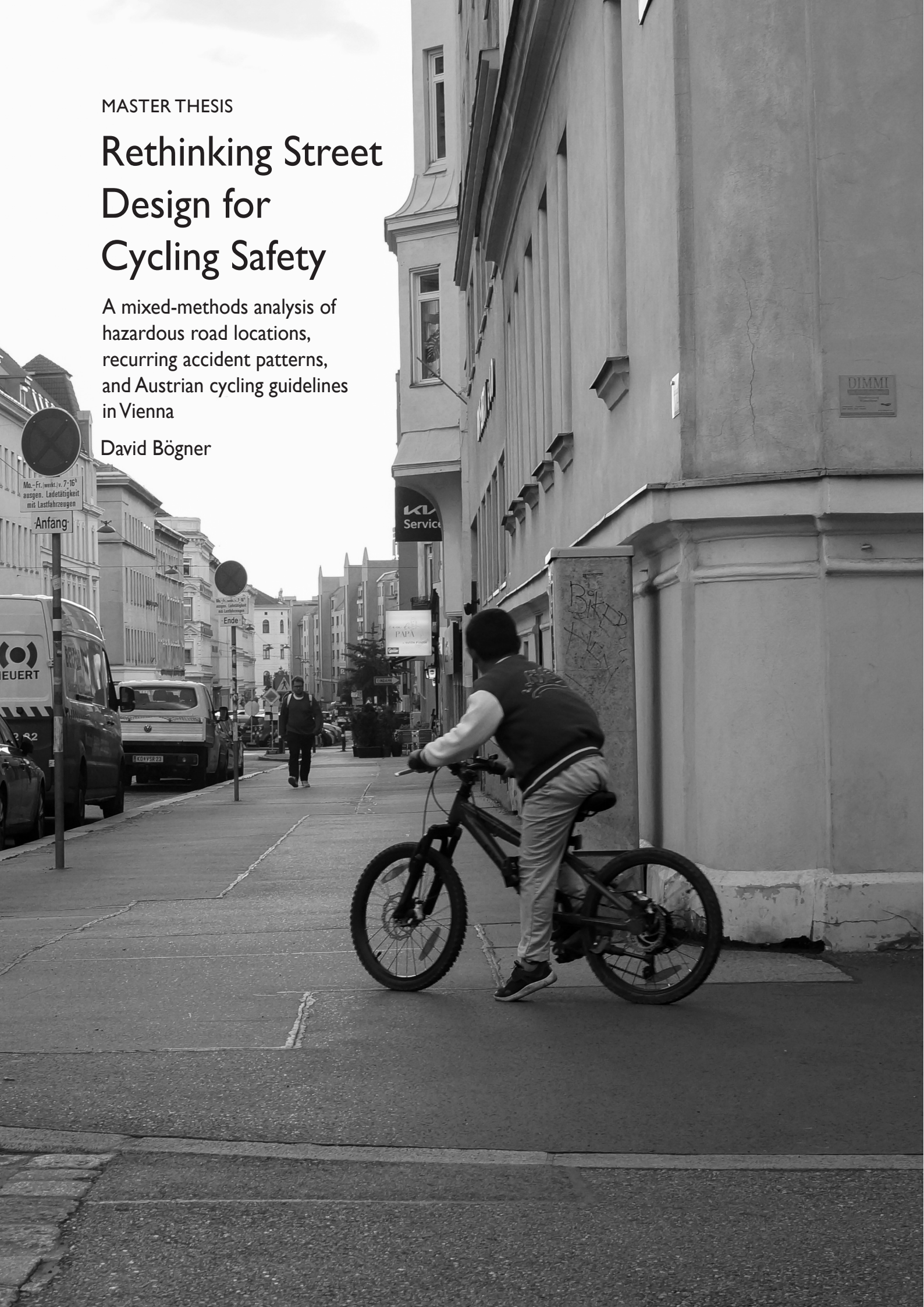
MASTER THESIS

Rethinking Street Design for Cycling Safety

A mixed-methods analysis of hazardous road locations, recurring accident patterns, and Austrian cycling guidelines in Vienna

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Master Thesis

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Abstract

Cycling is increasingly promoted as a mode of active mobility, especially in urban areas, because it supports climate, health, and liveability goals. In Austria, this promotion has been successful, with cycling increasing significantly in recent years. However, cyclist safety has not improved at the same pace. While most other modes of transport have become safer, the number of accidents involving cyclists has increased by 81 percent over the last twelve years. This suggests that factors contributing to cyclist accidents are still not sufficiently understood, especially regarding street infrastructure and its design.

This thesis examines this problem through hazardous road locations in Vienna. It asks how street characteristics at these locations influence cyclist safety and what this implies for the further development of Austrian cycling guidelines. A sequential mixed-methods design was used, combining Getis-Ord Gi* hot spot analysis of police-reported cyclist accident data from 2022 to 2024 with a qualitative analysis of selected locations. The quantitative analysis identified 91 hazardous road locations, of which 13 were selected as representative cases for different accident groups and assessed against the current RVS Bicycle Traffic.

The results show that many hazardous road locations have recurring accident patterns. These patterns were often connected to intersections, street layout and space allocation, public transport-related conflict points, and visibility conditions. The thesis shows that the RVS already provides a strong basis for safe cycling infrastructure, but that some criteria need to become clearer, more measurable, and more binding to better address recurring cyclist accident patterns.

Keywords

cycling safety; street design; hazardous road locations; recurring accident patterns; hot spot analysis; cycling infrastructure guidelines; Vienna

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List of abbreviations

ADT	Average Daily Traffic
FGC	Focus Group Cluster
FSV	Forschungsgesellschaft Straße – Schiene – Verkehr (Austrian Research Association for Roads, Railways and Transport)
GIS	Geographical Information System
HRL	Hazardous Road Location
KFV	Kuratorium für Verkehrssicherheit (Austrian Road Safety Board)
OGD	Open Government Data
RVS	Richtlinien und Vorschriften für das Straßenwesen (Guidelines and Regulations for Roads)
SRQ	Sub-research question
WUR	Wageningen University & Research

1 Introduction

1.1 Background and problem statement

The promotion of cycling as a mode of active mobility has been at the centre of global, European, and Austrian policies, as it aligns with broader climate, health, and liveability objectives (BMK, 2021, 2024; Council of the European Union, 2024; United Nations Environment Programme, 2016; WHO, 2022). In Austria, the promotion of active modes (BMK, 2021, 2024) has delivered intended outcomes. Cycling as a form of active mobility has increased significantly in recent years, particularly in urban areas, where the growth of distance cycled per person is up to four times higher than in rural regions (Land Niederösterreich, 2013, 2018; Land Oberösterreich, 2012, 2022; Land Salzburg, 2012, 2022; Land Vorarlberg, 2013, 2017, 2023). However, there is an urgent need to improve cycling safety in Austria, as the overall number of accidents involving cyclists has increased by 81 percent in the last twelve years. This stands in contrast to most other modes of transport, for which safety has generally improved over the same period (Statistik Austria, 2025).

The UN defined cycling safety as a key priority for their Second Decade of Action for Road Safety, aiming to halve the number of road traffic deaths and injuries between 2021 and 2030 (United Nations, 2020). The EU Road Safety Policy Framework for the same timeframe has similar aims and serves as the first step towards the aim of a Safe System - zero fatalities and serious injuries on European roads by 2050. The framework also sees active mobility as a game-changer in reducing emissions and improving liveability in urban areas. However, they do address the need for stronger active mobility policies to increase the safety of active mode users (European Commission, 2020).

While some research (Fyhri et al., 2017; Jacobsen, 2003) suggests a safety-in-numbers effect, a non-linear statistical relationship between the number of cyclists and the number of injured cyclists, this theory cannot be confirmed (yet) by road safety statistics in Austria. Cycling safety needs to be improved, as the number of accidents involving cyclists has been increasing at higher rates than the number of kilometres travelled by bike (Statistik Austria, 2025; Land Niederösterreich, 2013, 2018; Land Oberösterreich, 2012, 2022; Land Salzburg, 2012, 2022; Land Vorarlberg, 2013, 2017, 2023).

In 2023-24, cycling accounted for 21% of all traffic casualties and 30% of all seriously injured and killed road users, with this share rising to 39% within built-up areas (Statistik Austria, 2025). Compared with the most recent nationwide modal share data from 2013/14, where cycling accounted for 7% of trips in Austria, this suggests that cyclists are overrepresented in serious accident outcomes (BMVIT, 2016). The comparison is limited by the time gap between both datasets, but still shows the scale of the safety problem.

A closer look at accident patterns shows that risks are strongly concentrated in urban street environments, particularly at intersections (Statistik Austria, 2025). Street design characteristics such as insufficient separation between different transport modes and speeds or conflicts at tram tracks further contribute to these incidents (Statistik Austria, 2025). These patterns suggest the relevance of urban street design to improve road safety.

Current conditions present a critical window of opportunity: around one-third of Austria's road network is in poor or very poor condition, requiring extensive refurbishment in the coming years (Neubauer, 2025). This creates an opportunity to reassess urban street design, especially as public support for street redesign in favour of active modes is present (Wolf, 2025), and most fatal cycling crashes occur in mixed traffic rather than on dedicated cycling infrastructure (Statistik Austria, 2025).

In sum, as cycling in Austria is growing, particularly in urban areas, cyclist safety has not yet improved at the same pace. On the contrary, accidents involving cyclists have risen even faster than cycling itself over the last decade. This indicates a growing mismatch towards active mobility promotion and the national and international objective of Safe System, eliminating fatalities and serious injuries in traffic (see section 1.6). It therefore becomes increasingly important to examine why cyclists remain disproportionately exposed to risk in urban areas in Austria.

1.2 Research focus and scope

Cycling safety is influenced by a wide range of factors, including roadway, environmental, vehicle-related, driver-related, cyclist-related, and crash-related factors (Scarano et al., 2023). This thesis does not aim to analyse all of these dimensions equally. Instead, it focuses on roadway factors, understood here as street characteristics and street design. This focus is chosen because the street characteristics and street design are directly relevant for planning practice and can be addressed through infrastructure adaptation and policy recommendations. While the other mentioned factors are acknowledged as important, they are not the primary object of analysis in this thesis.

The spatial scope of the case study is the urban street space of Vienna, the capital of Austria. Vienna is a suitable case because it combines a large urban population of more than 2 million inhabitants, a dense and diverse street network, and a wide range of street typologies, from local residential streets to major roads and complex intersection environments. This makes it possible to analyse cyclist safety across different urban contexts. In addition, Vienna is also a relevant case study because cycling has been gaining popularity in recent years, with the share of trips made by bicycle increasing from 7% in 2019 to 11% in 2024. The share of cycling, however, is still much lower than the share of public transport (34 %), walking (30 %) and using motorised individual vehicles, such as cars and motorbikes (25 %) (Stadt Wien, 2025). This makes Vienna an interesting case for studying how cycling safety can be improved within a transport system still strongly shaped by other modes.

Although the empirical analysis is situated in Vienna, the relevance of the findings extends beyond the local case. The thesis evaluates street characteristics and design conditions in relation to the Austrian RVS guidelines, which are not limited to Vienna but provide a national framework for infrastructure planning across Austria. Therefore, the selected HRLs are also used to reflect on the current RVS framework, as further explained in section 1.5.

1.3 Research gap and aim

Although most modes of transport have become safer over the last twelve years, absolute cyclist accident numbers have increased rather than decreased (Statistik Austria, 2025). This suggests that important factors contributing to cyclist accidents are still not sufficiently understood, especially with regard to street infrastructure and its design (V. Zuser, personal communication, 16 October 2025). In particular, it remains unclear which street characteristics contribute to these patterns and whether the existing street design at these locations already complies with current Austrian guidelines. This is an important gap, because unsafe locations may either result from infrastructure that does not follow current RVS guidelines, or from situations where the current RVS itself is not sufficient to prevent serious cyclist accidents.

This thesis aims to contribute practical guidance for the design of urban streets in Austria in order to improve cyclist safety. It does so by identifying hazardous road locations, analysing their recurring accident patterns in relation to infrastructural characteristics, and assessing them against the current RVS *Bicycle Traffic*. Based on these findings, the thesis aims to provide a scientific basis for planners and

policymakers. In the longer term, the results may also help inform the further development of the Austrian RVS.

1.4 Research questions

Based on the identified research gap and the stated aim, the following research questions are derived for this thesis:

How do street characteristics at hazardous road locations in Vienna influence cyclist safety, and what does this imply for the further development of Austrian cycling guidelines?

SRQ1: Which street characteristics are identified in research as relevant for cyclist safety?

SRQ2: Which hazardous road locations in Vienna show recurring cyclist accident patterns, and which street characteristics are present at these locations?

SRQ3: To what extent do the street designs at these hazardous road locations comply with the current RVS Bicycle Traffic, and where do the findings suggest a need for infrastructure improvements or changes to the RVS?

The main research question will be answered by addressing the sub-research questions step by step. First, a theoretical framework will be developed to explain the connection between street characteristics and cyclist safety. Second, the analysis of cycling accident data will be used to identify statistically significant spatial clusters, which are defined in this thesis as hazardous road locations (HRL). These HRLs will then be examined in more detail using accident records in order to identify recurring cyclist accident patterns, and through field observations and operationalized indicators in order to identify street design characteristics that may contribute to these accidents. In the final step, the HRLs will be assessed against the current policy framework to determine whether they comply with the RVS and whether the findings point to a need for infrastructure improvements or changes to the RVS. The methods used to answer these questions will be described in more detail in chapter 3.

1.5 Societal and scientific relevance

This thesis is societally relevant because serious cyclist accidents cause a great amount of human suffering. This affects not only the cyclist directly involved, but also families, friends, and wider social networks. In the context of the Safe System approach, which aims to ensure that nobody is killed or seriously injured in road traffic (see section 1.6), improving cyclist safety is therefore highly important. Serious injuries and fatalities also create considerable economic costs for the wider economy (FSV, 2014). As cycling is increasing (see section 1.1), the need to improve cyclist safety becomes even more urgent. At the same time, a safer cycling environment can contribute to the liveability of cities. It can help create places where people can move around more freely, more independently, and with less fear of being seriously injured (BMK, 2021). Cycling is also an environmentally friendly mode of transport and therefore relevant for reducing emissions from the transport sector (BMK, 2021).

The scientific relevance of this thesis lies mainly in its contribution to policy improvement. While the case study is located in Vienna and the policy framework is Austrian, the broader questions are also relevant in other contexts: how street design at hazardous road locations influences cyclist safety, and whether existing guidelines are sufficient. The thesis therefore provides findings that may also be useful beyond Austria. In addition, it combines quantitative hot spot analysis, qualitative analysis of recurring accident patterns, and an assessment against the current RVS framework. This approach is described clearly and can be reproduced in other contexts. In this way, the thesis may also support future research on cyclist safety and the further development of design guidelines.

1.6 Safe System approach

The Safe System approach provides the normative safety framework for this thesis, as it shifts the focus of road safety from reducing crashes in general to preventing fatal and serious injury outcomes. Instead of aiming at safer roads only, it promotes the ambition of safe roads, meaning a road system in which crashes may still occur, but no longer result in fatal or serious consequences. The Safe System approach takes the ethical position that fatalities and serious injuries in road traffic are unacceptable and does not accept trade-offs between human lives and other priorities (BMK, 2021; ITF, 2016). However, it acknowledges that accidents without serious consequences will continue to occur (European Commission, 2020).

ITF (2016, p. 26) has defined four principles that underpin a Safe System in road traffic:

1. "People make mistakes that can lead to road crashes.
2. The human body has a limited physical ability to tolerate crash forces before harm occurs.
3. A shared responsibility exists amongst those who design, build, manage and use roads and vehicles and provide post-crash care to prevent crashes resulting in serious injury or death.
4. All parts of the system must be strengthened to multiply their effects; and if one part fails, road users are still protected."

Considering principles 1 and 2 and adhering to principles 3 and 4, this thesis takes on the responsibility of providing relevant knowledge for urban designers to make infrastructure a forgiving element that allows other parts of the system to fail, while still protecting road users from serious injuries. Cyclists are particularly vulnerable due to limited physical protection. That is why this thesis focuses on how infrastructure at hazardous road locations can be designed more safely, so that cyclist mistakes or conflicts with other road users do not result in serious or fatal injuries.

1.7 Policy and planning context

In Austria, the federal ministry issues relevant administrative instructions in the field of road planning. It also declares the "Guidelines and Regulations for Roads" (RVS, "Richtlinien und Vorschriften für das Straßenwesen") as binding. However, this binding character should be understood in context: the RVS are not laws in the formal sense, but technical regulations that become binding particularly where they are declared applicable by the competent authority or incorporated into administrative instructions, approvals, procurement documents or contracts (Austrian Standards Institute, 2025; BMIMI, n.d.).

The RVS are developed by the Austrian Research Association for Roads, Railways and Transport (FSV, "Forschungsgesellschaft Straße – Schiene – Verkehr") through expert working committees made up of representatives from public authorities, planning offices, academia, the construction sector, and infrastructure operators (FSV, n.d.). Overall, there are more than 350 RVS, covering many different topics. For this thesis, the most relevant categories are transport planning and road planning.

More precisely, this thesis mainly uses RVS 02.02.21 *Road Safety Analysis* (FSV, 2014) and RVS 03.02.13 *Bicycle Traffic* (FSV, 2022). The first one is used in chapter 3 to define HRLs. The second one provides the basis for understanding how cycling infrastructure is planned in Austria, including the main types of cycling infrastructure and the criteria for choosing between them. It is also the policy against which the HRLs are assessed in chapter 5. The policy design recommendations developed in this thesis also aim to inform the further development of the RVS *Bicycle Traffic*.

Every accident that is reported by the police is assigned one **accident type**, meaning the concrete conflict situation or specific traffic movement that was decisive for the occurrence of the accident. Based on these accident types, the RVS 02.02.21 *Road Safety Analysis* defines nine **accident groups**. The detailed

classification can be found in Appendix A. The terms accident type and accident group will continue to appear throughout this thesis with this meaning. The "Unfallmerkmalsgruppen", which are another way of grouping accidents based on cause-specific accident criteria, are beyond the scope of this thesis.

The RVS 03.02.13 *Bicycle Traffic* applies to the construction of new, and the redesign of existing, public traffic areas where cycling is allowed. It defines the main types of cycling infrastructure used in Austria, examples of which are shown in Figure 1 (FSV, 2022, p. 3f, Author's translation):

1. "A **separated cycle path** is a route intended for bicycle traffic and marked as such. It may be designated with or without mandatory use.
2. A **painted cycle lane** is a marked part of the carriageway intended for bicycle traffic, whose course is indicated by repeated bicycle symbols.
3. A **multi-use lane** is a cycle lane, or part of a cycle lane, that may also be used by other vehicles with special consideration for cyclists if the lane to the left is not wide enough or if directional arrows require vehicles to enter it in order to continue.
4. A **shared foot and cycle path** is a route intended and marked for both pedestrian and bicycle traffic. It may also be designated with or without mandatory use.
5. A **bicycle street** is a street or street section where all vehicle traffic except bicycle traffic is prohibited, apart from the vehicle types named in the Austrian road traffic code (§ 76a Abs. 5 StVO) and access traffic for arriving and leaving properties."



Figure 1: Main types of cycling infrastructure (Fürthner, 2024; Nader, 2023)

Another crucial part of these guidelines is the motor vehicle criterion. This provides a general basis for deciding which kind of cycling facility is suitable in a given situation. The main criteria for the choice between the principle of separation and the principle of mixed traffic are the speed and traffic volume of motor vehicles, as well as the share of heavy vehicles and buses. Figure 2 shows the guidance on the use of different types of cycling infrastructure depending on the speed limit and average daily traffic (ADT).

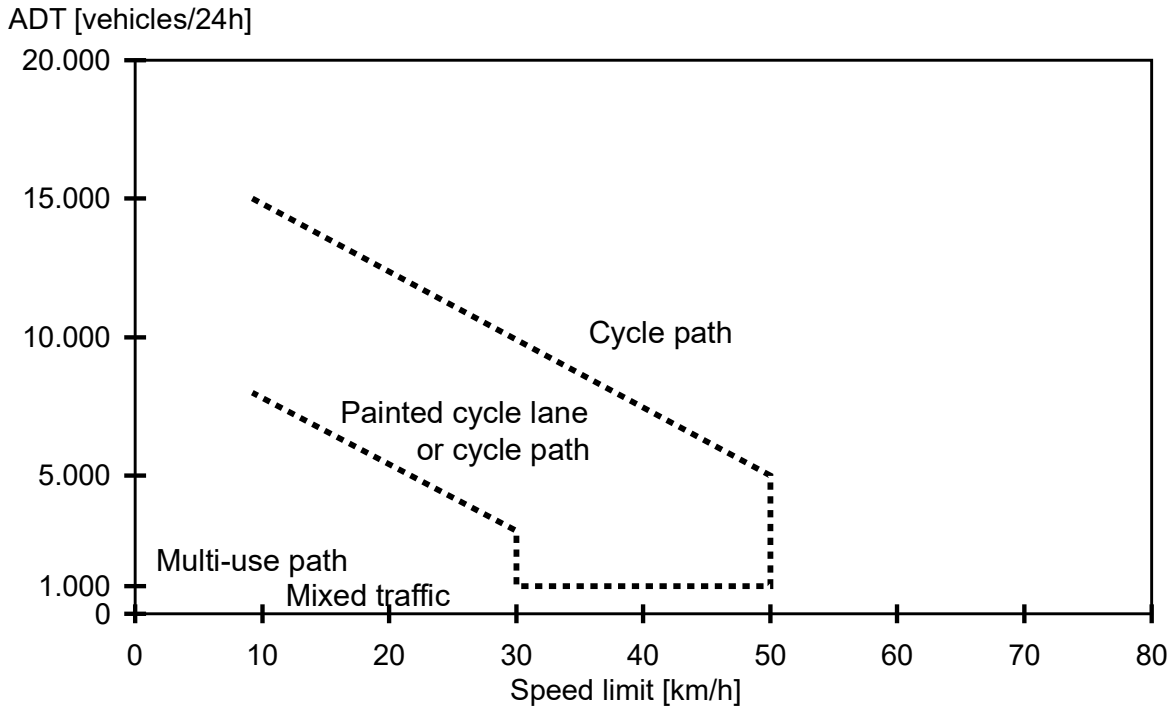


Figure 2: Guidance on the use of cycle facilities on main cycle routes, connecting routes, and collector routes (FSV, 2022, Author's translation)

The other relevant parts of the RVS *Bicycle Traffic* are introduced later in the thesis where they are needed.

1.8 Structure of the thesis

This thesis is structured into six main sections. After the Introduction, chapter 2 presents the Theoretical Framework. It explains the relationship between street characteristics and cyclist safety and ends with the conceptual framework of the thesis.

Chapter 3 describes the Methodology. It introduces the used data, explains the hot spot identification, the case selection, the operationalization, the qualitative analysis of hazardous road locations, and the RVS-based assessment and design recommendations.

Chapter 4 presents the Results. It first shows the results of the quantitative spatial analysis and the case selection. It then presents the qualitative hot spot analysis for the selected accident groups.

Chapter 5 presents the RVS-based assessment and design recommendations. It assesses the selected HRLs against the current RVS *Bicycle Traffic* and uses these assessments to derive physical design recommendations for the analysed locations as well as policy design recommendations for the RVS guidelines.

Chapter 6 contains the Discussion. Here, the main findings are interpreted in relation to the research questions, the theoretical framework, and the policy and planning context.

Finally, chapter 7 provides the Conclusion. It summarises the main results of the thesis and gives a short outlook.

2 Theoretical framework: street characteristics and cyclist safety

This theoretical framework addresses the first sub-research question: *Which street characteristics are identified in research as relevant for cyclist safety?* As no single established framework was found that fits the specific focus of this thesis, a new framework was developed based on the reviewed literature. Its purpose is not to explain cyclist safety as a whole, but to focus specifically on the relationship between street characteristics and cyclist safety.

2.1 Synthesis of relevant street characteristics

Cycling accidents are not randomly distributed across urban space, but tend to cluster at particular locations (Bassani et al., 2020; Kaygisiz & Hauger, 2017; Loidl et al., 2016; Schuurman et al., 2020; Toraldo et al., 2025). Such clusters may partly be explained by higher exposure, for example because more cyclists or more motor vehicles are present at these locations. At the same time, they may also point to problems related to street infrastructure and street design (Aldred et al., 2018).

Based on the reviewed literature, the relevant street characteristics were grouped into four concepts: traffic environment, intersection and conflict-point design, street layout and space allocation, and surface and topography. These concepts were formed to structure the indicators identified in the literature review and to guide the later analysis of the HRLs. Traffic environment is the only concept that is not directly related to infrastructure itself. It refers to the general traffic conditions at a location, especially cyclist volume, motorised traffic volume, and motorised traffic velocity. Intersection and conflict-point design focuses on locations where movements overlap and where conflicts are therefore more likely to occur. Street layout and space allocation captures planned street characteristics, especially how space is allocated to moving and parking motorised traffic, public transport, and cyclists. Surface and topography is closely related, but different, as it describes characteristics such as gradient and surface condition, which are not mainly a question of planned space allocation.

Table 1 shows these four concepts, their expected effects on cyclist safety, the measurable indicators used in this thesis, and the main literature on which these assumptions are based.

Table 1: Street characteristics contributing to cycling accidents.

Concept	Expected effect on cyclist safety	Indicator	References
Traffic environment	Higher motor traffic pressure is expected to reduce cyclist safety, while higher cyclist volumes may reduce individual risk.	Motorised traffic velocity	Aldred et al., 2018; Dozza & Werneke, 2014; Harris et al., 2013; Schuurman et al., 2020.
		Motorised Traffic volume	
		Cyclist volume	
Intersection and network conflict points	More overlapping movements and higher conflict density are expected to reduce cyclist safety.	Intersection	Bassani et al., 2020; Harris et al., 2013; Kaygisiz & Hauger, 2017; Reynolds et al., 2009.
		Intersection type	
		Distance to closest public transport stop or bicycle sharing station	
Street layout and space allocation	Cyclist safety is expected to depend on how street space is allocated between cycling, motor traffic, parking, public transport, and pedestrians. Designs that reduce separation or create spatial conflicts are expected to lower safety.	Road type	Aldred et al., 2021; Asadi et al., 2022; De Rome et al., 2014; Harris et al., 2013; Kapousizis et al., 2021; Lusk et al., 2011; Minikel, 2012; Odijk, 2023; Reynolds et al., 2009; Thomas & DeRobertis, 2013; Van Petegem et al., 2021; Von Stülpnagel & Binnig, 2022.
		On-street parking	
		Tram tracks	
		Cycling infrastructure type	

Surface and topography	Cyclist safety is expected to decrease where riding conditions reduce stability, visibility, braking, or reaction time.	Surface conditions	Aldred et al., 2021; Dozza & Werneke, 2014; Harris et al., 2013; Kapousizis et al., 2021; Scarano et al., 2023; Werneke et al., 2015.
		Gradient	

2.1.1 Traffic environment

Higher car speeds and motorised traffic volumes are expected to decrease cyclist safety (Dozza & Werneke, 2014; Harris et al., 2013), whereas higher cyclist volumes may decrease individual injury risk through a safety-in-numbers effect, although this relationship is not fully consistent across all contexts and studies (Aldred et al., 2018; Schuurman et al., 2020).

2.1.2 Intersection and network conflict points

Cyclist safety is expected to decrease at intersections and other network conflict points (Bassani et al., 2020; Harris et al., 2013; Kaygisiz & Hauger, 2017). Risk is expected to be particularly high at roundabouts, especially at multilane roundabouts, and at signalized intersections (Harris et al., 2013; Kaygisiz & Hauger, 2017; Reynolds et al., 2009), while crashes are also found to cluster around public transport stops and bicycle-sharing stations (Kaygisiz & Hauger, 2017).

2.1.3 Street layout and space allocation

Cyclist safety is expected to be lower on primary roads than on secondary or tertiary roads, on streets with on-street parking, and in the presence of tram tracks (Aldred et al., 2021; Asadi et al., 2022; Harris et al., 2013; Kapousizis et al., 2021; Reynolds et al., 2009; Van Petegem et al., 2021). Tram tracks are expected to be associated with a particularly strong increase in non-intersection injury risk (Harris et al., 2013). Multi-use shared paths and painted cycle lanes are expected to be associated with a higher risk of accidents (De Rome et al., 2014; Harris et al., 2013; Reynolds et al., 2009). In contrast, the presence of bicycle facilities is generally associated with lower risk, with separated bicycle facilities and bicycle streets generally associated with a lower risk of accidents (Aldred et al., 2021; Lusk et al., 2011; Minikel, 2012; Odijk, 2023; Thomas & DeRobertis, 2013; Van Petegem et al., 2021; Von Stülpnagel & Binnig, 2022). One-way separated cycle paths are considered safer than two-way cycle paths (Lusk et al., 2011; Thomas & DeRobertis, 2013).

2.1.4 Surface and topography

Individual cyclist safety is expected to decrease where the riding surface is poorly maintained, as poor surface conditions are prominent triggers of crashes and near-misses (Dozza & Werneke, 2014; Scarano et al., 2023; Werneke et al., 2015). At the same time, good road surfaces may also show higher accident numbers because they tend to attract more cyclists (Scarano et al., 2023). Downhill gradients are associated with increased risk at both intersections and non-intersections (Aldred et al., 2021; Harris et al., 2013; Kapousizis et al., 2021).

2.2 Conceptual framework

Based on the reviewed literature, cyclist accidents are understood as being influenced by several street-related characteristics. Since this thesis focuses on the role of street design and infrastructure, the conceptual framework is limited to these characteristics. Wider contextual factors, such as land use, socio-demographic structures, individual behaviour, weather conditions or vehicle-related factors, are not included in the framework. This does not mean that these factors are irrelevant for cyclist safety, but they are outside the analytical scope of this study.

The central outcome of the framework is cyclist accident risk. In this thesis, cyclist accident risk does not refer to a fully exposure-adjusted risk rate, meaning the number of accidents divided by the number of cyclists using a location. This is because cyclist volume data is not available for all locations. Instead, cyclist accident risk is understood as locations where cyclist accidents occur more frequently or form spatial clusters. The framework therefore focuses on street characteristics that may help explain why accidents concentrate at some locations rather than others.

The four main groups of the framework are the concepts used to organise the street characteristics identified in the literature. In the conceptual framework, each concept is linked to the indicators that are later used to operationalize it in the empirical analysis. While some indicators are directly measurable and are later used in the empirical analysis, others represent theoretical mechanisms that help explain how street characteristics may contribute to accident risk. The latter were not directly measured in this thesis.

Figure 3 shows the conceptual framework used in this thesis.

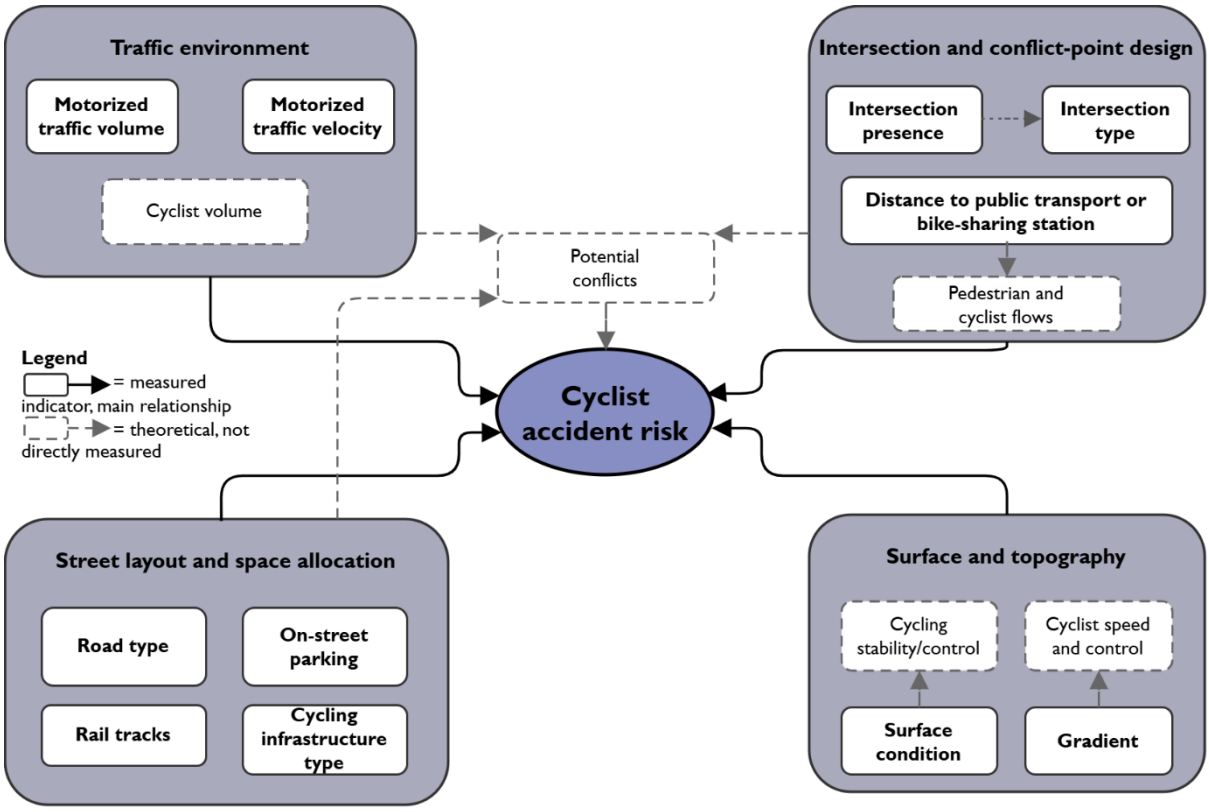


Figure 3: Conceptual framework of street characteristics influencing cyclist accident risk

The framework distinguishes between measured indicators and theoretical mechanisms. The measured indicators are shown as solid boxes and represent the measured variables in this thesis. The dashed boxes represent mechanisms that are conceptually relevant but not directly measured. The most important of these mechanisms is potential conflicts. The three related concepts themselves do not directly increase cyclist accident risk. Rather, they increase the likelihood of a conflict because the movement paths of cyclists and other road users overlap or come into close interaction. These potential conflicts can then lead to accidents (Schepers et al., 2014).

Other theoretical mechanisms are more specific to individual factor groups. Pedestrian and cyclist flows are relevant around public transport stops and bike-sharing stations, while cycling stability, speed and control help explain the role of surface conditions and gradient. These mechanisms are not measured separately, but help explain why the selected indicators may be relevant for cyclist accident risk.

Some indicators are also related to each other, although these relationships are not shown in the figure to keep the framework readable. For example, road type is linked to traffic volume and velocity, while traffic volume and velocity are also relevant for the type of cycling infrastructure provided or recommended. Similarly, public transport stops and tram tracks often occur together on streets with tram lines.

The framework therefore provides the basis for the methodology. In the following chapters, the measured indicators are translated into operational variables and later assessed at the identified accident locations and clusters. As the study focuses on accident clusters, the analysis can identify recurring street characteristics at locations with concentrated cyclist accidents, but it cannot fully prove the causal mechanisms behind them.

3 Methodology

This study adopts a mixed-methods research design combining quantitative spatial analysis with qualitative interpretative approaches. The research follows a sequential structure consisting of three main phases (Creswell & Plano Clark, 2018). This is chosen because the thesis first needs to identify where cyclist accidents cluster before these locations can be interpreted in detail. Quantitative spatial analysis is therefore used to identify hazardous road locations in a systematic way, while the qualitative analysis is needed to understand the recurring accident patterns and infrastructural characteristics behind these clusters. In the third phase, the qualitative findings are assessed against the current RVS *Bicycle Traffic* in order to derive infrastructure-related conclusions and design recommendations. The sequential structure fits the research because the results of each phase provide the basis for the next phase.

The first sub-research question, "*Which street characteristics are identified in research as relevant for cyclist safety*?", was addressed in the theoretical framework in chapter 2. The methodology therefore builds on these identified street characteristics and focuses on the three-phased empirical analysis of HRLs.

The first empirical phase uses police-reported cyclist accident data and spatial statistical methods to identify hazardous road locations in the study area. In the second phase, the selected hot spot clusters are analysed qualitatively with regard to their recurring accident patterns and infrastructural characteristics. This serves to answer the second sub-research question: "*Which hazardous road locations in Vienna show recurring cyclist accident patterns, and which street characteristics are present at these locations?"* Finally, the analysed HRLs are assessed against the current RVS *Bicycle Traffic* in order to answer the third sub-research question: *"To what extent do the street designs at these hazardous road locations comply with the current RVS Bicycle Traffic, and where do the findings suggest a need for infrastructure improvements or changes to the RVS?"* This phase, therefore, examines both whether the existing infrastructure follows current guidelines and whether the findings point to a need for changes at the HRLs or within the RVS itself.

Figure 4 visualizes the sequential Mixed-Methods research design.

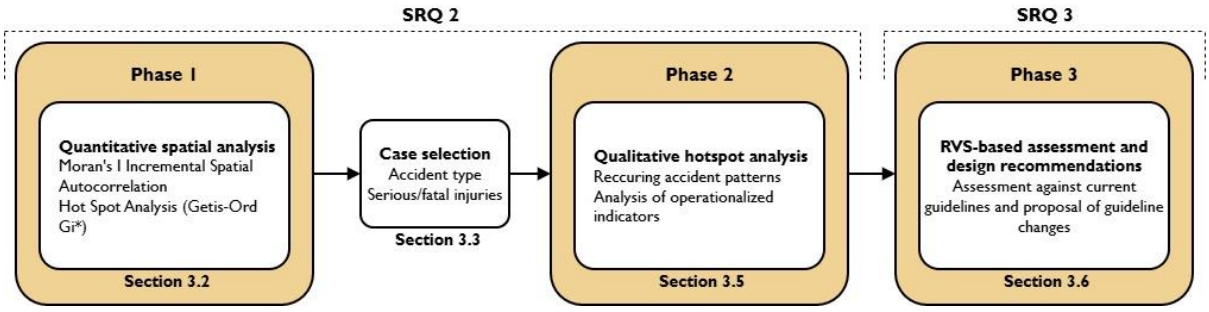


Figure 4: Methodological Framework

The study is applied and practice-oriented and can be characterized as primarily exploratory and explanatory. While it aims to explain why specific locations emerge as cyclist accident hot spots, it does not seek to establish causal effects in a strict statistical sense.

This chapter describes the methodology used in this thesis. It begins with the data sources used for the analysis in section 3.1. Section 3.2 then explains how the hazardous road locations were identified through quantitative spatial analysis. Building on this, section 3.3 describes the case selection process. Section 3.4 presents the operationalization of the indicators used in the qualitative analysis, before section 3.5 explains how the selected HRLs were analysed qualitatively. Section 3.6 then describes the RVS-based assessment and the development of design recommendations. Finally, section 3.7 reflects on positionality and ethical considerations.

3.1 Data

This thesis uses several spatial datasets. Table 2 gives an overview of the main data sources, their providers, time periods, and their role in the analysis. The datasets are described in more detail in the following subsections.

Table 2: Used datasets with their source, time period, and role

Dataset	Source	Time period	Main role in thesis
Accident data	Statistik Austria, 2026.	2022-2024	Hot spot identification and interpretation of recurring accident patterns
Graph Integration Platform Vienna	OGD Austria, 2025b.	2025	Network basis for calculating accident neighbourhoods in the hot spot analysis
Main cycle network Vienna	OGD Austria, 2026.	2026	Extension of the network dataset with important cycling routes
TomTom Move Traffic Stats	TomTom, 2026.	08/2024	Motorised traffic volumes and velocity data at HRLs
Digital Terrain Model	OGD Austria, 2025a.	n.a.	Derivation of street gradient as a topographic indicator
Public Transport Stops	OGD Austria, 2025c.	2025	Proximity indicator for public transport-related conflict points
WienMobil Bike Sharing Stations	OGD Austria, 2025d.	2025	Proximity indicator for bike-sharing-related conflict points

3.1.1 Accident data

The first data source is georeferenced police-reported accidents resulting in injuries involving cyclists between 2022 and 2024 in Vienna. The data was obtained from Statistik Austria, Austria's Federal Statistical Office (Statistik Austria, 2026).

The accident query covered the traffic mode group Bicycle+. These included accidents involving bicycles and e-bikes. Due to a change in category structure, the definition is not identical across all years. Accidents involving e-scooters were classified in the same traffic mode group in 2022, before they were listed separately from 2023 onwards. This should be considered when interpreting the accident dataset across the full study period.

The focus on a three-year period was chosen because it follows the official definition of an accident hot spot in the Austrian Guidelines and Regulations for Roads (FSV 2014, p. 9, Author's translation):

> "A intersection or stretch of road up to 250 metres in length is to be designated as an accident blackspot if, at that location
>
> - At least three similar accidents resulting in personal injury have occurred within three years and the relative coefficient[1] reaches or exceeds 0.8
>
> Or
>
> - At least five similar accidents (including accidents involving damage to property) have occurred in one year."

[1] The relative coefficient is used in the RVS to relate the number of injury accidents to annual average daily traffic and, therefore to account for traffic exposure.

In this study, the RVS definition was used as an orienting framework in three ways: first, through the use of a three-year observation period; second, through the spatial focus on road sections of up to 250 m; and third, through the requirement that accidents had to be similar and involve personal injury in order to qualify as an HRL.

Only parts of the full definition could be applied. The second criterion could not be used because accidents involving only property damage were not available for this study. The relative coefficient could not be applied systematically, as average daily traffic data were not available for many streets. Therefore, the study uses the three-year period, the spatial extent of up to 250 m, and the occurrence of similar injury accidents as the main reference points, but not the full accident hot spot definition.

The accident data is used in several parts of the thesis. First, it forms the empirical basis for the identification of HRLs in the quantitative spatial analysis. Second, accident type and stated circumstances are used in the qualitative part of the thesis to interpret recurring cyclist accident patterns at the identified HRLs.

Table 3 shows an overview of the accident data. It is worth noting that the significantly higher number of accidents in 2022 is due to the aforementioned inclusion of e-scooters in the Bicycles+ category. There have been from 389 to 569 accidents per type, except for single-bicycle accidents, which only account for 158. This is likely due to this category being underreported, as cyclists often do not report accidents without other parties (M. Donabauer, personal communication, 16 April 2026).

Table 3: Overview of accident dataset

Total number of cyclist injury accidents		4.245
by year	2022	1.752
	2023	1.227
	2024	1.266
by accident type	Single-bicycle accidents	158
	Conflicts in same-direction traffic	569
	Conflicts in opposing traffic	432
	Turning and U-turn conflicts – same direction	389
	Turning and U-turn conflicts – opposite direction	412
	Intersection conflicts – right-angle, no turning	495
	Intersection conflicts – right-angle, with turning	421
	Conflicts with parked vehicles	471
	Pedestrian conflicts	468
	Other	430
Severity Overview	Injured Persons	6
	Seriously Injured Persons	488
	Fatalities	4.233

3.1.2 Network data

The Graph Integration Platform, the official Austrian traffic network, was used as the network dataset for the spatial analysis (OGD Austria, 2025b). As this dataset is primarily intended for motorists, featuring all streets for cars, it was extended by four main cycling routes, where no nearby streets were available in the road network: Donaukanal, Prater Hauptallee, Donauinsel, and Donau Nordufer (mentioned from southwest to northeast, see Figure 5). These were added based on data from the City of Vienna (OGD Austria, 2026). This decision was made after comparing the accident locations with the Graph Integration Platform and identifying repeated cyclist accidents on routes that were not sufficiently represented in the

original road dataset. Including these routes made sure that important cyclist links were part of the network analysis. Also, non-cyclable routes, such as highways, were removed from the network dataset.

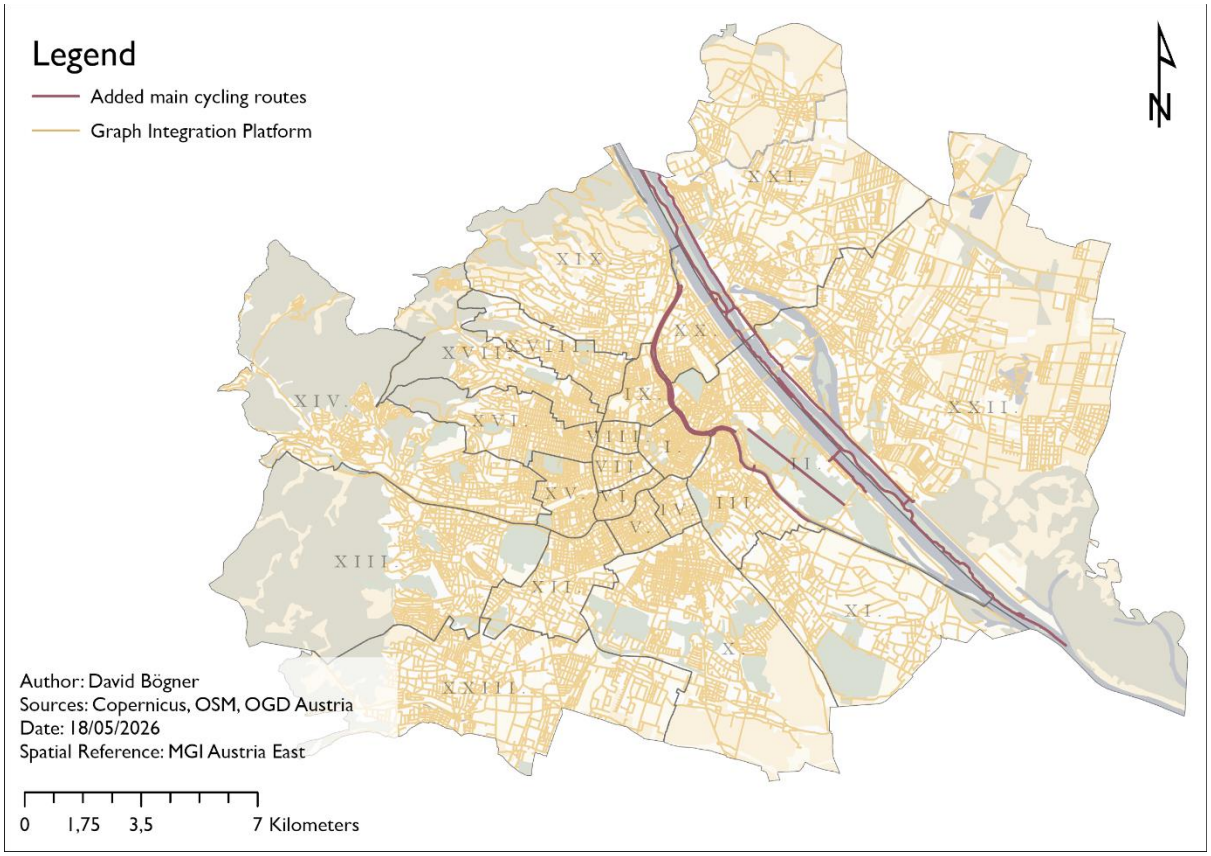


Figure 5: Graph Integration Platform, including the added main cycling routes

3.1.3 Motorised traffic statistical data

TomTom Move Traffic Stats data was used for motorised traffic volume and motorised traffic velocity (TomTom, 2026). TomTom Move is based on devices that use TomTom application services and provides traffic statistics (TomTom, n.d.). Due to restricted data availability, it was only possible to use data from 1 August to 30 August 2024 for this study. At the same time, the use of August data creates a limitation, as traffic patterns during summer holidays may differ from the rest of the year. Commuter and school-related traffic may be lower, while leisure-related trips may play a larger role. The data should therefore be interpreted mainly as a relative comparison between streets within the same time period and not as a representation of average yearly traffic conditions.

The selected time periods were 7:00 to 10:00 and 15:00 to 19:00. These morning and afternoon peak periods were chosen because they are more likely to show the traffic importance of a street under high load. During off-peak hours, traffic is more dispersed across the city and differences between streets may be less clear (Zeng et al., 2019). Using the same peak periods for all streets also improves comparability. The motorised traffic volume data is not suitable for calculating annual average daily traffic, but it is useful for comparing streets in Vienna within the same time periods.

For motorised traffic velocity, the 85th percentile speed of the same dataset was used. This is a common indicator in traffic analysis and reduces the influence of unusually slow drivers and extreme speeding values.

3.1.4 Additional spatial data

Data on public transport stops (OGD Austria, 2025c) and bicycle sharing stations (OGD Austria, 2025d) were provided by the City of Vienna through Open Government Data (OGD). These datasets were used to assess the proximity of potential conflict points to the identified HRLs. For each HRL, the distance to the closest public transport stop or bicycle-sharing station were measured. This made it possible to examine whether the hot spot locations were situated close to areas with potentially increased interaction between cyclists and other road users.

In addition, a digital terrain model provided by the City of Vienna (OGD Austria, 2025a) was used to calculate street gradient. A digital terrain model is a raster-based elevation dataset that represents the height of the earth's surface, excluding built structures and vegetation. In this study, it was used to derive the slope conditions at the HRLs.

3.1.5 Field observations

Field observations were carried out on 13 and 14 April 2026 during the morning peak (7:00-10:00) and afternoon peak (15:00-19:00) and on 11 May 2026 in the afternoon peak. Data was collected using QField, an open-source mobile GIS (Geographic Information System) application for field data collection (OpenGIS, n.d.). These observations were used to document current infrastructural conditions at the hot spot locations that could not be fully assessed from secondary data alone. This included detailed intersection, road, and cycling infrastructure layout, the presence of on-street parking, and the condition of cycling surfaces, including tram tracks. The observations were structured around the operationalized indicators in order to support a consistent comparison across cases.

3.2 Quantitative spatial analysis

The first phase of this thesis aimed to find statistically significant hazardous road locations for cyclists based on accident clusters. The subsections describe the separate phases in more detail. A visual representation of the data processing can be viewed in Appendix B.

3.2.1 Moran's I Incremental Spatial Autocorrelation

Before identifying local hot spots, Global Moran's I (Moran, 1950) was used to assess whether cyclist accidents are randomly distributed or spatially clustered. A statistically significant positive Moran's I indicates that accident locations are more spatially clustered than expected by chance and therefore supports the use of a Hot Spot Analysis. Incremental Spatial Autocorrelation repeats this test across a series of increasing distance bands. This makes it possible to identify the distances at which clustering is most pronounced. In this procedure, the resulting z-score peaks indicate the distance bands where clustering deviates most strongly from randomness. These peaks can therefore be used as suitable threshold distance choices for the following Hot Spot Analysis (Habib et al., 2023).

3.2.2 Hot Spot Analysis (Getis-Ord Gi*)

In many studies, the distance threshold for Getis-Ord Gi* (Getis & Ord, 1992; Ord & Getis, 1995) is derived from Incremental Spatial Autocorrelation using Euclidean distance (Abid, 2024; Grigorev et al., 2025; Mesquitela et al., 2022; Muduli et al., 2025). This is a common approach in accident analysis, but it is less suitable when accidents occur on a road network and when the analysis is conducted at a small urban scale. In dense street networks, Euclidean distance may connect locations that are geographically close but not directly related along the network (see Figure 6). Habib et al. (2023) show that Euclidean threshold distances can misrepresent clustering in network-constrained settings. For this reason, a network-based approach was used in this study.

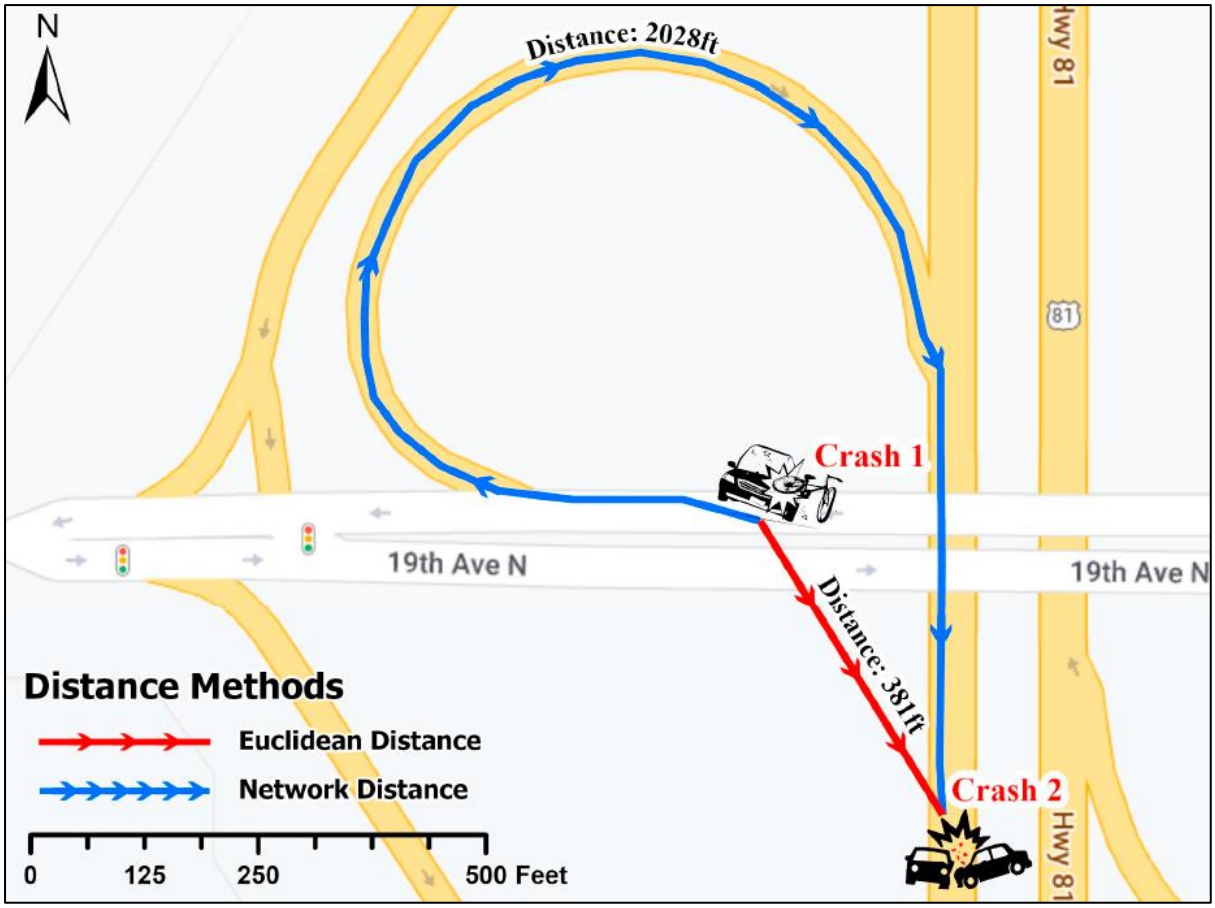


Figure 6: Comparison of Euclidean Distance and Network Constraint Distance (Habib et al., 2023)

The z-score peaks identified in the Incremental Spatial Autocorrelation were used as candidate threshold distances for the network-based hot spot analysis. All candidate distances were tested in the network-based hot spot analysis (Esri, n.d.-a). The final threshold was selected based on the statistical significance of the resulting local hot spots and the spatial definition of HRLs used in this thesis.

In ArcGIS Pro, the Generate Network Spatial Weights tool creates a spatial weights matrix based on the network dataset rather than straight-line distance, which makes it suitable for network-constrained accident analysis. A spatial weights matrix file was therefore created using the Graph Integration Platform network, including the four additional main cycling routes described in section 3.1.2.

Figure 7 illustrates the spatial weights matrix, which defines the neighbourhood structure used in the hot spot analysis. In this example, X is the accident location being evaluated. Accidents A and B are treated as neighbours of X because they are connected to X within the selected network threshold distance. The distance is measured along the road network, not as a straight-line distance. Because inverse distance was used, the closer accident location A receives a stronger weight than the more distant accident location B. Accident locations outside the selected network threshold distance, such as C and D, are not treated as neighbours of X.

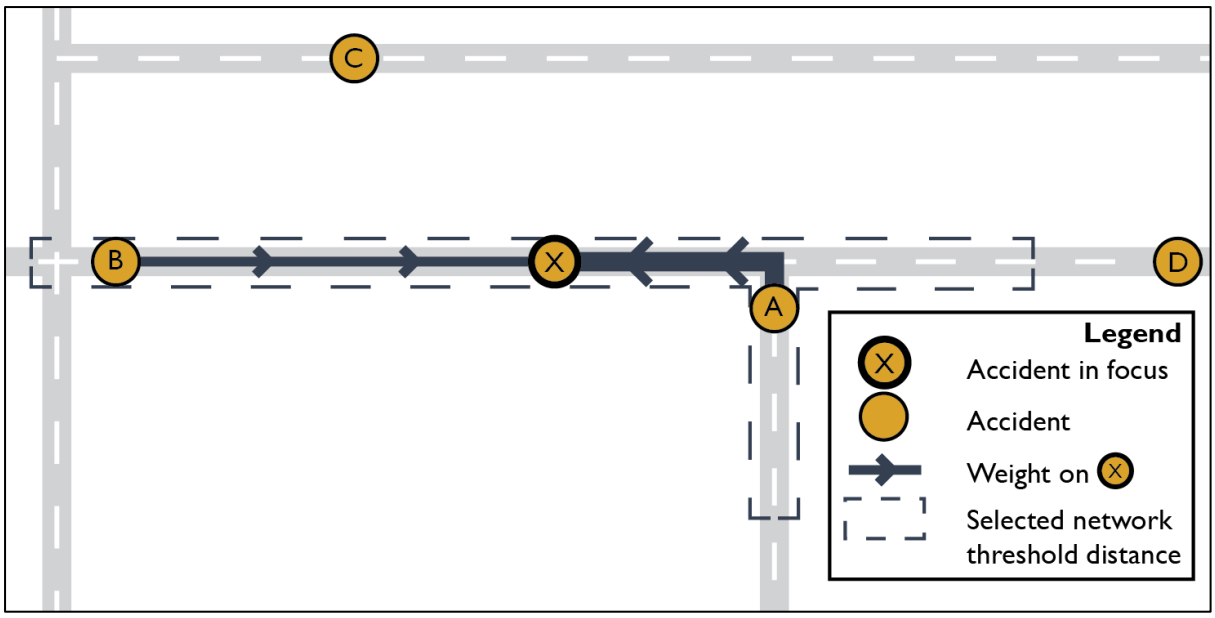


Figure 7: Conceptual illustration of the network-based spatial weights matrix

The resulting spatial weights matrix was then used in the Hot Spot Analysis (Getis-Ord Gi*). According to Esri (n.d.), the tool evaluates each feature in the context of its neighbours and returns z-scores and p-values that indicate whether high or low values cluster spatially. A location is only identified as a statistically significant hot spot when high values are surrounded by other high values.

3.3 Case selection

The hot spots identified by the Getis-Ord Gi* analysis were then validated using the RVS definition (see section 3.1.1). To operationalize the RVS reference to intersections or road sections of up to 250 m in length, a radius of 125 m was used around each hot spot location. To qualify as an accident hot spot, at least three accidents from the same accident group had to occur within this radius. The categorization for accident groups (FSV, 2014) can be found in Appendix A.

In this thesis, the RVS definition was applied only to accidents involving cyclists. This means that the identified locations qualify as cyclist-related HRLs and also fulfil the RVS logic within the scope of this research. However, this approach is stricter than the official RVS definition in one respect: accidents without bicycle involvement were not included. Therefore, additional locations could qualify as accident hot spots under the full RVS definition if, for example, two cyclist accidents and one car-only accident of the same accident group occurred at the same location. Such locations were not included here, because the focus of this thesis is specifically on cyclist safety.

To further narrow down the case selection, only HRLs where cyclists suffered serious or fatal injuries were included. This decision follows the Safe System approach introduced in section 1.6, which places a strong focus on preventing all serious injuries and fatalities in road traffic. For this reason, HRLs with only slight injuries were not prioritised for the qualitative case analysis.

The final case selection followed a purposeful sampling logic. Purposeful sampling is commonly used in qualitative research to identify information-rich cases while making effective use of limited resources (Palinkas et al., 2015). In this study, the final cases were selected based on the accident group. A maximum of two HRLs per accident group was included. As nine accident groups were distinguished (see Table 4), this would have resulted in a theoretical maximum of 18 cases. In practice, the final number was lower because of the inclusion and exclusion criteria described above. This selection strategy made it

possible to analyse a manageable number of cases in depth while still covering a broader range of cyclist accident patterns.

The nine accident groups used for case selection follow the RVS definition (see section 3.1.1). In this definition, accident types starting with 6 are not treated as a standalone group, but are grouped together with Group 5, right-angle collisions. For clarity, this combined category is labelled as Group 5(/6) in Table 4 (FSV, 2014).

Table 4: RVS Accident Groups

Accident Group Number	Accident Group Name
0	Single-bicycle accident
1	Conflicts in same-direction traffic
2	Conflicts in opposing traffic
3	Turning conflicts in the same direction of travel
4	Turning conflicts in the opposite direction of travel
5(/6)	Right-angle collisions
7	Conflicts with parked vehicles
8	Conflicts with pedestrians
9	Other

When more than two HRLs were present within one accident group, the representatives were selected based on spatial heterogeneity. This was done to avoid drawing conclusions from two locations on the same street or within the same local setting. Another selection criterion was that the HRLs should not have undergone major transformations since 2022, the first year of the accident data. This criterion was used to ensure that the current infrastructure could still be meaningfully compared with the recorded accidents. All identified HRLs, together with their inclusion or exclusion and the respective reason, are presented in section 4.2.

3.4 Operationalization

To derive measurable indicators from the street characteristics contributing to cycling accidents identified in the literature review (see Table 1), the following operationalization was developed (see Table 5). The coding column indicates the expected impact of each indicator on cyclist safety. It uses an ordinal scale ranging from very favourable conditions for cyclist safety (++) to very unfavourable conditions (--). The codes are used to structure the qualitative comparison of HRLs and should not be understood as a statistical score.

The number of classes differs between indicators. For ratio-scale indicators, the values were grouped into five classes using natural breaks. For nominal, ordinal, or binary indicators, the expected impact was assigned based on findings from the literature. Therefore, some indicators have fewer than five classes, because the nature of the indicator or the available literature did not support a more detailed distinction. The codes should mainly be interpreted within each indicator, rather than as directly comparable values across all indicators.

The focus group cluster (FGC) describes accidents from the same accident group that are concentrated at a particular location within the 250 m diameter of the HRL. This was included because the FGC was often relevant for deciding which specific part of an HRL was analysed in more detail.

Table 5: Operationalization

Concept	Indicator	Operational definition	Measurement / data source	Coding
Recurring cyclist accident patterns	Reccuring accident type	Accident type that appears more than once in police reports for the same HRL	Accident data	Listed in order of frequency
	Reccuring stated accident circumstances	Stated accident circumstance that appears more than once in police reports for the same focus group at the HRL	Accident data	Listed in order of frequency
	Mode combination	Combination of transport modes involved in accidents that appears more than once for the same focus group at the HRL	Accident data	Listed in order of frequency
Traffic environment	Motorised traffic velocity	Mean 85th percentile speed of motorised vehicles on the closest road segments to the focus group cluster (FGC), measured in km/h	TomTom Move dataset, categorisation based on natural breaks	++ = ≤ 28 km/h; + = 28,1 – 32,5 km/h; ~ = 32,6 – 39 km/h; - = 39,1 – 43 km/h; -- = > 43 km/h
	Motorised traffic volume	Maximum motorised traffic counts on the closest road segments to the FGC, measured as vehicles per month	TomTom Move dataset, categorisation based on natural breaks	++ = ≤ 2152 veh; + = 2153 – 8982 veh; ~ = 8983 – 13432 veh; - = 13433 – 16659 veh; -- = > 16659 veh
Intersection and network conflict points	Intersection	Whether the FGC is at a point where more than two roads, paths, or traffic streams meet	Field observation / accident data	+ = NO; - = YES
	Intersection type	The type of intersection present at the FGC	Field observation / accident data	~ = not applicable; - = non-signalized; -- = roundabout; -- = signalized
	Distance to closest public transport stop or bicycle sharing station	Distance in meters from FGC to closest bus stop, tram stop, metro exit or WienMobil bicycle-sharing station, measured in m	Measured in QGIS	+ = > 25 m; - = ≤ 25 m
Street layout and space allocation	Road type	Classification of the road type at the FGC based on the number and marking of motorised traffic lanes; if several road types were present, the category with the most unfavourable expected impact on cyclist safety was used.	Field observation	++ = other (driveway; pedestrian zone); + = tertiary; ~ = secondary; -- = primary
	On-street parking	Presence and type of legal on-street parking within 25 m of the FGC	Field observation / Measured in QGIS	+ = NO; - = angled; - = parallel; - = perpendicular
	Tram tracks	Presence of tram tracks within 25 m that intersect with or share space with the cyclist route	Field observation / Measured in QGIS	+ = NO; - = YES
	Cycling infrastructure type	Type of cycling facility that cyclists have to use; if several types were present, the category with the most unfavourable expected impact on cyclist safety was used	Field observation	++ = 1-way separated; + = 2-way separated; + = bicycle street; + = living street; - = painted; - = multi-use; - = shared foot/cycle; -- = mixed traffic
Surface and topography	Surface conditions	Presence of major visible surface damage at the FGC, such as holes or missing asphalt	Field observation	+ = no damage present; -- = damage present
	Gradient	Maximum average slope of cyclist routes within 10 m of the FGC, measured in percent	Derived in QGIS from digital surface model	+ = flat (<1%), - = moderate (1–2%), -- = steep (>2%)

3.5 Qualitative analysis of hazardous road locations

The goal of the second part of the research was to interpret why particular locations emerge as cyclist accident hot spots and which infrastructural features may contribute to these patterns.

To do so, the accident data at the identified HRLs were first examined in detail. This included the assessment of recurring accident types, stated accident circumstances, and mode combinations. While the recurring accident types are listed for all accident groups, the latter two indicators only include accidents from the respective focus accident group.

This choice was made because accident types from different groups can sometimes be closely related. For example, accident type 322, "Vehicles turning left and vehicles going straight ahead", belonging to group 3, and accident type 411, "Collision whilst turning left", belonging to group 4, may occur at the same intersection. In both cases, left-turning motorists fail to yield to cyclists travelling either in the same or the opposite direction of travel (see section 4.3.3.1).

By contrast, this broader approach was not used for stated accident circumstances and mode combinations. These indicators were considered only within the respective focus accident group, because different accident groups can have very different typical circumstances and mode combinations. For example, intersection-related accident groups 3, 4, 5, and 9 are often linked to right-of-way violations, while accident group 7 "Conflicts with parked vehicles" is mainly linked to "opening car door" and "inattention / distraction". A similar difference can be seen in the mode combinations. While car/bicycle accidents are dominant in most accident groups, accident group 2 "Conflicts in opposing traffic" mainly includes bicycle/bicycle or bicycle/e-scooter accidents, and accident group 8 "Conflicts with pedestrians" mainly includes bicycle/pedestrian accidents. For these indicators, combining all accidents at one HRL would therefore often not be meaningful, especially at locations where many accidents of different groups occur.

It is important to note that stated accident circumstances are not always directly related to infrastructure. Some circumstances, such as unlawful behaviour or inattention, may primarily describe the behaviour of individual road users. However, these circumstances are not the main focus of this thesis. They are used only as supporting information where they help to interpret recurring accident patterns at the analysed HRLs.

The selected HRLs were then analysed using the operationalized indicators (see Table 5) related to traffic environment, intersection and conflict-point design, street layout and space allocation, and surface and topography. Each indicator was categorized into up to five classes according to its expected impact on cyclist safety. From best to worst, these were "++" for very favourable, "+" for somewhat favourable, "~" for neutral or not applicable, "-" for somewhat unfavourable, and "--" for very unfavourable conditions for cyclist safety.

3.6 RVS-based assessment and design recommendations

In the final part of the thesis, the analysed HRLs were assessed against the current RVS in order to identify whether the existing infrastructure complies with the guideline framework and where additions to the RVS may be needed. To do so, the main findings of the qualitative analysis were first summarised in bullet points for each accident group. These bullet points were then used as prompts for NotebookLM, an AI research tool that analyses specified input sources, to identify relevant sections of the current RVS *Bicycle Traffic* (for further details and ethical considerations, see Appendix C).

These relevant RVS sections were then applied to the analysed HRLs in order to assess their compliance. Compliance was categorised as full compliance, partial compliance, or non-compliance. For some criteria,

additional measurements of the road infrastructure were necessary. Widths and radii of the street infrastructure were measured in ArcGIS Pro using the Geoland Orthofoto 2024 with a resolution of 30 cm per pixel.

Finally, design recommendations were derived at two levels. First, physical design recommendations were developed for the HRLs themselves, meaning adjustments towards compliance with the current RVS. Second, policy design recommendations were made for the RVS guidelines, especially in cases where following the current RVS still did not seem sufficient and stricter or more context-sensitive rules appeared necessary.

3.7 Positionality and ethics

My positionality in this research is shaped by both personal and professional proximity to the topic. I lived in Vienna for three years during my bachelor studies and know the city well – academically and from an every-day perspective. I am a passionate cyclist, both for commuting and for sports, and I believe that cycling infrastructure in Vienna should be improved. At the same time, I also use other modes of transport, including walking, public transport, the car and the motorbike. This gives me an understanding of perspectives of different modes' users, but it does not make me neutral. My positive attitude towards improving cycling conditions influence the way I approach the topic.

My position is also shaped by previous work experience with the Austrian Road Safety Board (KFV, "Kuratorium für Verkehrssicherheit"), which is collaborating with me on this thesis. I completed an internship there, and later worked there as a freelancer. In addition, KFV provides financial compensation for the completion of the research. These connections are an advantage in terms of access, trust and practical relevance, but they also require reflexivity. They may influence how strongly I focus on producing practice-oriented outcomes. My aim is therefore not to claim objectivity in an absolute sense, but to be transparent about these influences.

From an ethical perspective, this research is not highly sensitive, as it does not include interviews or other direct participation by human subjects. The study is based mainly on secondary spatial data, police-reported accident data, and field observations in public space. Even though the accident data is georeferenced, the analysis does not focus on individual persons but on spatial patterns of cyclist crashes and infrastructural conditions at hot spot locations. Personal information that is not relevant to the research questions was not used in the analysis. The data was handled carefully and only used for scientific purposes within the scope of this thesis. The field observations were limited to public street space and focused on infrastructural characteristics, not on the behaviour or identity of individual road users. No personal data was collected during these observations.

Personal communication was only used as a reference after approval by the respective person. Although no formal interviews were conducted, some informal exchanges provided useful contextual information for the thesis. Where such information was cited, the exact indirect wording was shared with the respective person and only included after confirmation.

The use of generative AI also raised methodological and ethical considerations. These included questions of transparency, reliability, data privacy, copyright, and environmental impact. A more detailed reflection on the use of generative AI in this thesis is provided in Appendix C.

4 Results

This chapter presents the results of the analysis described in the previous section. It follows the same order as the methodological framework (see Figure 4). First, the results of the quantitative spatial analysis are presented, including the spatial clustering of cyclist accidents and the identified hazardous road locations. Second, the results of the case selection are shown. Third, the selected HRLs are analysed qualitatively, focusing on recurring accident patterns and the street characteristics present at each location. Together, these results provide the basis for the later RVS-based assessment and design recommendations.

4.1 Quantitative spatial analysis

The quantitative spatial analysis is structured in three parts. Firstly, the result of the Global Spatial Autocorrelation is presented, before showing the suitable distance bands through the Incremental Spatial Autocorrelation. Lastly, the result of the Hot Spot Analysis is presented through maps.

4.1.1 Moran's I Incremental Spatial Autocorrelation

Global Moran's I can indicate three general spatial patterns: dispersed, random, or clustered. A dispersed pattern would mean that accident locations are more evenly spread out than expected by chance. A random pattern would mean that there is no statistically significant spatial structure. A clustered pattern means that accident locations are located close to other accident locations more often than would be expected randomly (Esri, n.d.-b). Figure 8 depicts the results of the first part of the Moran's I test.

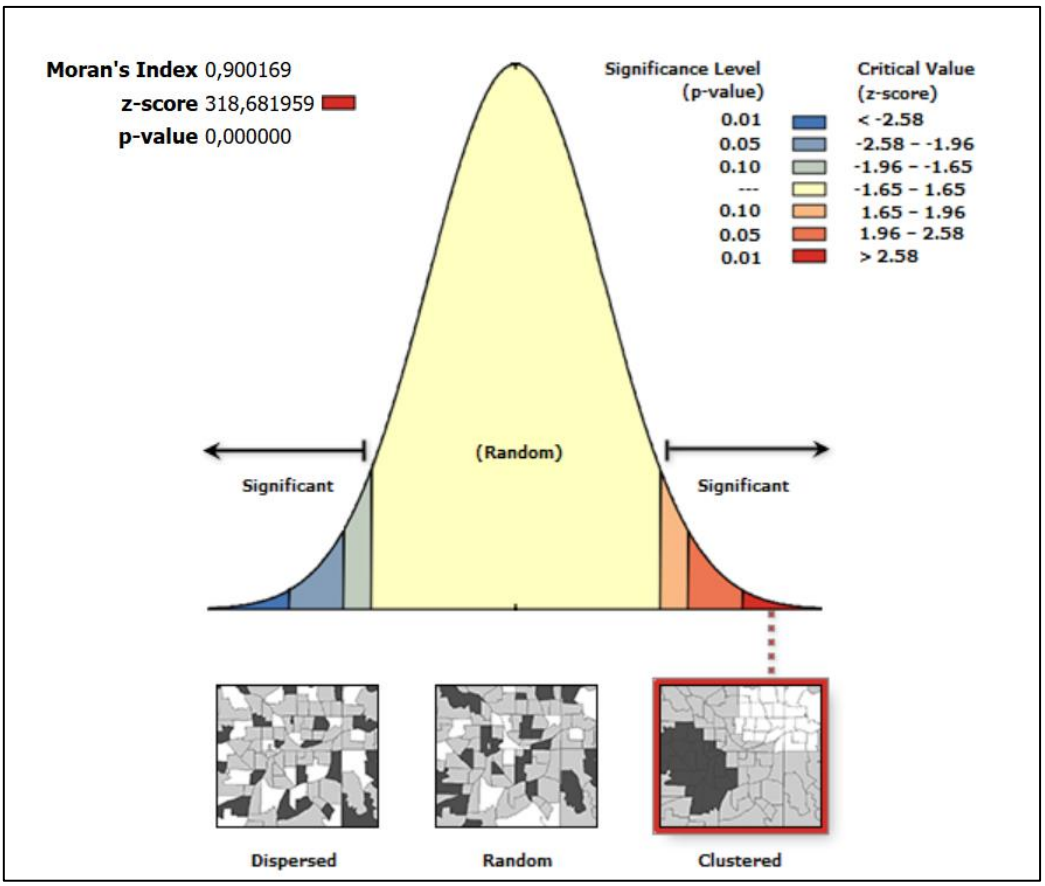


Figure 8: Global Spatial Autocorrelation of cycling accidents

In this study, the result does not support a dispersed or random pattern. The Global Moran's I result confirms that cyclist accidents are not randomly distributed across the study area, but show a clear global clustering pattern. The Moran's I value of 0,900169, together with a z-score of 318,681959 and a p-value of 0,000000, indicates a highly statistically significant clustered pattern. There is less than 1 percent likelihood that this clustered pattern could be the result of random chance. This means that the observed pattern is clearly on the clustered side of the distribution and supports the use of a local hot spot analysis.

The Incremental Spatial Autocorrelation (see Figure 9) then showed that clustering was especially pronounced at 250 m and 375 m, where local z-score peaks were identified. These distances were therefore taken forward as relevant candidate threshold distances for the following hot spot analysis.

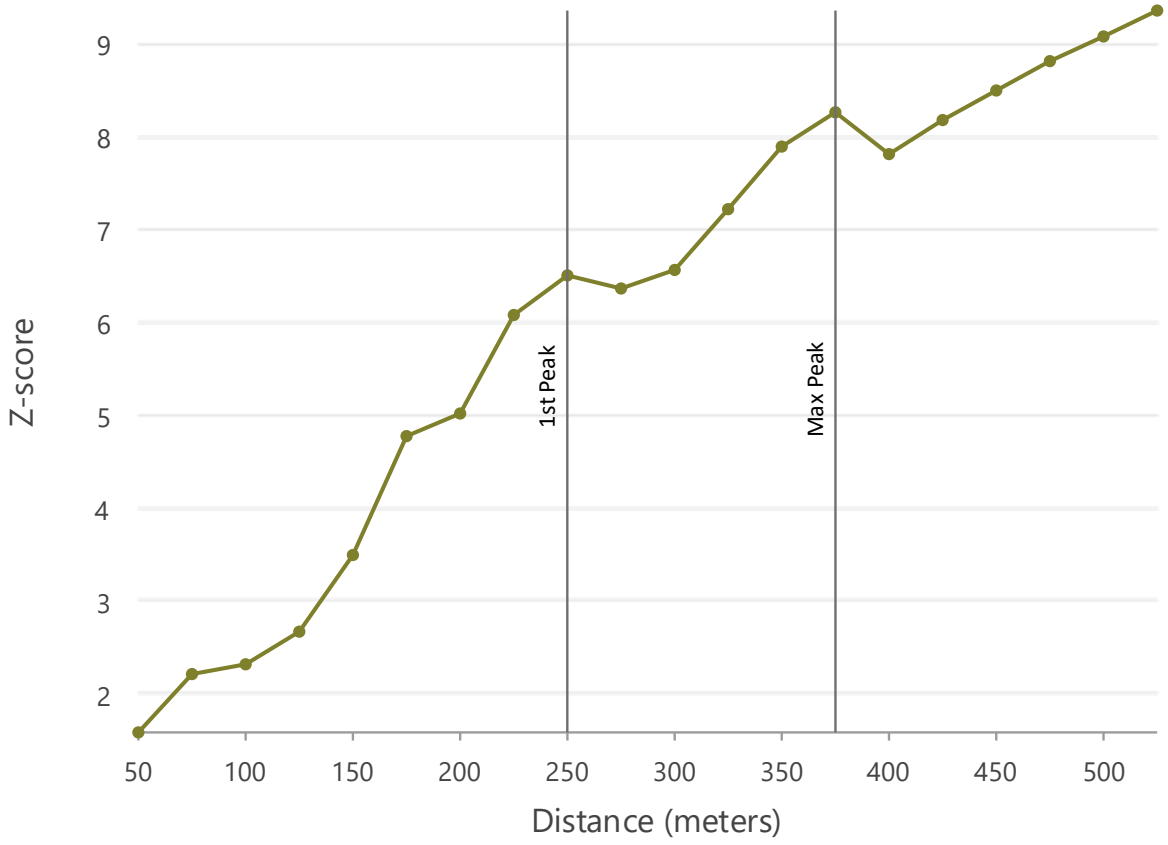


Figure 9: Graph of the Incremental Spatial Autocorrelation of cycling accidents by distance

The 250 m threshold was selected for the final analysis because it produced highly significant local hot spots and also matched the RVS reference to intersections or road sections of up to 250 m (FSV, 2014). By contrast, the 375 m threshold did not produce highly significant local hot spots in the Getis-Ord Gi* analysis and was therefore not used further.

4.1.2 Hot Spot Analysis (Getis-Ord Gi*)

The Hot Spot Analysis produced 91 highly significant hazardous road locations (HRLs) (see Figure 10).

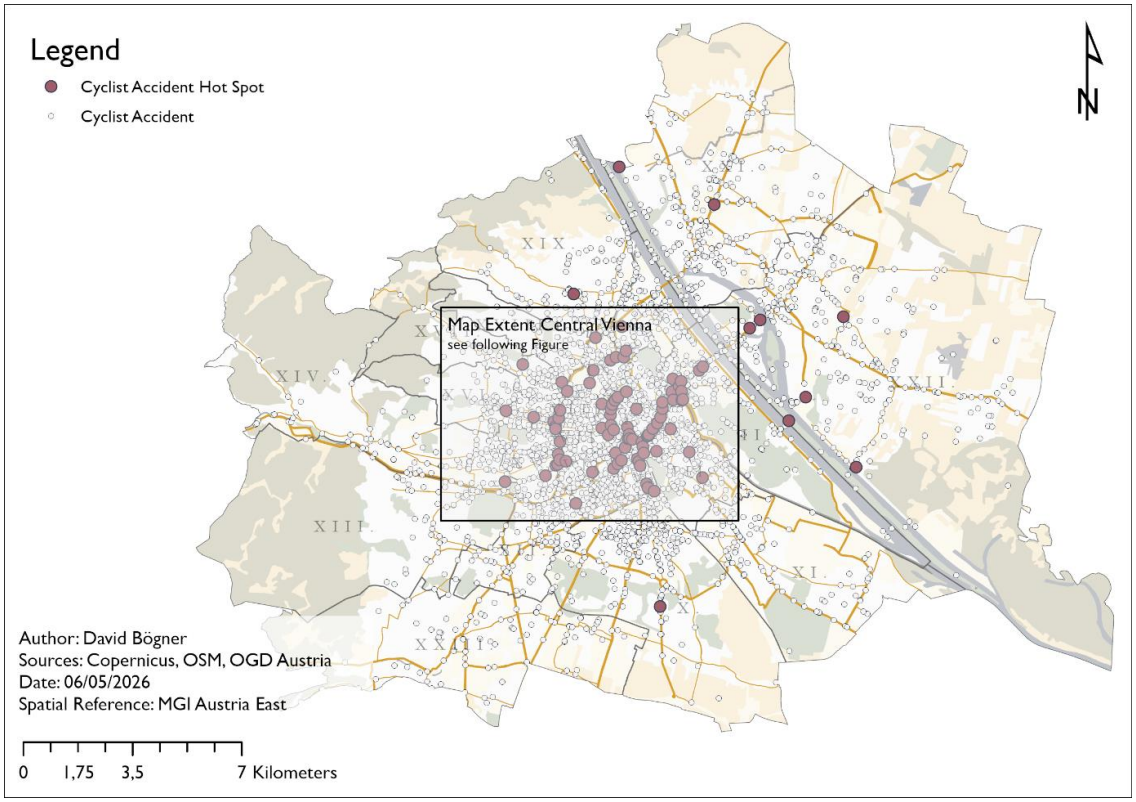


Figure 10: Highly significant hazardous road locations for cyclists in Vienna

Most of them are located in Central Vienna. This is expected as the share of cycling trips is significantly higher in more densely populated areas where average trip lengths are shorter (Millard-Ball et al., 2025). Figure 11 shows only the inner districts of Vienna, where 81 of the 91 locations are located:

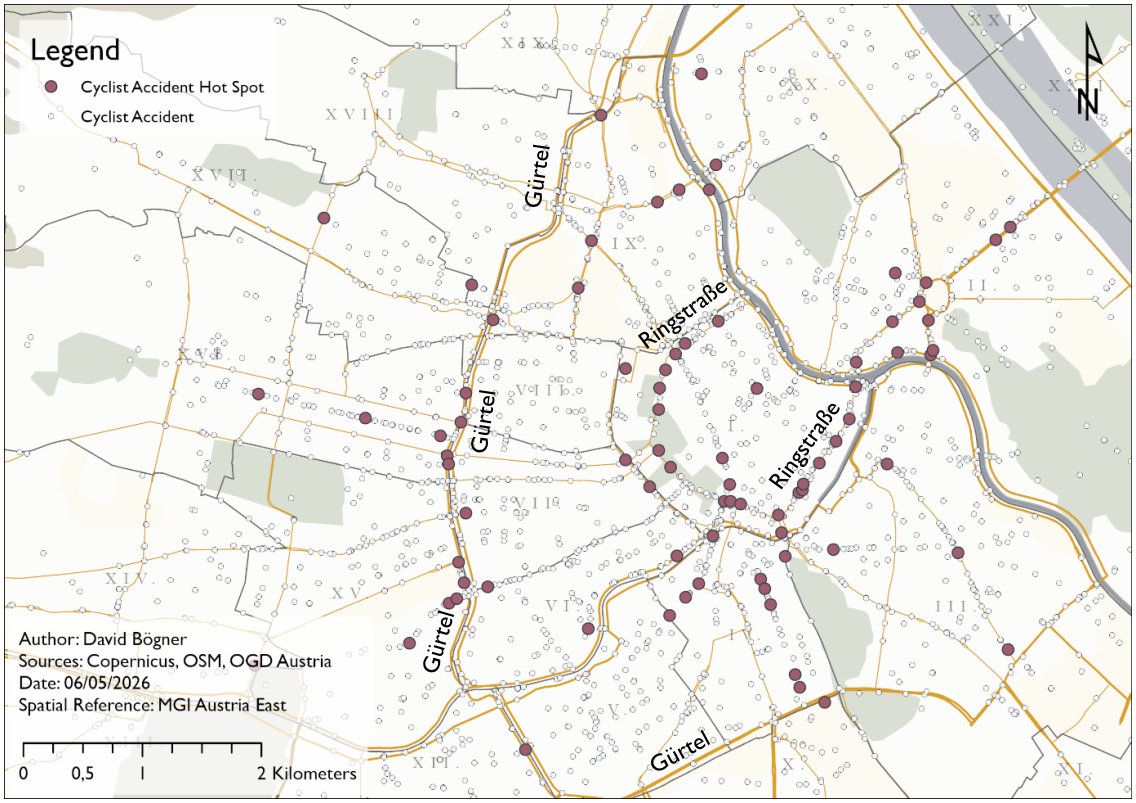


Figure 11: Highly significant hazardous road locations for cyclists in Central Vienna

In this map, some streets can be recognized as particularly hazardous, having multiple HRLs. The western part of the Gürtel, as well as the ring road "Ringstraße" stand out, having more than 10 HRLs each. This is likely due to large amounts of motorised traffic and cycling volumes and their resulting conflicts when crossing each other's paths.

4.2 Case selection

To find representative locations for the qualitative analysis, the 91 HRLs identified in the hot spot analysis first had to be narrowed down. This was necessary because the qualitative analysis focuses on locations where recurring cyclist accident patterns can be meaningfully related to the current street design. HRLs were therefore excluded if they did not show a clear pattern by accident group, if they only involved accidents with light injuries, or if the infrastructure had changed substantially since the accident period.

Following the RVS-based validation defined in section 3.1, 9 of the 91 identified HRLs were excluded because no clear pattern by accident group was visible. In other words, no single accident group was represented at least three times within the last three years.

Of the remaining 82 HRLs, 22 were excluded because only accidents with light injuries occurred at these locations. As the thesis focuses on the most critical safety problems, priority was given to locations where cyclists were seriously injured or killed. This follows the Safe System approach and the Austrian Road Safety Strategy, which aim to prevent serious injuries and fatalities on Austrian roads.

Of the remaining 60 HRLs, a further 14 were excluded because they underwent major infrastructural transformations between 2022 and 2026, or were under construction at the time of the field observation. After these exclusion steps, 46 HRLs remained as potential locations for the final representative case selection.

A map of the final selected locations is shown in Figure 12. For readability, the map focuses on the main map extent used in the qualitative analysis. Ten HRLs were located outside this map extent and are therefore not shown in Figure 12. These locations were not excluded because of their peripheral location; they were assessed using the same selection criteria as all other HRLs. Their reasons for exclusion are shown in Appendix D.

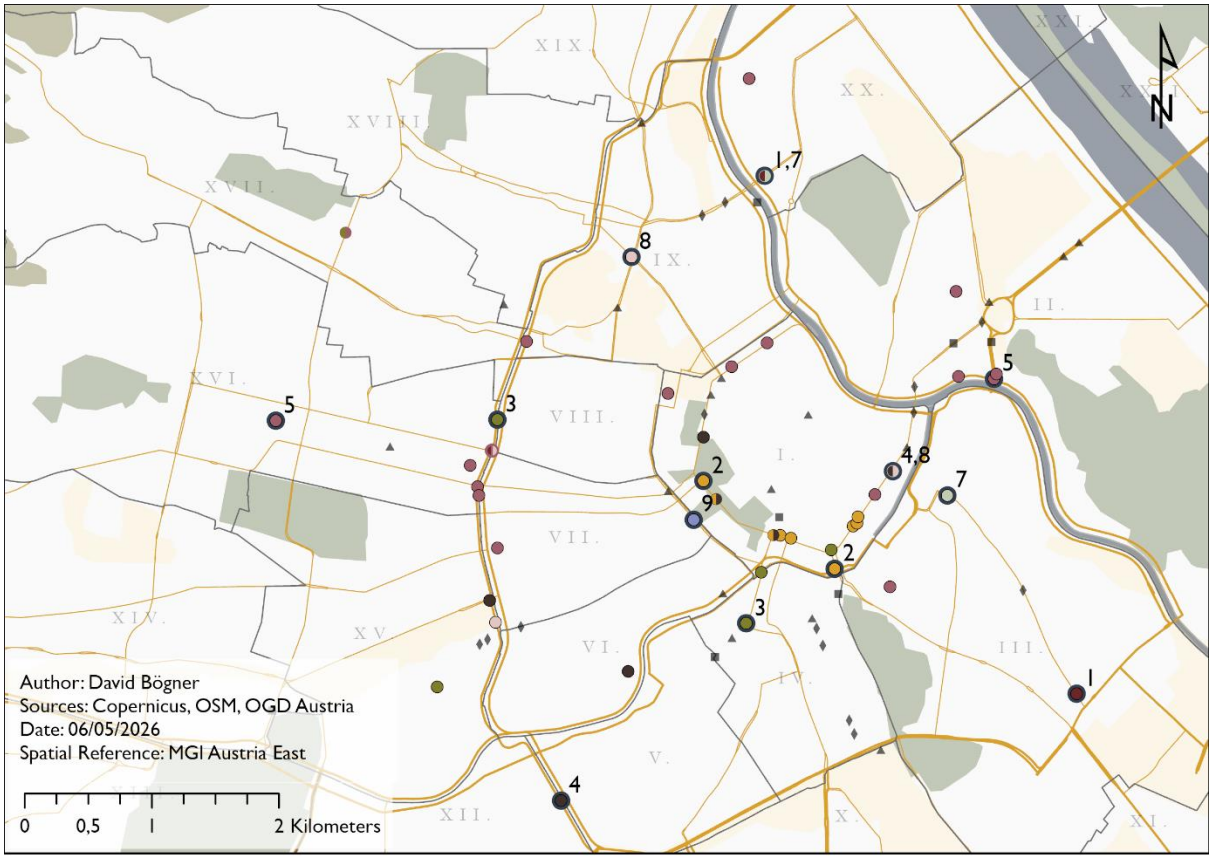


Figure 12: Case Selection Map of Central Vienna

Figure 12 shows the HRLs that remained after the exclusion steps and were considered for the final case selection. Each point represents an HRL with at least three accidents from the same accident group within the three-year study period. The colour of the point indicates the accident group that occurs most often at that location. If two or three accident groups occur equally often, the point is shown with more than one colour. These combinations are used only to show that more than one accident group is relevant at the same HRL; they are not treated as separate categories in the analysis.

The following sections then present the selected cases by accident group. For each accident group, a maximum of two HRLs was selected for detailed qualitative analysis. In some cases, one HRL can be relevant for more than one accident group if both groups are equally represented at that location.

Eight of the nine accident groups, defined by the RVS *Road Safety Analysis*, were represented as the accident type of hot spot locations found in the hot spot analysis. The only group that does not cluster in

specific locations is Group 0 "single-bicycle accidents". However, this could also be explained by the underreporting of single-bicycle accidents (M. Donabauer, personal communication, 16 April 2026).

Whereas for group 9 only one hot spot could be identified, for all others, a minimum of two hot spots were found. It is also worth noting that some hot spots are classified in more than one category. This is because at these locations, accidents of multiple types tend to occur equally frequently.

4.3 Qualitative hot spot analysis

The results of the qualitative hot spot analysis are sorted by accident group, each group having a maximum of two HRLs as case studies. HRLs that are classified in more than one category are analysed multiple times from the angle of their category to prevent generalization. The structure of the analysis is as follows: firstly, the HRL is located on a map displaying all accidents involving cyclists in the studied timeframe. The detailed accident types can be looked up in Appendix A using the accident type ID, which is also used to label the accident points in the map. Also, photos from the field observations are marked and displayed on the right side of the map. Thereafter, recurring accident patterns of cycling accidents from the analysed group are being extracted from the detailed accident report and ranked based on frequency. At last, the operationalized indicators for the four factors contributing to cyclist accidents are classified qualitatively, before synthesising the different parts briefly.

4.3.1 Group 1: Conflicts in same-direction traffic

4.3.1.1 Landstraßer Hauptstraße I

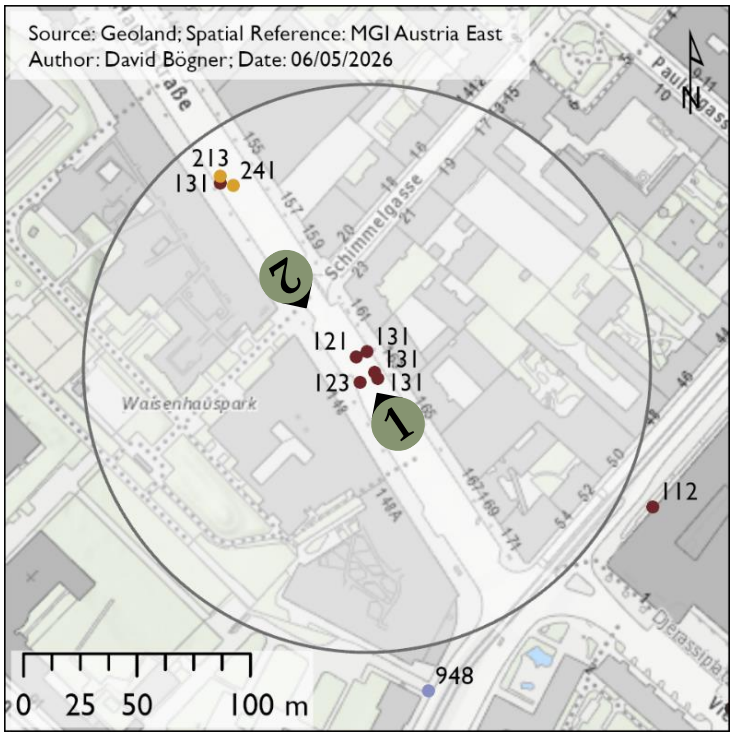


Figure 15: Cycling accidents at HRL Landstraßer Hauptstraße I



Figure 13: NW view Landstraßer Hauptstr. toward centre



Figure 14: SE view Landstraßer Hauptstr. toward Schlachthausgasse

This HRL is located in the 3rd district in the southeast of Vienna, along Landstraßer Hauptstraße. It also includes two other streets, but as no cycling accidents occurred there, the focus is clearly on the cluster of same-direction conflicts at Landstraßer Hauptstraße 163. Further northwest, approximately 100 metres from the cluster, there is another cluster of accidents, two of which are "conflicts in opposing traffic" and one of which is another "conflict in same-direction traffic".

On both sides of the Landstraßer Hauptstraße, cars are parked at an angle, with one extending into the painted cycle lane, as seen in Figure 14. At the same spot, the designated cycling infrastructure ends, and cyclists are expected to share the street with other modes.

Table 6 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 6: Recurring cyclist accident patterns at HRL Landstraßer Hauptstraße I

Indicator	Results
Recurring accident types	 131: Rear-ending a moving vehicle on a straight stretch of road (4)
Recurring stated accident circumstances	Inattention / distraction (6), Fall from vehicle (5), Collision with moving vehicle (4), Changing lane (2), Right-of-way violation / failure to yield (2)
Recurring mode combinations	car/bicycle (4)

The only recurring accident type is rear-ending accidents between moving vehicles on a straight stretch of road. This type occurred four times within the studied timeframe of three years. The main accident circumstance within the accident group is "inattention / distraction", which was recorded six times. Two of the accidents each happened partly because of lane changing and right-of-way violations. These two stated circumstances could be directly related to the painted cycling path and angled parking, which force cyclists to change lanes. The only recurring mode combinations were collisions between cars and bicycles.

Table 7 displays the expected safety impact of the street characteristics of the HRL.

Table 7: Street characteristics contributing to cycling accidents at HRL Landstraßer Hauptstraße I

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	40 km/h	-
	Motorised traffic volume	8982 veh	+
Intersection and network conflict points	Intersection	NO	+
	Intersection type	/	
	Distance to closest public transport stop or bicycle sharing station	122 m	+
Street layout and space allocation	Road type	secondary	~
	On-street parking	angled	-
	Cycling infrastructure type	painted	-
	Tram tracks	NO	+
Surface and topography	Surface conditions	no damage present	+
	Gradient	flat	+

Three of the assessed indicators, namely motorised traffic volume, on-street parking and cycling infrastructure type, indicate potential risk factors for cyclists. On the one hand, above-average car speeds may contribute to cyclist accident risk at this HRL. This could partly be related to the fact that the location is one of the few HRLs that is not directly situated at an intersection, meaning that motorists are less likely to slow down because of turning movements or signal control. However, the measured speed of 40 km/h is still below the legal speed limit of 50 km/h. Therefore, the issue is not mainly illegal speeding, but rather the relatively high operating speed compared with other HRLs. On the other hand, on-street parking, especially in an angled manner directly at the hot spot, is certainly not ideal for cyclists' safety. Larger vehicles often require more space than the assigned parking space, extending into the cyclists' painted cycle lane and forcing them to diverge from their preferred line of travel. The third negatively classified factor is the cycling infrastructure type. While cycling infrastructure is present, the painted cycle lane is regarded as less safe than other types of infrastructure.

In summary, there is no clear link between the occurrence of accidents involving cyclists and the researched indicators. However, the clustering of rear-ending a moving vehicle on a straight stretch of road, in combination with multiple negative factors and related accident circumstances, suggests that the angled parking directly next to the painted cycling path appears to be an important contributor to the occurrence of accidents.

4.3.1.2 Wallensteinstraße

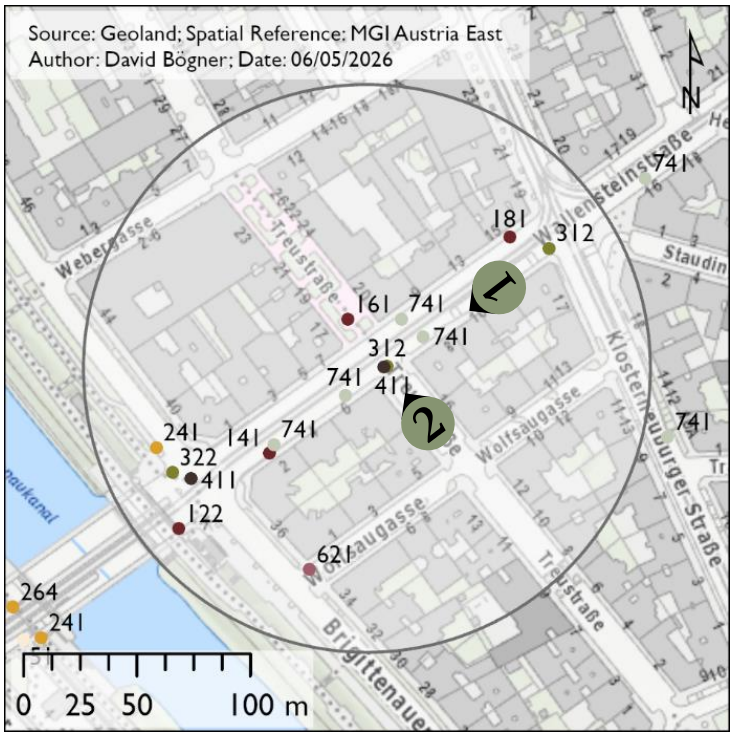


Figure 18: Cycling accidents at HRL Wallensteinstraße



Figure 16: SW view Wallensteinstr. toward Donaukanal



Figure 17: NW view Treustraße

This HRL is located in the 20th district in the northeast of Vienna, along Wallensteinstraße. Apart from that street, there was also one accident in Wolfsaugasse. In this section of Wallensteinstraße, no clear cluster at one specific location emerges. Instead, the accidents are spread out between the intersections with Brigittenauer Lände and Klosterneuburger Straße. The two largest groups are conflicts in same-direction traffic and conflicts with parked vehicles. This section focuses on the former, while section 4.3.6.2 focuses on the latter.

It is important to note that the part of Treustraße on the opposite side of the intersection depicted in Figure 17 was redesigned as a pedestrian zone in 2024 (Google Street View, 2024). Table 8 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 8: Recurring cyclist accident patterns at HRL Wallensteinstraße

Indicator	Results
Recurring accident types	 741: Drive past on the left of the parking vehicle (4),  312: Vehicles turning right and vehicles going straight ahead (2)
Recurring stated accident circumstances	Inattention / distraction (3), Fall from vehicle (3), Insufficient safety distance (2), Collision with stationary vehicle (2)
Recurring mode combinations	car/bicycle (2)

The only recurring accident types are four accidents of type "drive past on the left of the parking vehicle" and two accidents of type "vehicles turning right and vehicles going straight ahead". Both types are not represented in group 1, conflicts in same-direction traffic, which is the main focus group of this subsection. All accidents that occurred within that group were of different accident types. The main accident circumstances within the accident group are "inattention / distraction" and "fall from vehicle", each recorded three times. "Insufficient safety distance", which was stated twice, indicates possible infrastructural shortcomings. The only recurring mode combinations were collisions between cars and bicycles.

Table 9 displays the expected safety impact of the street characteristics of the HRL in discussion.

Table 9: Street characteristics contributing to cycling accidents at HRL Walllensteinstraße

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	29 km/h	+
	Motorised traffic volume	9863 veh	~
Intersection and network conflict points	Intersection	NO	+
	Intersection type		
	Distance to closest public transport stop or bicycle sharing station	88 m	+
Street layout and space allocation	Road type	secondary, tertiary, other	~
	On-street parking	parallel	-
	Cycling infrastructure type	mixed traffic	--
	Tram tracks	YES	--
Surface and topography	Surface conditions	no damage present	+
	Gradient	moderate	-

At HRL Wallensteinstraße, four indicators have an expected negative effect on cyclist safety. While the traffic environment and intersection and network conflict points have no negative effect, the street layout and space allocation and surface and topography are important factors. Firstly, parallel on-street parking on both sides of Wallensteinstraße creates a dooring risk. Additionally, cyclists are expected to cycle in mixed traffic, as no separate cycling infrastructure is available. This, together with the presence of tram tracks, is a negative factor influencing cyclist safety. A moderate street gradient towards the northeast further contributes to safety risks.

In summary, there is no distinct location where conflicts in same-direction traffic occur. In general, accidents of several different types and groups occur in this road segment, indicating a general mismatch between the street layout and space allocation and cyclist safety. This argument is strengthened by the fact that there is currently no designated cycling infrastructure.

4.3.1.3 Synthesis

For the accident group of "conflicts in same-direction traffic", the qualitative analysis mainly pointed to problems at streets with **on-street parking** and **inadequate cycling infrastructure**. At the analysed HRLs, cyclists and motor vehicles move in the same direction, and the recurring conflicts seem to be linked especially to **close passing**, and **narrow cycling space**.

4.3.2 Group 2: Conflicts in opposing traffic

4.3.2.1 Burgring

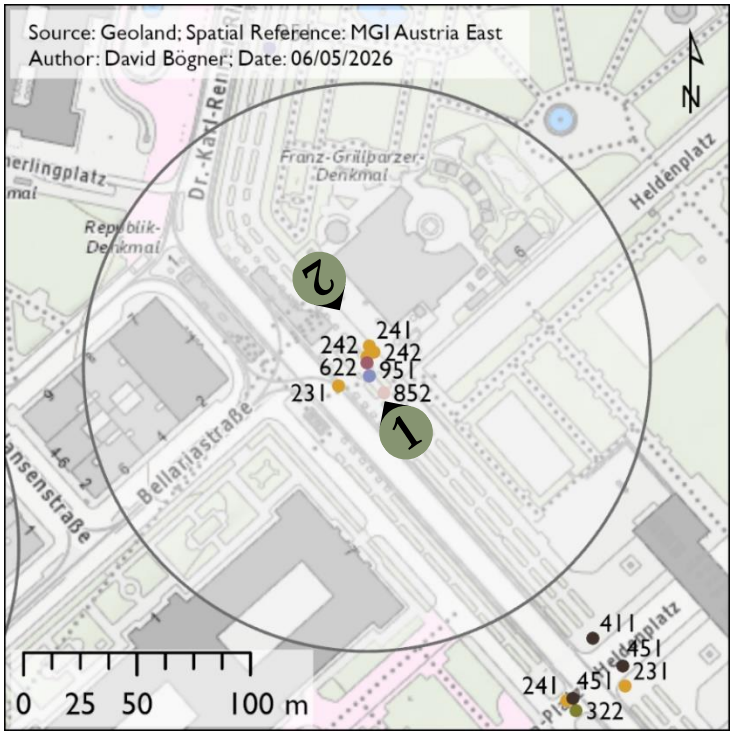


Figure 21: Cycling accidents at HRL Burgring



Figure 19: NW view toward Metro station



Figure 20: SE view Burgring toward Heldenplatz

This HRL is located in the 1st district in the centre of Vienna, along the cycle path next to Burgring. All accidents cluster within a diameter of 25 metres in front of the exit of metro station Volkstheater. The largest group of accidents are conflicts in opposing traffic, which is the focus group of this subsection. All other groups are only represented by a maximum of one accident.

Trees acting as obstacles are visible in Figure 19 and Figure 20. Apart from that, Figure 20 shows two further possible safety implications. Firstly, the electrical distribution boxes on the right of the image may hinder cyclists' view of oncoming traffic, especially from the right side. In addition, pedestrians are forced to cross the cycle path in order to move along Burgring.

Table 10 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 10: Recurring cyclist accident patterns at HRL Burgring

Indicator	Results
Recurring accident types	 242: Head-on collision on a bend (2)
Recurring stated accident circumstances	Fall from vehicle (6), Inattention / distraction (3), Left roadway departure (3), Insufficient right-hand driving (3), Improper / unlawful behavior (2), Evasive maneuver / swerving (2), Inappropriate speed (2)
Recurring mode combinations	bicycle/bicycle (3)

The only recurring accident type are two "head-on collisions on a bend". The main accident circumstance within the accident group is "fall from vehicle", which was recorded six times. circumstances that could be linked to inadequate street design are "insufficient right-hand cycling" (3), "left roadway departure" (3), and "inappropriate speed" (2). The only recurring mode combinations were three collisions between bicycles.

Table 11 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 11: Street characteristics contributing to cycling accidents at HRL Burgring

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	56 km/h	--
	Motorised traffic volume	60363 veh	--
Intersection and network conflict points	Intersection	YES	-
	Intersection type	non-signalized	-
	Distance to closest public transport stop or bicycle sharing station	3 m	-
Street layout and space allocation	Road type	primary	--
	On-street parking	NO	+
	Cycling infrastructure type	2-way separated	+
	Tram tracks	YES	--
Surface and topography	Surface conditions	damage present	--
	Gradient	moderate	-

At HRL Burgring, the street characteristics contributing to cycling accidents appear to be crucial, with 9 of the 11 indicators scoring negatively. The two indicators for traffic environment, motorised traffic speed and motorised traffic volume, appear to be very negative. However, cyclists only interact with motorists when they cross Ringstraße, one of Austria's busiest roads, at a signalised intersection. The location of the accident cluster is beside the primary road, on the cycle path. While cyclists usually do not conflict with motorised traffic, there is a public transport station and a bicycle sharing station in direct proximity (see Figure 19, metro station straight ahead, bicycle sharing station on the left). These two stations are responsible for pedestrian traffic possibly conflicting with cyclists. Similar to the traffic environment indicators, tram tracks are only crossed perpendicularly at the signalised intersection and can therefore be regarded as less influential. Surface conditions do seem to contribute to cyclist safety, as holes were present on the surface coming from the northwest of the intersection. Also, the surface change next to the trees, from asphalt to metal, could lead to potential hazards because of increased slipperiness, especially when wet.

In summary, a connection between injury accidents involving cyclists and street characteristics is likely at HRL Burgring. The cluster of accidents between opposing traffic at the intersection is evident, and the large number of indicators scoring negatively suggests shortcomings in the design of the intersection.

4.3.2.2 Schwarzenbergplatz

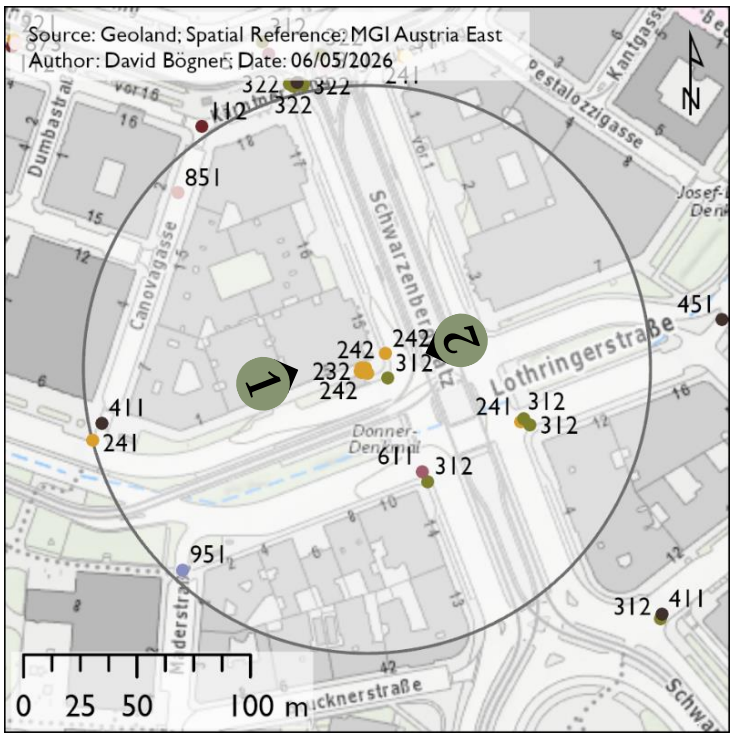


Figure 24: Cycling accidents at HRL Schwarzenbergplatz



Figure 22: E view Lothringerstraße



Figure 23: W view Lothringerstraße

This HRL is located in the 1st district in the centre of Vienna, at the intersection of Lothringerstraße and Schwarzenbergplatz. Clear clusters emerge on three of the four corners of the main intersection. The most prominent cluster is located northwest of the intersection and includes 13 accidents, 12 of which are conflicts in opposing traffic. In total, four turning accidents in the same direction of travel also occurred at this intersection, but with much less weight compared to the cluster of conflicts in opposing traffic.

In Figure 22 and Figure 23 it is clearly visible that there was construction work at the time of the field observations[2], the grey service building forcing the cycle path into an S-curve is expected to remain after the construction is finished, as it was also present before the construction started. The service building is located in a way that cyclists cannot see oncoming traffic, and the curve is designed in a way that it is only possible to pass through at reduced speeds. The pillars visible in Figure 23 act as additional obstacles for cyclists, but will likely be removed once the construction is finished.

Table 12 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 12: Recurring cyclist accident patterns at HRL Schwarzenbergplatz

Indicator	Results
Recurring accident types	 242: Head-on collision on a bend (7),  312: Vehicles turning right and vehicles going straight ahead (4),  232: Side-on collision on a bend (3),  241: Head-on collision on the straight (2)
Recurring stated accident circumstances	Fall from vehicle (21), Visibility obstruction by vehicle/object (14), Insufficient right-hand driving (13), Improper / unlawful behavior (6), Inappropriate speed (4), Failure to comply with prescribed direction of travel (4), Inattention / distraction (2)
Recurring mode combinations	bicycle/bicycle (5), e-scooter/bicycle (5)

There are multiple recurring accident types at HRL Schwarzenbergplatz, with "head-on collision on a bend" being the most frequent type, followed by "vehicles turning right and vehicles going straight ahead", "side-on collision on a bend" and "head-on collision on the straight". The main accident circumstance within the accident group is "fall from vehicle", which was recorded 21 times. circumstances that could be linked to inadequate street design are "visibility obstruction by vehicle/object" (14), "insufficient right-hand driving" (13) and "inappropriate speed" (4). The mode combinations of bicycles colliding with bicycles and bicycles colliding with electric scooters occurred five times each.

Table 13 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 13: Street characteristics contributing to cycling accidents at HRL Schwarzenbergplatz

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	43 km/h	-
	Motorised traffic volume	28415 veh	--
	Intersection	YES	-

[2] The construction work started after August 2025 and was therefore not present during the time period of the accident data (Google Street View, 2025).

Intersection and network conflict points	Intersection type	signalized	--
	Distance to closest public transport stop or bicycle sharing station	18 m	-
Street layout and space allocation	Road type	primary	--
	On-street parking	NO	+
	Cycling infrastructure type	2-way separated	+
	Tram tracks	YES	--
Surface and topography	Surface conditions	no damage present	+
	Gradient	moderate	-

Similar to HRL Burgring, HRL Schwarzenbergplatz scores negatively on 8 of the 11 indicators contributing to cyclist safety. High motorised traffic volume and motorised traffic speed on the adjacent roads do not affect cyclist safety as strongly, as separate cycling infrastructure is available and most accidents occurred between non-motorised modes. The HRL is also located at a large signalised intersection in close proximity to a bus stop, making conflicts with other modes of transport likely. The indicators serving as measurements for street layout and space allocation are partly positive and partly negative. The primary road types of Schwarzenbergplatz and Lothringerstraße and tram tracks present at the intersection are additional potential risk factors. Additionally, a moderate gradient towards the east is expected to have a negative impact on cycling safety.

In summary, the clear cluster in the Northwest of the intersection, combined with the high number of similar accidents hint towards shortcomings in the provision of cycling infrastructure. At the field observation the prominent circumstance visibility obstruction by vehicle/object, stated 14 times, was recognized as a factor likely leading to accidents.

4.3.2.3 Synthesis

For the accident group of "conflicts in opposing traffic", the qualitative analysis mainly pointed to problems occurring on **two-way separated cycle paths**. At both HRLs, **obstacles** were present both in the middle of the cycle path and along the side of the path, impairing **visibility** and **creating conflicts in combination with sharp turns**. Common infrastructure-related stated circumstances at both HRLs were **inappropriate speed, potentially strengthened by the moderate gradients present**, and **insufficient right-hand cycling**. The qualitative analysis of street characteristics further points towards conflicts caused by a high likelihood of interaction between cyclists or e-scooter drivers.

4.3.3 Group 3: Turning conflicts in the same direction of travel

4.3.3.1 Lerchenfelder Gürtel

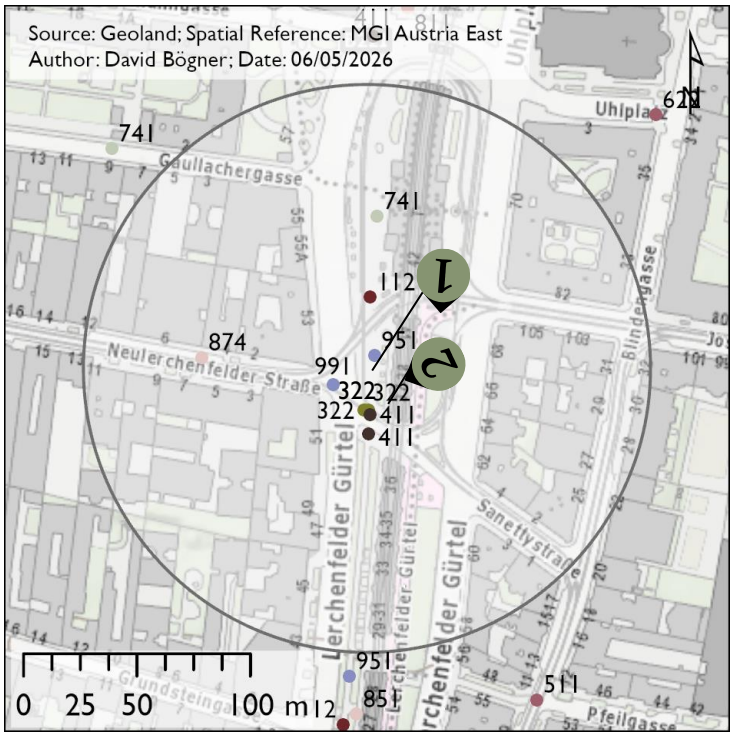


Figure 27: Cycling accidents at HRL Lerchenfelder Gürtel



Figure 25: S view Lerchenfelder Gürtel

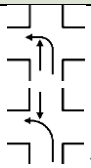


Figure 26: SW view Lerchenfelder Gürtel

This HRL is located in western Vienna, at the intersection of Neulerchenfelder Straße and Lerchenfelder Gürtel. The location where the majority of accidents happened, is the signalised intersection between Lerchenfelder Gürtel heading south and its left turn through the underpass towards the centre of Vienna. At this location, seven accidents accumulated within 10 metres, including several turning conflicts in the same direction of travel, several turning conflicts in the opposite direction of travel and other accidents.

Figure 25 and Figure 26 show the discussed intersection, where the majority of accidents occurred. It is worth noting that the traffic light for cyclists heading south and the traffic light for motorists travelling in the same direction turn green simultaneously. Motorists turning left from Lerchenfelder Gürtel also do not have a separate lane. The tram has a separate green phase. Table 14 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 14: Recurring cyclist accident patterns at HRL Lerchenfelder Gürtel

Indicator	Results
Recurring accident types	 322: Vehicles turning left and vehicles going straight ahead (3), 411: Collision whilst turning left (2)
Recurring stated accident circumstances	Fall from vehicle (3), Right-of-way violation / failure to yield (3)
Recurring mode combinations	car/bicycle (3)

There are two recurring accident types at HRL Lerchenfelder Gürtel. Both involve vehicles turning left from the main road into the underpass: one with cyclists heading south and one with cyclists heading north. Together with the main accident circumstances, "fall from vehicle" and "right-of-way violation / failure to yield", both of which were recorded for every accident at the intersection, this creates a clear accident pattern. The only recurring mode combination is collisions between bicycles and cars.

Table 15 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 15: Street characteristics contributing to cycling accidents at HRL Lerchenfelder Gürtel

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	40 km/h	-
	Motorised traffic volume	6756 veh	+
Intersection and network conflict points	Intersection	YES	-
	Intersection type	signalized	--
	Distance to closest public transport stop or bicycle sharing station	40 m	+
Street layout and space allocation	Road type	primary, secondary, tertiary	--
	On-street parking	NO	+
	Cycling infrastructure type	2-way separated	+
	Tram tracks	YES	--
Surface and topography	Surface conditions	no damage present	+
	Gradient	Steep	--

At HRL Lerchenfelder Gürtel, six indicators have an expected negative effect on cyclist safety. As each factor includes at least one positive and one negative indicator, none of the factors can be ruled out as having an effect on cyclist safety. The 85th percentile speed of 40 kilometres per hour is high, especially for an intersection where motorists have to give way to cyclists. While the motorised traffic volume seems low, it only accounts for motorists turning left through the underpass. The traffic volume going straight is expected to be much higher. The HRL being located at a signalised intersection also has a negative effect on cyclist safety. Additionally, street layout and space allocation indicators, such as the location next to a primary road and cyclists having to cross tram tracks diagonally, further add to the hazard. While the surface is not visibly damaged, the street and cycle path face steeply downhill towards the south. Therefore, it can be expected that cyclists arrive at the intersection at high speeds when travelling southbound.

In summary, this intersection shows a clear accident pattern of motorists turning left and not yielding for oncoming cyclists approaching from either side. The fact that every accident includes a stated right-of-way violation further strengthens this pattern. With both motorised traffic and cyclists lawfully travelling at high speeds when heading south, the effects of a mismatch between infrastructure and its usage become visible.

4.3.3.2 *Margaretenstraße*

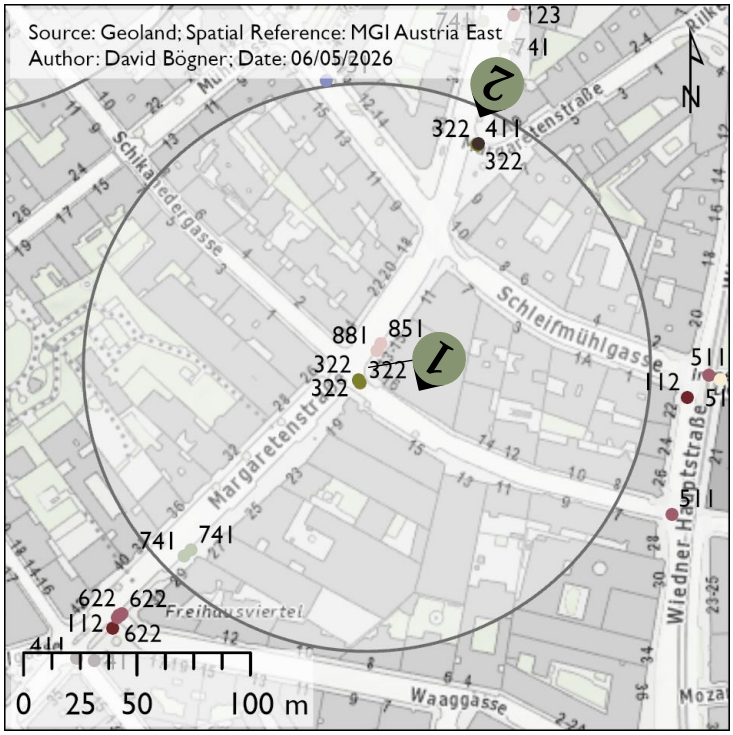


Figure 30: Cycling accidents at HRL Margaretenstraße



Figure 28: SW view Margaretenstraße/Paulanergasse

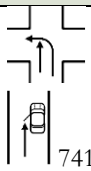


Figure 29: SW view Margaretenstraße/Margaretenstr.

This HRL is located in the 4th district in the southwest of Vienna, at the intersection of Margaretenstraße and Paulanergasse. The part of this HRL where most injury accidents involving cyclists occurred is the non-signalised intersection between Margaretenstraße heading south and its left turn into Paulanergasse. At this location, three turning conflicts in the same direction of travel and two conflicts with pedestrians occurred. Another cluster of accidents occurred 100 metres further north and south of the centre of this HRL, with the main groups being turning conflicts in the same direction of travel and conflicts with parked cars, respectively.

Figure 28 shows the non-signalised intersection where the majority of the turning conflicts occurred in the direction of motorised traffic. Similarly, Figure 29 shows the location of the cluster further north. Two important aspects to take into account are that motorists have their own lane for left turns at the main intersection but not at the intersection further north. Table 16 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 16: Recurring cyclist accident patterns at HRL Margaretenstraße

Indicator	Results
Recurring accident types	 322: Vehicles turning left and vehicles going straight ahead (5), 741: Drive past on the left of the parking vehicle (2)
Recurring stated accident circumstances	Right-of-way violation / failure to yield (5), Fall from vehicle (4), Inappropriate speed (2)
Recurring mode combinations	car/bicycle (5)

There are two recurring accident types at HRL Margaretenstraße. "Vehicles turning left and vehicles going straight ahead" mostly occurred at the central and northern clusters. At the southern cluster, cyclists had accidents while driving past on the left of a parking vehicle. The main accident circumstance within the accident group is "right-of-way violation / failure to yield", which was recorded five times. "Inappropriate speed" is an infrastructure-related recurring circumstance, which was stated twice. All five accidents involved bicycles and cars.

Table 17 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 17: Street characteristics contributing to cycling accidents at HRL Margaretenstraße

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	39 km/h	~
	Motorised traffic volume	9772 veh	~
Intersection and network conflict points	Intersection	YES	-
	Intersection type	non-signalized	-
	Distance to closest public transport stop or bicycle sharing station	104 m	+
Street layout and space allocation	Road type	secondary, tertiary	~
	On-street parking	parallel	-
	Cycling infrastructure type	2-way separated	+
	Tram tracks	NO	+
Surface and topography	Surface conditions	no damage present	+
	Gradient	flat	+

At HRL Margaretenstraße, three indicators have an expected negative effect on cyclist safety. While the traffic environment and surface and topography have no negative effect, intersection and network conflict points and street layout and space allocation include indicators scoring negatively. Firstly, the location at a non-signalised intersection creates crossing paths with other road users, which could lead to potential conflicts. The only negative indicator of street layout and space allocation is the presence of on-street parking.

In summary, this HRL consists of multiple hot spots, two of which are classified as predominantly turning conflicts in the same direction of travel, the focus of this analysis. Both of these locations show similar accident patterns, with motorists mostly turning left into tertiary roads, crossing the cycle path and not seeing oncoming cyclists in their left blind spot, leading to collisions.

4.3.3.3 Synthesis

For the accident group of "turning conflicts in the same direction of travel", the qualitative analysis mainly pointed to problems occurring on **two-way** separated cycle paths that are **crossed by turning motorists at intersections**. At both HRLs, "**right-of-way violation / failure to yield**" was the most prominent stated accident circumstance. Speed also appears to be an issue: at Lerchenfelder Gürtel, motorised traffic speeds are **high**, while at Margaretenstraße, "**inappropriate speed**" was commonly

stated as an accident circumstance. In both cases, **blind spots** to the left of the turning vehicle appear to be a major accident contributor. One location is signalised but gives cyclists and motorists the same green phase, while the other is non-signalised.

4.3.4 Group 4: Turning conflicts in the opposite direction of travel

4.3.4.1 Gaudenzdorfer Gürtel

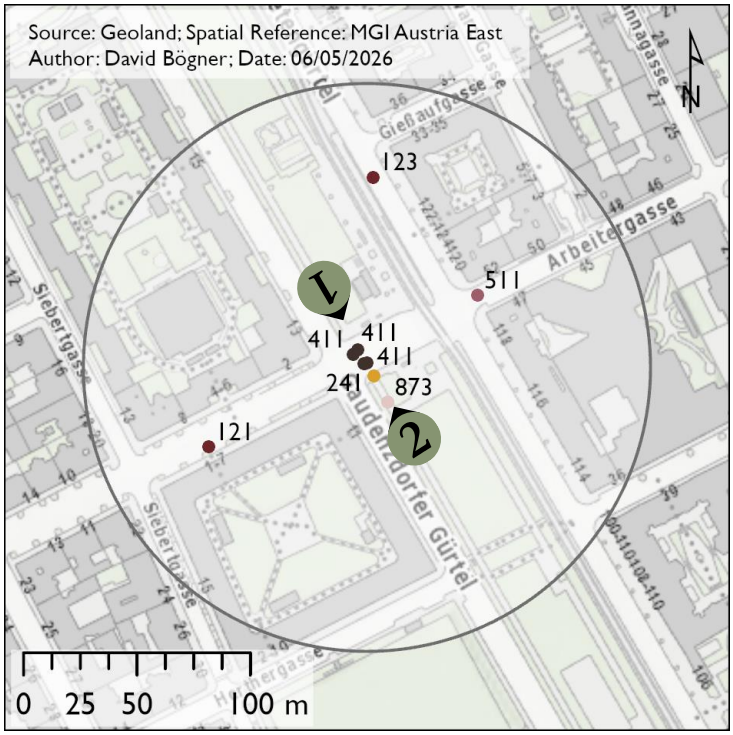


Figure 33: Cycling accidents at HRL Gaudenzdorfer Gürtel



Figure 31: S view Gürtel toward Matzleinsdorfer Platz



Figure 32: N view Gürtel

This HRL is located in the 12th district in the southwest of Vienna, mainly at the signalised intersection of Gürtel and Arbeitergasse. With five turning conflicts in the opposite direction of travel occurring at the centre of this HRL, this becomes the largest accident group and therefore the focus of this analysis.

Figure 31 depicts the cyclists' point of view on Gürtel when travelling south, parallel to the motorists. Figure 32 shows the cyclists' point of view when heading north. In this figure, a left-turning vehicle is visible. Motorists turning left from Gürtel towards Arbeitergasse have the same green phase as cyclists crossing Arbeitergasse and no separate turning lane.

Table 18 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 18: Recurring cyclist accident patterns at HRL Gaudenzdorfer Gürtel

Indicator	Results
Recurring accident types	 411: Collision whilst turning left (5)
Recurring stated accident circumstances	Fall from vehicle (5), Right-of-way violation / failure to yield (4), Inattention / distraction (2)
Recurring mode combinations	car/bicycle (4)

There is one recurring accident type at HRL Gaudenzdorfer Gürtel, type 411, "collision whilst turning left". All five accidents of this type occurred on the cyclist crossing of Arbeitergasse (see Figure 31 and Figure 32). The main accident circumstance within the accident group "turning conflicts in the opposite direction of travel" is "fall from vehicle", which was recorded five times. The only recurring mode combination is between bicycles and cars, which was recorded four times.

Table 19 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 19: Street characteristics contributing to cycling accidents at HRL Gaudenzdorfer Gürtel

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	54 km/h	--
	Motorised traffic volume	55973 veh	--
Intersection and network conflict points	Intersection	YES	-
	Intersection type	signalized	--
	Distance to closest public transport stop or bicycle sharing station	5 m	-
Street layout and space allocation	Road type	primary, secondary	--
	On-street parking	parallel	-
	Cycling infrastructure type	2-way separated	+
	Tram tracks	NO	+
Surface and topography	Surface conditions	no damage present	+
	Gradient	steep	--

At HRL Gaudenzdorfer Gürtel, eight indicators have an expected negative effect on cyclist safety. With high average speeds and high motorised traffic volume, the traffic environment is an important factor contributing to cyclist accidents. The HRL is located at a signalised intersection in close proximity to a bus stop, creating conflict points for cyclists. Street layout and space allocation-related factors, such as Gaudenzdorfer Gürtel being a primary road and on-street parking being present, further negatively affect cyclist safety. The steep gradient for cyclists heading north also increases the accident risk at the intersection.

In summary, this intersection shows a clear accident pattern of motorists turning left and colliding with oncoming cyclists from the opposite side. The stated accident circumstances, with nearly every accident including a right-of-way violation, further strengthen this pattern. With motorists and cyclists likely travelling at higher speeds, the latter because of the gradient when heading north, the effects of a mismatch between infrastructure and its usage become visible.

4.3.4.2 Parkring

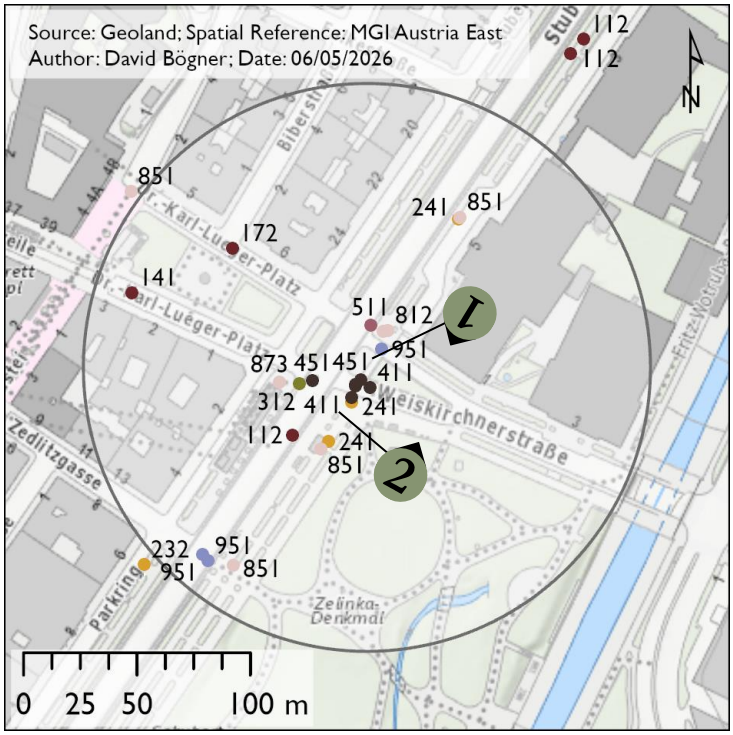


Figure 36: Cycling accidents at HRL Parkring



Figure 34: SW view Stubenring toward Staatsoper



Figure 35: NE view Parking toward Urania

This HRL is located in the 1st district in central Vienna, mainly at the signalised intersection of the ring road and Weiskirchnerstraße. With six turning conflicts in the opposite direction of travel and six conflicts with pedestrians occurring at this HRL, these are the largest accident groups. This section focuses on the former, while section 4.3.7.1 focuses on the latter.

In Figure 34, a left-turning vehicle is visible. Motorists turning left from Stubenring towards Weiskirchnerstraße have the same green phase as cyclists crossing Weiskirchnerstraße and no separate turning lane. When turning left, they first cross the tram tracks for the opposite direction and then the pedestrian crossing. Table 20 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 20: Recurring cyclist accident patterns at HRL Parkring

Indicator	Results
Recurring accident types	411: Collision whilst turning left (4), 241: Head-on collision on the straight (3), 851: Pedestrian coming from the right (3), 951: Collision with cyclists crossing the road (3), 451: Turning right where there is separated oncoming traffic (2),

	 873: Pedestrian walking on the right-hand side of the lane (2)
Recurring stated accident circumstances	Fall from vehicle (7), Right-of-way violation / failure to yield (5), Inattention / distraction (3)
Recurring mode combinations	car/bicycle (5)

There are six recurring accident types at HRL Parkring. Two of them, type 411 "collision whilst turning left" and type 451 "turning right where there is separated oncoming traffic", are part of this subsection's focus group. All six accidents classified as these types occurred at the intersection, five of which occurred on the cyclist crossing at Weiskirchnerstraße (see Figure 34). The main accident circumstance within the accident group "turning conflicts in the opposite direction of travel" is "fall from vehicle", which was recorded seven times. With five accidents having the circumstance "right-of-way violation / failure to yield", the clear accident pattern gets strengthened. The only recurring mode combination is between bicycles and cars, which was recorded five times.

Table 21 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 21: Street characteristics contributing to cycling accidents at HRL Parkring

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	51 km/h	--
	Motorised traffic volume	71185 veh	--
Intersection and network conflict points	Intersection	YES	-
	Intersection type	signalized	--
	Distance to closest public transport stop or bicycle sharing station	14 m	-
Street layout and space allocation	Road type	primary, secondary	--
	On-street parking	NO	+
	Cycling infrastructure type	shared foot/cycle	-
	Tram tracks	YES	--
Surface and topography	Surface conditions	no damage present	+
	Gradient	moderate	-

At HRL Parkring, nine indicators have an expected negative effect on cyclist safety. With high average speeds and high motorised traffic volume, the traffic environment is an important factor contributing to cyclist accidents. The HRL is located at a signalised intersection in close proximity to metro, tram and bus stops, creating conflict points for cyclists. Street layout and space allocation-related factors, such as Stubenring and Parkring being primary roads, shared foot and cycle paths, and the presence of tram tracks, further negatively affect cyclist safety. The moderate gradient for cyclists also increases the hazard of the intersection.

In summary, many different accidents occur at this HRL. The accident group analysed in this subsection, "turning conflicts in the opposite direction of travel", shows a clear accident pattern of motorists turning left into Weiskirchnerstraße and colliding with oncoming cyclists from the opposite side. The stated accident circumstances, with nearly every accident including a right-of-way violation, further strengthen this pattern. The high number of different accidents involving cyclists, together with high motorised traffic volumes and average speeds, indicates a mismatch between cycling infrastructure and demand.

4.3.4.3 Synthesis

For the accident group of "turning conflicts in the opposite direction of travel", the qualitative analysis mainly pointed to problems at **signalised intersections**. Both HRLs show clusters of **left-turning motorists colliding with cyclists** on **two-way cyclist crossings**, with a high number of **right-of-way violations**. In both cases, motorists travel on **primary roads** with high traffic volumes and high average speeds, **without** having a **separate turning lane or green** phase when turning left. Additionally, **conflicts with other modes** are likely, as **public transport nodes** are located in close proximity. **Downhill gradients** further increase accident likelihood, as cyclists are likely to travel at **higher speeds** across the intersection.

4.3.5 Group 5: Right-angle collisions

4.3.5.1 Hasnerstraße

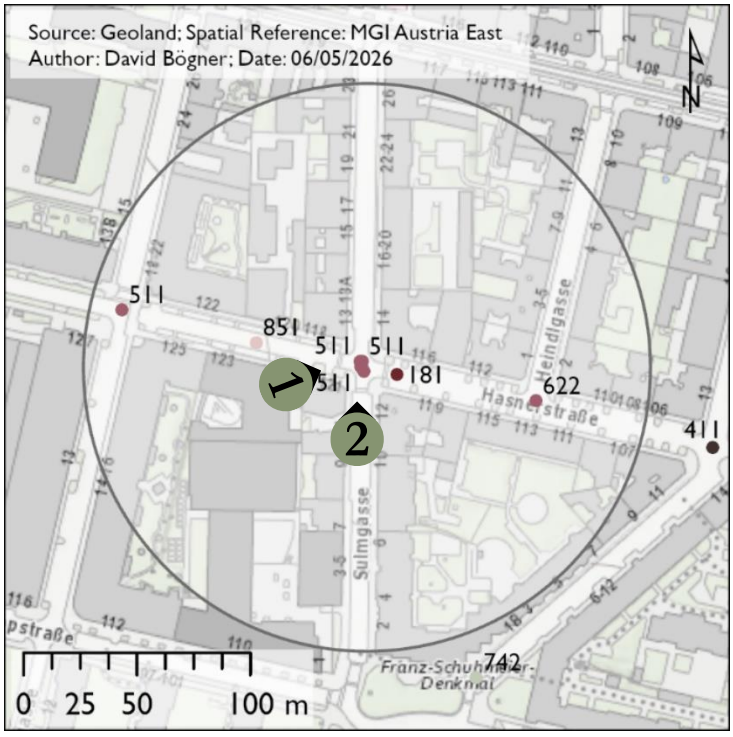


Figure 39: Cycling accidents at HRL Hasnerstraße



Figure 37: E view Hasnerstraße toward centre



Figure 38: N view Sulmgasse

This HRL is located in the 16th district in the west of Vienna, at the non-signalised intersection of Hasnerstraße and Sulmgasse. With six right-angle collisions occurring at the centre of this HRL and another two occurring at the parallel intersections to the west and east, right-angle collisions are the largest accident group.

Road users coming from Sulmgasse (see Figure 38) are supposed to yield to cyclists on Hasnerstraße, which is a popular marked cycling route through the 16th district. Additional measures, such as the speed bump (see Figure 38) and the crossing cyclists marking (see Figure 37), have been installed to warn oncoming traffic from the south.

Table 22 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 22: Recurring cyclist accident patterns at HRL Hasnerstraße

Indicator	Results
Recurring accident types	 511: Collision at an intersection (7)
Recurring stated accident circumstances	Fall from vehicle (7), Right-of-way violation / failure to yield (7)
Recurring mode combinations	car/bicycle (5)

The only recurring accident type at HRL Hasnerstraße is "collision at intersection". The main accident circumstances within the accident group are "fall from vehicle" and "right-of-way violation / failure to yield", each recorded seven times. These results form a clear pattern in which motorists fail to yield to crossing cyclists on Hasnerstraße and then collide with them. The only recurring mode combination is between bicycles and cars, which occurred five times.

Table 23 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 23: Street characteristics contributing to cycling accidents at HRL Hasnerstraße

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	26 km/h	++
	Motorised traffic volume	2152 veh	++
Intersection and network conflict points	Intersection	YES	-
	Intersection type	non-signalized	-
	Distance to closest public transport stop or bicycle sharing station	243 m	+
Street layout and space allocation	Road type	tertiary	+
	On-street parking	perpendicular/parallel	-
	Cycling infrastructure type	mixed traffic	--
	Tram tracks	NO	+
Surface and topography	Surface conditions	no damage present	+
	Gradient	moderate	-

At HRL Hasnerstraße, five indicators have an expected negative effect on cyclist safety. The only factor that can be ruled out is traffic environment, which scores very positively on both indicators due to low motorised traffic volumes and speeds. The presence of non-signalised intersections has a negative effect on cyclist safety at HRL Hasnerstraße. The same applies to on-street parking along all streets included in the HRL. While parking along perpendicular streets does not create a dooring risk, it can still block

sightlines at intersections (see Figure 37). Additionally, the absence of dedicated cycling infrastructure has a strongly negative effect on cyclist safety. While Hasnerstraße is officially declared a cycling route, it does not have designated cycling infrastructure in this section. Hasnerstraße also runs downhill when heading east, which likely increases cyclists' speeds and therefore shortens reaction times before potential conflicts.

In summary, this section of Hasnerstraße shows a clear accident pattern of collisions at intersections, particularly at the intersection with Sulmgasse. While measures are in place to warn approaching motorists of crossing cyclists and their right of way, these measures do not seem to work, as they had already been installed before the studied timeframe (Google Street View, 2021). The combination of risk-enhancing indicators, such as on-street parking, no cycling infrastructure and a downhill gradient, further contributes to cyclist risk.

4.3.5.2 Untere Donaustraße

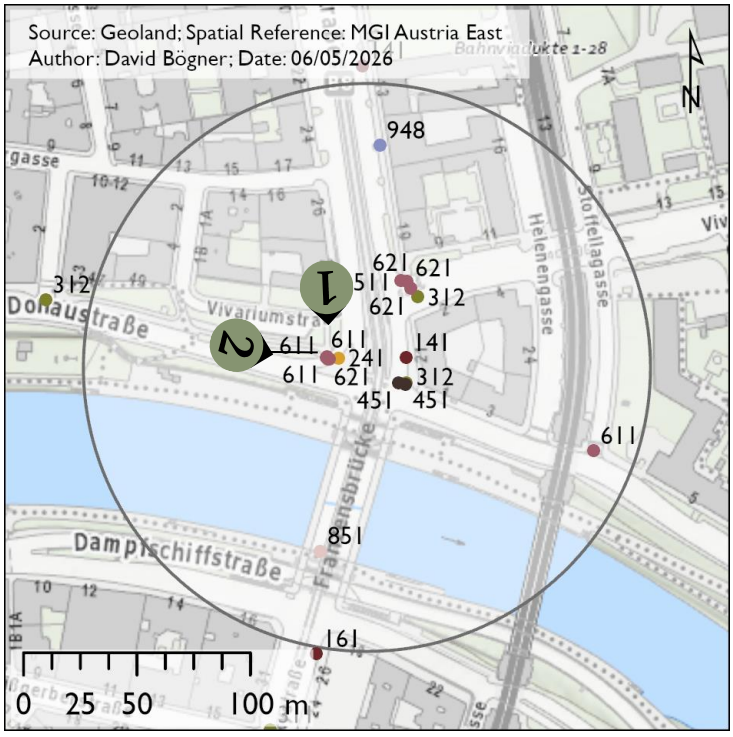


Figure 42: Cycling accidents at HRL Untere Donaustraße



Figure 40: S view Franzensbrückenstraße



Figure 41: E view Untere Donaustraße

This HRL is located in the 2nd district in central Vienna, mainly at the non-signalised intersection of Franzensbrückenstraße and Untere Donaustraße. With four right-angle collisions occurring at the centre of this HRL, another two occurring at a non-signalised intersection close by to the north and one occurring at Stoffellagasse in the east, right-angle collisions are the largest accident group.

While the main intersection is signalised, this exact relation is non-signalised. Similar to HRL Hasnerstraße, additional measures, such as a speed bump and a large exclamation mark warning motorists of an oncoming hazardous intersection, have been installed (both see Figure 40 and Figure 41).

Table 24 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 24: Recurring cyclist accident patterns at HRL Untere Donaustraße

Indicator	Results
Recurring accident types	 611: Collision with a vehicle turning right whilst travelling in the same direction (4),  621: Collision with a vehicle turning right whilst driving in the opposite direction (4),  451: Turning right where there is separated oncoming traffic (2)
Recurring stated accident circumstances	Fall from vehicle (9), Right-of-way violation / failure to yield (8), Inattention / distraction (5), Improper / unlawful behavior (2), Visibility obstruction by vehicle/object (2)
Recurring mode combinations	car/bicycle (9)

There are three recurring accident types at HRL Untere Donaustraße. "Collision with a vehicle turning right whilst travelling in the same direction" mostly occurs at the discussed non-signalised part of the main intersection. At the cluster further north, at the intersection between Franzensbrückenstraße and Vivariumstraße, multiple "collisions with a vehicle turning right whilst cycling in the opposite direction" occurred. On the other side of the main intersection, "turning right accidents where there is separated oncoming traffic" cluster. The main accident circumstance within right-angle collisions is "fall from vehicle", which was recorded nine times. The only recurring mode combination is between bicycles and cars, which was also recorded nine times.

Table 25 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 25: Street characteristics contributing to cycling accidents at HRL Untere Donaustraße

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	29 km/h	+
	Motorised traffic volume	16659 veh	-
Intersection and network conflict points	Intersection	YES	-
	Intersection type	non-signalized	-
	Distance to closest public transport stop or bicycle sharing station	20 m	-
Street layout and space allocation	Road type	primary	--
	On-street parking	NO	+
	Cycling infrastructure type	2-way separated	+
	Tram tracks	YES	--
Surface and topography	Surface conditions	no damage present	+
	Gradient	steep	--

At HRL Untere Donaustraße, seven indicators have an expected negative effect on cyclist safety. The high traffic volume of 16.659 vehicles passing through the intersection has a negative effect on cyclist safety. As the HRL is located at a non-signalised intersection in close proximity to a tram stop, all indicators of the factor intersection and network conflict points score negatively. The remaining two factors include both positive and negative scores on expected impact. The presence of tram tracks, the surrounding primary roads and the steep downhill gradient on Untere Donaustraße when heading east are expected to negatively affect cyclist safety.

In summary, this section of Untere Donaustraße has multiple accident clusters with distinct dominant accident types. While measures are in place to warn approaching motorists of crossing cyclists and their right of way, these measures do not seem to fully work, as they had already been installed before the studied timeframe (Google Street View, 2021). The combination of risk-enhancing indicators, such as high traffic volume on primary roads, the presence of tram tracks, multiple intersection and conflict points and a downhill gradient, further contributes to cyclist risk.

4.3.5.3 Synthesis

For the accident group of "right-angle collisions", the qualitative analysis mainly pointed to problems at **non-signalised intersections**. Both HRLs show multiple clusters of accidents classified as "right-angle collisions". With "**right-of-way violation / failure to yield**" stated for almost every accident, a clear pattern of motorists not yielding to crossing cyclists emerges. Additional **warning measures**, such as **speed bumps and road markings**, do not seem to fully work. **Downhill gradients** for cyclists entering the intersection further contribute to safety risks, as they are likely to travel at **higher speeds**.

4.3.6 Group 7: Conflicts with parked vehicles

4.3.6.1 Landstraßer Hauptstraße II

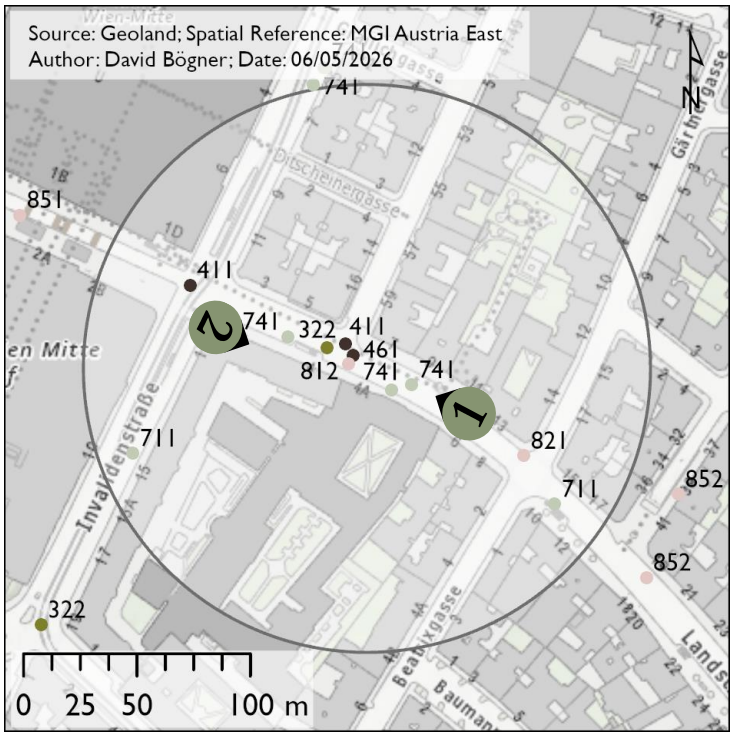


Figure 45: Cycling accidents at HRL Landstraßer Hauptstraße II



Figure 43: SW view Landstraßer Hauptstr. toward centre



Figure 44: NE view Landstraßer Hauptstraße

This HRL is located in the 3rd district in the southeast of Vienna. Most accidents occurred on Landstraßer Hauptstraße, but there was also one accident in Invalidenstraße. In this section of

Landstraßer Hauptstraße, no clear cluster at one specific location emerges. The conflicts with parked vehicles are mostly located around the intersection with Untere Viaduktgasse.

As visible in Figure 43 and Figure 44, both sides of Landstraßer Hauptstraße are used for on-street parking. While designated cycling infrastructure is available for cyclists heading west, cyclists heading east use a painted cycle lane.

Table 26 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 26: Recurring cyclist accident patterns at HRL Landstraßer Hauptstraße II

Indicator	Results
Recurring accident types	 741: Drive past on the left of the parking vehicle (3), 411: Collision whilst turning left (2), 711: vehicle is stopping or parking on the right (2)
Recurring stated accident circumstances	Fall from vehicle (5), Inattention / distraction (4), Opening car door (3)
Recurring mode combinations	car/bicycle (3)

The only recurring accident types are three accidents of type "drive past on the left of the parking vehicle," and two accidents each of type "collision whilst turning left" and "vehicle is stopping or parking on the right". In the accident group "conflicts with parked vehicles", the main accident circumstance is "fall from vehicle", which was recorded in all five cases. Three of the five accidents were dooring accidents. The only recurring mode combination is between bicycles and cars, which was recorded three times.

Table 27 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 27: Street characteristics contributing to cycling accidents at HRL Landstraßer Hauptstraße II

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	36 km/h	~
	Motorised traffic volume	8557 veh	+
Intersection and network conflict points	Intersection	NO	+
	Intersection type		
	Distance to closest public transport stop or bicycle sharing station	81 m	+
Street layout and space allocation	Road type	secondary, tertiary	~
	On-street parking	parallel	-
	Cycling infrastructure type	mixed traffic, painted	--

	Tram tracks	NO	+
Surface and topography	Surface conditions	no damage present	+
	Gradient	steep	--

At HRL Landstraßer Hauptstraße II, three indicators have an expected negative effect on cyclist safety. While the traffic environment and intersection and network conflict points have no negative effect, street layout and space allocation and surface and topography are important factors. Firstly, parallel on-street parking on both sides of Landstraßer Hauptstraße creates a dooring risk. Additionally, cyclists are expected to cycle in mixed traffic in one direction and on a painted cycle lane in the other. This, together with a steep downhill gradient towards the city centre, further contributes to safety risks.

In summary, conflicts with parked vehicles occurred repeatedly on this road segment. While the police-recorded accident circumstances do not clearly show a recurring accident pattern, the street characteristics of low-quality cycling infrastructure, on-street parking and a steep gradient are negative factors for cyclist safety.

4.3.6.2 Wallensteinstraße

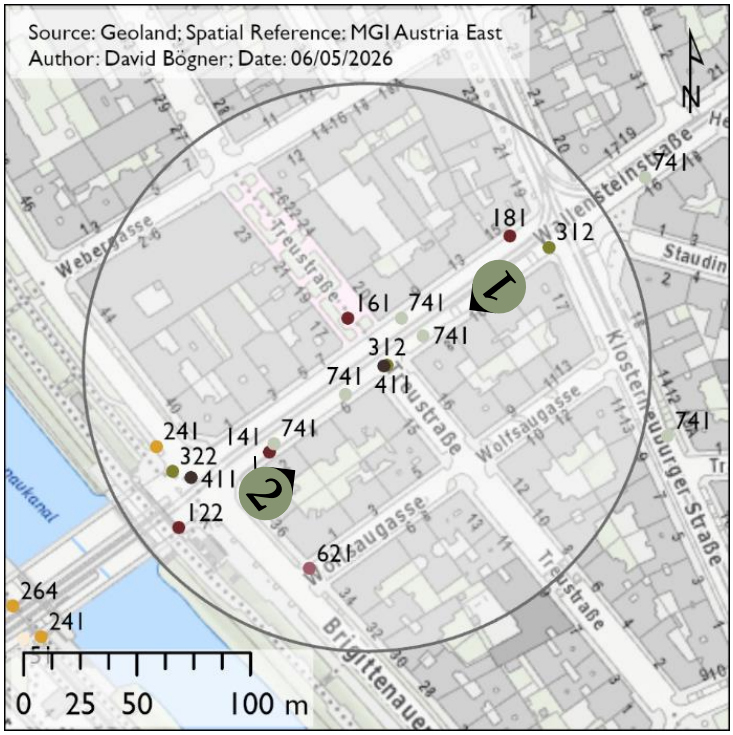


Figure 48: Cycling accidents at HRL Wallensteinstraße



Figure 46: SW view Wallensteinstr. toward Donaukanal



Figure 47: NE view Wallensteinstraße

This HRL is located in the 20th district in the northeast of Vienna, along Wallensteinstraße. Most accidents occurred on Wallensteinstraße, but there was also one accident in Wolfsaugasse. In this section of Wallensteinstraße, no clear cluster at one specific location emerges. The conflicts with parked vehicles are located around the intersection with Treustraße. Apart from conflicts with parked vehicles, the other largest group, conflicts in same-direction traffic, also includes four accidents (see section 4.3.1.2).

As visible in Figure 46 and Figure 47, both sides of Wallensteinstraße are used for parallel on-street parking.

Table 28 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 28: Recurring cyclist accident patterns at HRL Wallensteinstraße

Indicator	Results
Recurring accident types	 741: Drive past on the left of the parking vehicle (4),  312: Vehicles turning right and vehicles going straight ahead (2)
Recurring stated accident circumstances	Passing (4), Fall from vehicle (4), Opening car door (4), Inattention / distraction (4)
Recurring mode combinations	car/bicycle (3)

The only recurring accident types are four accidents of type "drive past on the left of the parking vehicle" and two accidents of type "vehicles turning right and vehicles going straight ahead". In the accident group "conflicts with parked vehicles", all four accidents have the exact same stated circumstances. The circumstances "passing" and "opening car door" indicate that these were dooring accidents. The only recurring mode combinations were collisions between cars and bicycles.

Table 29 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 29: Street characteristics contributing to cycling accidents at HRL Walllensteinstraße

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	29 km/h	+
	Motorised traffic volume	9863 veh	~
Intersection and network conflict points	Intersection	NO	+
	Intersection type		
	Distance to closest public transport stop or bicycle sharing station	88 m	+
Street layout and space allocation	Road type	secondary, tertiary, other	~
	On-street parking	parallel	-
	Cycling infrastructure type	mixed traffic	--
	Tram tracks	YES	--
Surface and topography	Surface conditions	no damage present	+
	Gradient	moderate	-

At HRL Wallensteinstraße, four indicators have an expected negative effect on cyclist safety. While the traffic environment and intersection and network conflict points have no negative effect, the street layout and space allocation and surface and topography are important factors. Firstly, parallel on-street parking on both sides of Wallensteinstraße creates a dooring risk. Additionally, cyclists are expected to cycle in mixed traffic, as no separate cycling infrastructure is available. This, together with the presence of tram

tracks, is a major negative factor influencing cyclist safety. A moderate street gradient towards the northeast further contributes to safety risks.

In summary, conflicts with parked vehicles occurred repeatedly on this road segment. The police-recorded accident circumstances further indicate that these were dooring accidents. The absence of designated cycling infrastructure, the presence of tram tracks and the moderate gradient towards the northeast further amplify cycling risks.

4.3.6.3 Synthesis

For the accident group of "conflicts with parked vehicles", the qualitative analysis mainly pointed to problems along **secondary street segments with parallel on-street parking on both sides**. Both HRLs have recurring stated accident circumstances of "**opening car door**" and "**inattention / distraction**", pointing towards dooring accidents. Street characteristics such as the **absence of separate cycling infrastructure** and **downhill gradients** further increase cycling risks.

4.3.7 Group 8: Conflicts with pedestrians

4.3.7.1 Parkring

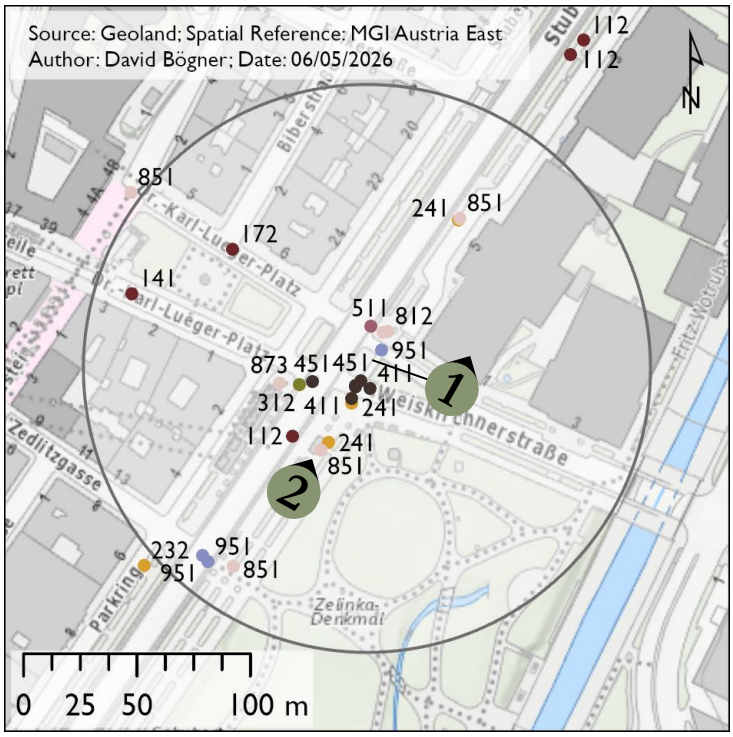


Figure 51: Cycling accidents at HRL Parkring



Figure 49: NE view Stubenring toward Urania



Figure 50: NE view Parking toward Urania

This HRL is located in the 1st district in central Vienna, mainly at the signalised intersection of the ring road and Weiskirchnerstraße. With six conflicts with pedestrians and six turning conflicts in the opposite direction of travel occurring at this HRL, these are the largest accident groups. This section focuses on the former, while section 4.3.4.2 focuses on the latter. Conflicts with pedestrians occurred at multiple locations within the defined HRL area; however, the majority occurred on the southeastern side of the ring road.

Figure 49 shows the small amount of space that is allocated to pedestrians on the opposite side of the pedestrian crossing.

Table 30 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 30: Recurring cyclist accident patterns at HRL Parkring

Indicator	Results
Recurring accident types	 411: Collision whilst turning left (4),  241: Head-on collision on the straight (3),  851: Pedestrian coming from the right (3),  951: Collision with cyclists crossing the road (3),  451: Turning right where there is separated oncoming traffic (2),  873: Pedestrian walking on the right-hand side of the lane (2)
Recurring stated accident circumstances	Improper / unlawful behavior (3), Inattention / distraction (3), Visibility obstruction by vehicle/object (2), Insufficient safety distance (2), Fall from vehicle (2)
Recurring mode combinations	bicycle/pedestrian (6)

There are six recurring accident types at HRL Parkring. Two of them, type 851 "pedestrian coming from the right" and type 873 "pedestrian walking on the right-hand side of the lane", are part of this subsection's focus group. No clear cluster at one specific location emerges from the accidents; rather, the whole segment along the ring road can be regarded as hazardous. The main accident circumstances within the accident group "conflicts with pedestrians" are "improper / unlawful behaviour" and "inattention / distraction", each recorded three times. The circumstances "visibility obstruction by vehicle/object" and "insufficient safety distance" are also highly relevant for this analysis, as they indicate possible infrastructural shortcomings. All six accidents occurred between bicycles and pedestrians.

Table 31 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 31: Street characteristics contributing to cycling accidents at HRL Parkring

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	51 km/h	--
	Motorised traffic volume	71185 veh	--
Intersection and network conflict points	Intersection	YES	-
	Intersection type	signalized	--
	Distance to closest public transport stop or bicycle sharing station	14 m	-
Street layout and space allocation	Road type	primary, secondary	--
	On-street parking	NO	+

	Cycling infrastructure type	shared foot/cycle	-
	Tram tracks	YES	--
Surface and topography	Surface conditions	no damage present	+
	Gradient	moderate	-

At HRL Parkring, nine indicators have an expected negative effect on cyclist safety. With high average speeds and high motorised traffic volume, the traffic environment is an important factor contributing to cyclist accidents. The HRL is located at a signalised intersection in close proximity to metro, tram and bus stops, creating conflict points for cyclists. Street layout and space allocation-related factors, such as Stubenring and Parkring being primary roads, partly shared foot and cycle paths, and the presence of tram tracks, further negatively affect cyclist safety. The moderate gradient for cyclists also increases the hazard of the intersection.

In summary, many different accidents occur at this HRL. Within the accident group analysed in this subsection, "conflicts with pedestrians", the accidents are not concentrated at one clearly defined point within the HRL. Instead, they appear to be linked to the wider situation around the public transport stations. The stated accident circumstances of "visibility obstruction by vehicle/object" and "insufficient safety distance", together with the high number of pedestrians entering and exiting the public transport stations and the unclear routing of cycle and foot paths, suggest that the available active mobility infrastructure does not clearly accommodate the level of pedestrian and cyclist demand.

4.3.7.2 Spitalgasse

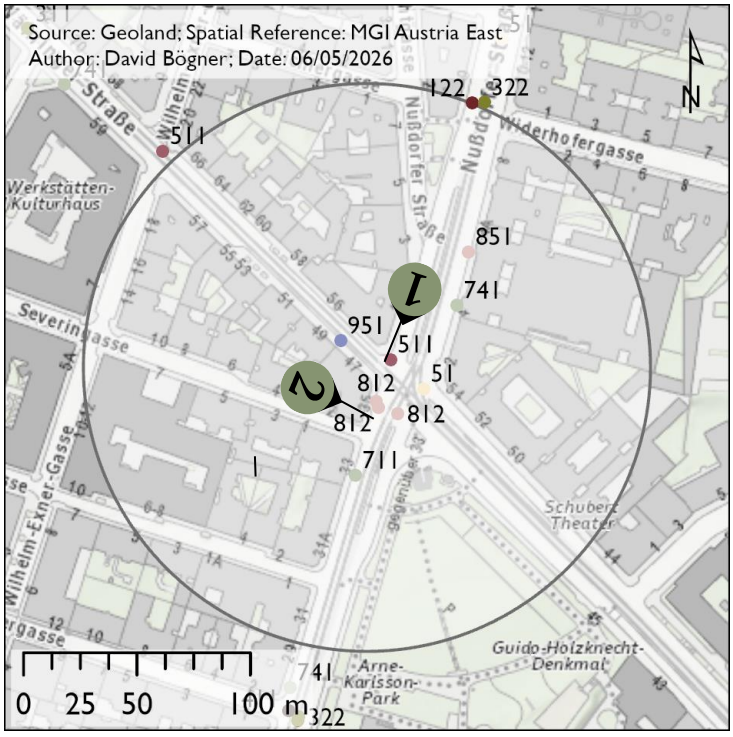


Figure 54: Cycling accidents at HRL Spitalgasse



Figure 52: SW view Spitalgasse



Figure 53: NE view Spitalgasse

This HRL is located in the 9th district in the north of Vienna, at the intersection of Spitalgasse, Währinger Straße and Nußdorfer Straße. All accidents at this HRL occurred within 50 metres of the main intersection. Accidents of the largest group, conflicts with pedestrians, occurred especially around the pedestrian crossing south of the intersection.

This southern part of the intersection is depicted in both Figure 52 and Figure 53. As visible in both figures, tram tracks on all streets, as well as the current construction work on Spitalgasse, serve as risk factors for cyclists.

Table 32 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 32: Recurring cyclist accident patterns at HRL Spitalgasse

Indicator	Results
Recurring accident types	 812: After the crossroad, pedestrians coming from the right (3)
Recurring stated accident circumstances	Red-light violation (3), Improper / unlawful behavior (2), Fall from vehicle (2)
Recurring mode combinations	bicycle/pedestrian (4)

The only recurring accident type is three accidents of type "after the crossroad, pedestrians coming from the right". The main accident circumstance within "conflicts with pedestrians" is "red-light violation", which was recorded three times. The only recurring mode combination is bicycles colliding with pedestrians.

Table 33 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 33: Street characteristics contributing to cycling accidents at HRL Spitalgasse

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	32,5 km/h	~
	Motorised traffic volume	13607 veh	+
Intersection and network conflict points	Intersection	YES	-
	Intersection type	signalized	--
	Distance to closest public transport stop or bicycle sharing station	10 m	-
Street layout and space allocation	Road type	secondary	~
	On-street parking	NO	+
	Cycling infrastructure type	painted	-
	Tram tracks	YES	--
Surface and topography	Surface conditions	damage present	--
	Gradient	flat	+

At HRL Spitalgasse, six indicators have an expected negative effect on cyclist safety. While the traffic environment has no negative effect, the other three factors include indicators scoring negatively. Firstly, the interaction between multiple modes of transport at the intersection and the presence of a tram stop

create conflict points. Additionally, the absence of separated cycling infrastructure and the presence of tram tracks are further negative factors influencing cyclist safety. In combination with holes in the pavement and changes in surface material and height, these factors contribute to this intersection being an HRL.

In summary, conflicts with pedestrians cluster in the southern part of this intersection. The police-recorded accident circumstances further indicate that these accidents are either red-light violations or right-of-way violations circumstanced by cyclists or pedestrians. As this is a major tram intersection with many passengers entering and exiting public transport, several modes of transport share the space, leading to conflicts.

4.3.7.3 Synthesis

For the accident group of "conflicts with pedestrians", the qualitative analysis mainly pointed to problems **at and around signalised intersections**. Only few characteristics are shared by both HRLs. The **proximity to tram stops**, and therefore also the presence of **tram tracks**, appears to be a clear factor. As public transport is the most used mode of transport in Vienna, major tram stops are known to induce a **high frequency of pedestrians** entering and exiting the transport hub (see section 1.2). Apart from that, "improper / unlawful behaviour" was a recurring stated accident circumstance at both locations.

4.3.8 Group 9: Other conflicts

4.3.8.1 Museumsplatz

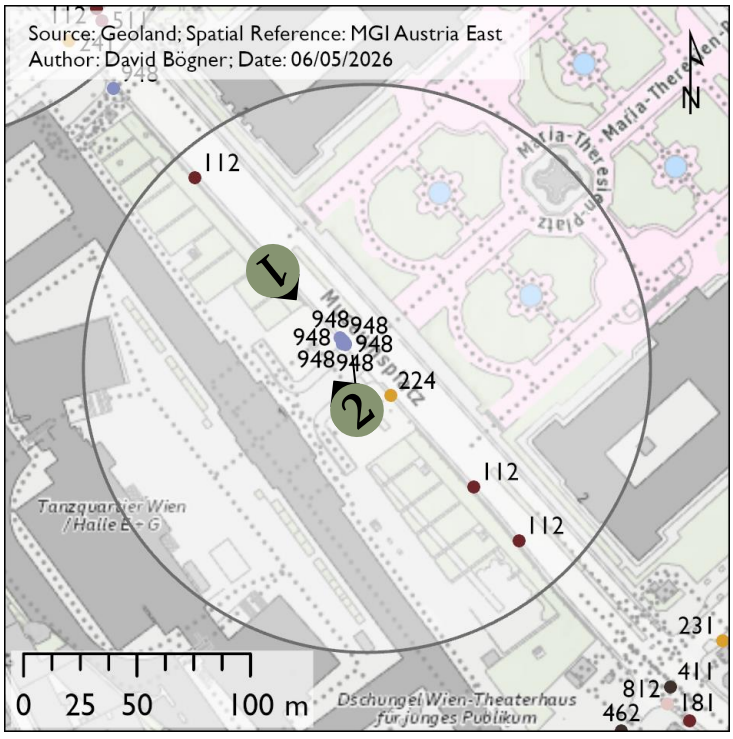


Figure 57: Cycling accidents at HRL Museumplatz



Figure 55: SE view Museumplatz toward Naschmarkt



Figure 56: NW view Museumplatz

This HRL is located in the 7th district in the west of Vienna, mainly at the signalised pedestrian crossing of Museumsplatz. With nine conflicts classified as "other conflicts", this is the largest accident group. All nine of these accidents occurred at the exact driveway of a parking garage.

Motorists on the road and cyclists on the cycle path are only allowed to travel southeast. Motorists do not have a separate turning lane to enter the parking garage (see Figure 55).

Table 34 displays recurring cyclist accident patterns at this HRL within the studied timeframe.

Table 34: Recurring cyclist accident patterns at HRL Museumplatz

Indicator	Results
Recurring accident types	 948: Collision when entering or exiting the driveway (9),  112: Overtake on the left (3)
Recurring stated accident circumstances	Fall from vehicle (9), Right-of-way violation / failure to yield (8), Inattention / distraction (4)
Recurring mode combinations	car/bicycle (8)

There are two recurring accident types at HRL Museumsplatz. All nine accidents of type "collision when entering or exiting the driveway" occurred at the driveway to the parking garage. The three accidents of type "overtake on the left" occurred along the same cycle path, but were not clustered and did not occur at the driveway. The main accident circumstance within the accident group is "fall from vehicle", which was recorded in all nine cases. "Right-of-way violation / failure to yield" was also stated eight times. Eight accidents involved bicycles and cars, which was the only recurring mode combination.

Table 35 displays a qualitative classification of the street characteristics of the HRL in discussion.

Table 35: Street characteristics contributing to cycling accidents at HRL Museumplatz

Factor	Indicator	Raw value	Expected safety impact
Traffic environment	Motorised traffic velocity	46 km/h	--
	Motorised traffic volume	37667 veh	--
Intersection and network conflict points	Intersection	YES	-
	Intersection type	signalized	--
	Distance to closest public transport stop or bicycle sharing station	151 m	+
Street layout and space allocation	Road type	primary, other	--
	On-street parking	NO	+
	Cycling infrastructure type	1-way separated	++
	Tram tracks	NO	+
Surface and topography	Surface conditions	no damage present	+
	Gradient	flat	+

At HRL Museumsplatz, five indicators have an expected negative effect on cyclist safety. With high average speeds and high motorised traffic volume, the traffic environment is an important factor contributing to cyclist accidents. The HRL is located at a signalised intersection, creating conflict points for cyclists. Museumsplatz being a primary road further negatively affects cyclist safety.

In summary, "other conflicts" accidents at HRL Museumsplatz clearly cluster at the driveway to the parking garage. The accident group analysed in this subsection shows a clear accident pattern of motorists turning right into the driveway and colliding with cyclists travelling in the same direction. The stated accident circumstances, with nearly every accident including a **right-of-way violation**, further strengthen this pattern. The **high motorised traffic volumes and average speeds**, in combination with motorists **not having a separate turning lane or green phase**, indicate a mismatch between infrastructure and demand.

5 RVS-based assessment and design recommendations

While the previous chapter identified recurring accident patterns and relevant street characteristics at the selected HRLs, this chapter examines what these findings mean from the perspective of the current RVS *Bicycle Traffic*. The aim is therefore not only to assess whether the analysed locations comply with the existing guideline framework, but also to identify where infrastructure improvements or changes to the RVS may be needed.

The design recommendations are organised and generalised at the level of each accident group. The structure of each group's recommendation is as follows: first, the main findings of the qualitative analysis are summarised in bullet points. Second, the relevant sections of the current RVS *Bicycle Traffic* are identified. These are then applied to the analysed HRLs in order to assess their compliance. Finally, physical design recommendations are made for the HRLs, and policy design recommendations are made for the RVS guidelines.

5.1 Group 1: Conflicts in same-direction traffic

The identified issues regarding "conflicts in same-direction traffic" are:

- on-street parking,
- inadequate and narrow cycling infrastructure,
- and close passing.

HRL compliance to current relevant RVS criteria

The RVS identifies mixed-traffic situations as especially critical when there are large speed differences between cyclists and motor vehicles and when overtaking happens with too little side distance (FSV, 2022, section 4.2). It also states that the choice between mixed traffic and separated cycling infrastructure depends mainly on motor traffic speed and traffic volume. At higher speed levels, separated infrastructure may already be necessary even where traffic volumes are not very high (see Figure 2; FSV, 2022, section 6.1). If, due to high motor traffic volumes and speed levels, physically separated cycling infrastructure would in principle be required but cannot be implemented because of space constraints, the RVS allows the reduction of motor vehicle speeds as a way to create more suitable conditions for mixed traffic or multi-use lanes (FSV, 2022, section 6.1). More generally, the RVS gives preference to cycle paths on higher-level roads and heavily trafficked roads, while mixed traffic should only be used where conditions are suitable (FSV, 2022, section 8.2.1). The RVS further highlights that mixed traffic is particularly hazardous where parked vehicles and narrow overtaking conditions are present, especially with lane widths between 3,0 m and 3,75 m (FSV, 2022, section 8.2.1). For parking next to cycling facilities, it requires a safety clearance of at least 0,75 m (FSV, 2022, section 8.1 and 8.1.1). In section 8.1, it also specifies that painted cycle lanes including this safety clearance must have a minimum width of 2,0 m.

Table 36: Assessment of analysed HRLs against measurable RVS criteria for "conflicts in same-direction traffic"

RVS Section	Section-Title	HRL Landstraßer Hauptstr. I	HRL Wallen-steinstr.
6.1	Criteria for the use of cycle facilities - Motor vehicle criterion		

8.1.1	Route area - Cycle facilities – Cycle lanes		
8.2.1	Route area - Mixed traffic – Cycling in mixed traffic without special measures		

Legend

	does comply
	does partly comply
	does not comply
	not applicable

The analysed HRLs **do not comply** with the RVS. Based on the available traffic volume and speed information, the mix of motor traffic and cycling traffic is likely too high for a mixed-traffic solution (see Figure 2). Although average daily traffic information is not available, the roads are likely above the level where separated cycling infrastructure would be more suitable. In addition, the existing widths are not sufficient. At Landstraßer Hauptstraße I, the painted cycle lane is only about 1,4 m wide and therefore clearly narrower than the required 2,0 m. At Wallensteinstraße, the carriageway width of 3,2 m lies exactly within the width range that the RVS describes as critical for mixed traffic.

HRL design implications

Regarding RVS sections **6.1**, **8.1.1** and **8.2.1**, the main design implication is a clearer separation between cyclists and motor vehicles. This could be achieved by converting parking space into space for cycling infrastructure, especially where parking currently narrows or blocks the cycling area. Where full separation is not possible, lower maximum speeds of 30 km/h would help reduce speed differences and create more homogeneous traffic conditions. Overall, the current layout should move away from mixed traffic or undersized cycling facilities towards a design that gives cyclists more protected space.

RVS design implication: Speed reductions when space constraints

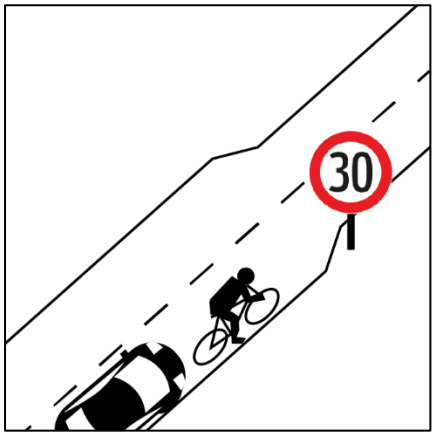


Figure 58: Speed reductions when space constraints

From an RVS perspective, the two analysed HRLs, Landstraßer Hauptstraße I and Wallensteinstraße, are sufficiently covered by the current guideline framework. The RVS already provides clear guidance on the relevance of motor traffic speed, traffic volume, overtaking conflicts, parking-related risks, and minimum width requirements for cycling infrastructure. If these principles were applied more consistently at the two locations, the infrastructure for cyclists would likely be safer. At the same time, some parts of the RVS might be too open in their wording. In particular, the statement that speed reductions may be used where separated cycling infrastructure would in principle be required but cannot be implemented because of space constraints leaves too much room for interpretation. More measurable criteria could help to trigger such decisions earlier and more consistently. This could make it easier to implement low-cost measures such as speed reductions more quickly in situations where safe cycling infrastructure cannot yet be provided.

5.2 Group 2: Conflicts in opposing traffic

The identified issues regarding "conflicts in opposing traffic" are:

- obstacles on and beside the cycle path, impairing visibility and creating conflicts in combination with sharp turns,
- inappropriate speed, potentially strengthened by the moderate gradients present,
- insufficient right-hand cycling on two-way separated cycle paths.

HRL compliance to current relevant RVS criteria

The RVS points out that two-way cycle paths can cause safety deficits at intersections (FSV, 2022, section 6.3). It also names too-small radii, poor sight lines, and obstacles in the traffic space as clear infrastructural deficiencies (FSV, 2022, section 5.3). According to the RVS, sufficient sight fields must be kept free at all points of a cycling facility so that hazards can be recognised early (FSV, 2022, section 7.4). It further states that radii of at least 8 m should generally be used and that the traffic space in curves must be widened depending on cycling speed in order to avoid conflicts (FSV, 2022, section 7.5). In addition, unsuitable speed is listed as one of the main causes of accidents on cycling facilities (FSV, 2022, section 4.1). For two-way cycle paths, the RVS also requires clear marking and states a minimum width of 2,6 m, with a centre line as an important measure to separate the two directions of travel (FSV, 2022, section 8.1.3).

Table 37: Assessment of analysed HRLs against measurable RVS criteria for "conflicts in opposing traffic"

RVS Section	Section-Title	HRL Burgring	HRL Schwarzenbergplatz
7.4	Design elements – Sight distances		
7.5	Design elements – Alignment		
8.1.3	Route area – Cycle facilities – Cycle paths		

Legend

	does comply
	does partly comply
	does not comply
	not applicable

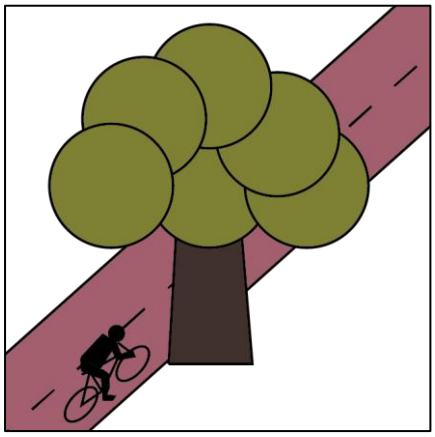
HRL Burgring **complies partly** and HRL Schwarzenbergplatz **does not comply** with the RVS. At both locations, sufficient sight fields are not kept free. This is visible in the field observations and is also supported by the recurring stated accident circumstance at Schwarzenbergplatz, where visibility obstruction by a vehicle or object was recorded repeatedly. The required minimum radius of 8 m is also not met. The smallest inner radius is 6,3 m at Burgring and only 1,4 m at Schwarzenbergplatz. While the traffic space is widened in the curve area at Burgring, this also appears necessary because of trees located directly next to the cycle path. At Schwarzenbergplatz, this widening is missing. In addition, neither HRL

has a centre marking. The narrowest width is 2,0 m at Burgring and 2,3 m at Schwarzenbergplatz, so both fall below the RVS minimum width of 2,6 m for two-way cycle paths.

HRL design implications

Regarding RVS sections **7.4**, **7.5** and **8.1.3**, the main design implication is a change in the alignment of the two-way cycle paths. The current routing creates tight curves and poor sight lines at exactly the points where cyclists need to recognise conflicts early. A redesign should therefore aim to create a smoother alignment with larger radii and open sight fields. This would likely also reduce the problems currently caused by trees, poles, or other obstacles, because these would no longer be located directly after tight turns. More generally, it would also make sense to separate pedestrian and cycle traffic more consistently and to guide both more clearly. As there are no parking lanes at these HRLs, but there are multi-lane carriageways for motor traffic, it would make sense to reallocate road space from motor traffic to cycling infrastructure in order to improve both safety and comfort.

RVS design implications: Obstacles



The RVS leaves some room for improvement regarding obstacles within cycle paths. In section 2.2, the traffic space is generally defined as an area that should be kept free of obstacles. However, section 6.4 only states that trees, poles, construction sites, and similar problem points should be assessed separately and may justify a change in the type of cycling provision. This might be too vague. Obstacles located within or directly next to cycle paths should only be acceptable where sight lines remain clearly open, where they are not placed directly after tight curves, and where they do not affect the cycling surface itself.

Figure 59: Obstacles

5.3 Group 3: Turning conflicts in the same direction of travel

The identified issues regarding "turning conflicts in the same direction of travel" are:

- two-way cyclist crossing in blind spots of left-turning motorists at intersections,
- "right-of-way violation / failure to yield" was the most prominent stated accident circumstance,
- high or inappropriate speeds by motorists.

HRL compliance to current relevant RVS criteria

The RVS identifies turning conflicts at cycling facilities as a frequent accident pattern, especially where right-turning motorists fail to give way to cyclists going straight ahead. It also explicitly states that restricted visibility from turning motor vehicles towards straight-through cyclists can be caused either by the street layout or by the vehicle itself, for example through blind spots (FSV, 2022, section 4.1). At intersections, the RVS therefore requires good visibility and close spatial proximity between the cycling facility and the parallel motor traffic lanes, especially in the last 20 m before the intersection. In particular, sight lines must not be blocked by parked vehicles or other obstacles (FSV, 2022, section 9.1.1). The RVS also notes that two-way cycle paths can cause considerable safety deficits at intersections (FSV, 2022, section 6.3). For the alignment of cycle paths at intersections, the RVS states that in urban areas the standard solution is a non-set-back alignment directly next to the motor traffic lane, because this provides

the best visibility between drivers and cyclists. A set-back alignment is only acceptable where the distance from the carriageway is at least 5,0 m (see Figure 60), in order to reduce conflicts with turning motor vehicles (FSV, 2022, section 9.1.2).

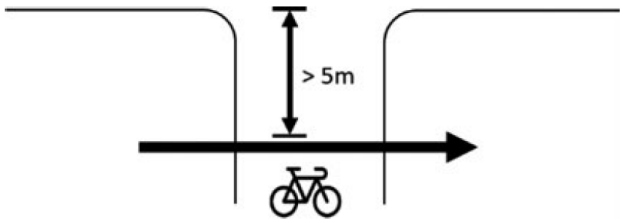


Figure 60: Suggested set-back of cycle path from carriageway (FSV, 2022)

In addition, at intersections with minor side streets, the RVS recommends raised cycle crossings, as these reduce the crossing speed of motor vehicles and therefore improve cyclist safety (FSV, 2022, section 9.2.1).

Table 38: Assessment of analysed HRLs against measurable RVS criteria for "turning conflicts in the same direction of travel"

RVS Section	Section-Title	HRL Lerchenfelder Gürtel	HRL Margaretenstraße
9.1.1	Nodes – General recommendations – Safety and comfort		
9.1.2	Nodes – General recommendations – Set-back or non-set-back routing		
9.2.1	Nodes – Nodes in built-up areas – Cycle path		

Legend

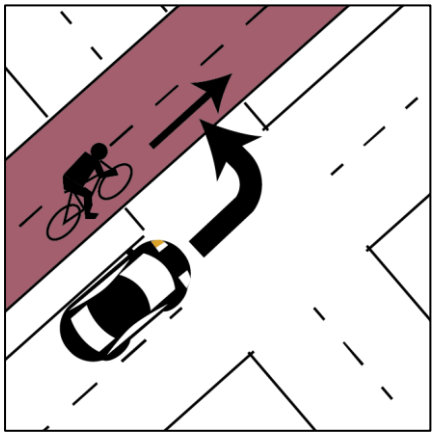
	does comply
	does partly comply
	does not comply
	not applicable

The analysed HRLs **only partly comply** with the RVS. The required sight contact within the last 20 m before the intersection is given at both locations. However, the alignment of the cycle path does not meet the RVS recommendations. At Lerchenfelder Gürtel, the cycle path is set back by about 4 m. At Margaretenstraße, the distance is about 1 m at the cluster where most accidents happened, and around 2,5 m at the cluster further north. While 1 m qualifies for the standard non-set-back solution, due to the safety clearance of at least 0,75 m between cycle path and carriageway, the other two intersections do not meet the minimum distance of 5,0 m required for a set-back solution. In addition, neither HRL has a raised cycle crossing. Taken together, this suggests that neither location provides an intersection design that is fully in line with the RVS.

HRL design implications

Regarding RVS sections **9.1.1**, **9.1.2** and **9.2.1**, the main design implication is that the cycle path should either be guided directly next to the carriageway or set back more clearly to at least 5.0 m where space allows. The current intermediate distances of around 2.5 m to 4.0 m appear particularly hazardous, because they reduce visibility and make cyclist priority less legible for turning drivers. In addition, the cycle crossings should be raised. This would likely reduce the turning speed of motor vehicles and make the crossing situation safer for cyclists.

RVS design implication: Left-turning motor vehicles



The current RVS addresses blind-spot risks mainly in relation to right-turning motor vehicles. In the two HRLs analysed here, however, the main conflict involves left-turning motor vehicles in one-way streets that overlook cyclists approaching from behind on the left side. As this situation may be less expected by drivers, it deserves more attention in the guideline framework. This specific conflict type should be examined further and translated into more explicit guidance based on best-practice examples.

Figure 61: Left-turning motor vehicles

5.4 Group 4: Turning conflicts in the opposite direction of travel

The identified issues regarding "turning conflicts in the opposite direction of travel" are:

- left-turning motorists colliding with cyclists on two-way signalized cyclist crossings, with a high number of right-of-way violations by motorists,
- motorists travel on primary roads with high traffic volumes and high average speeds, without having a separate turning lane or green phase when turning left,
- cyclists are likely to travel at higher speeds due to downhill gradients,
- conflicts with other modes are likely, as public transport nodes are located in close proximity.

HRL compliance to current relevant RVS criteria

The RVS identifies conflicts between turning motor vehicles and oncoming cyclists going straight ahead as one of the main accident circumstances on carriageways with motor traffic (FSV, 2022, section 4.2). It also states that two-way cycle paths can create safety deficits at intersections (FSV, 2022, section 6.3). At signalised intersections, the RVS recommends that cyclist traffic should be guided conflict-free in a separate phase where heavily used cycle paths are crossed by strong turning flows. For two-way cycle paths of development standard A and B, such a phase separation should in any case be examined (FSV, 2022, section 9.2.6). The RVS further stresses that, because of the particularly high crash risk of turning conflicts, a very careful assessment is needed before giving up a protected turning solution. Concerns about the capacity of motor traffic should be secondary to safety, and instead the green time allocation should be adjusted (FSV, 2022, section 9.2.6). In addition, cyclists on cycle paths should receive an advanced green phase of around 2 s so that they are already visible to turning drivers when motor traffic starts moving (FSV, 2022, section 9.2.6). Finally, the RVS states that higher speeds require longer

stopping sight distances, for example 25 m at 30 km/h, and that these must be kept clear at all points of the facility (FSV, 2022, section 7.4).

Table 39: Assessment of analysed HRLs against measurable RVS criteria for "turning conflicts in the opposite direction of travel"

RVS Section	Section-Title	HRL Gaudenzdorfer Gürtel	HRL Parking
7.4	Design elements – Sight distances		
9.2.6	Nodes – Nodes in built-up areas – Signal-controlled nodes		

Legend

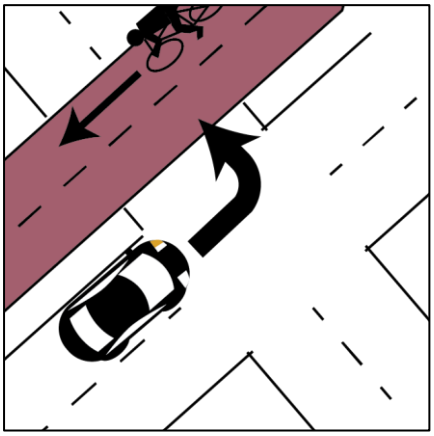
	does comply
	does partly comply
	does not comply
	not applicable

HRL Gaudenzdorfer Gürtel **complies partly** and HRL Parkring **does not comply** with the RVS. At both locations, the cycle paths are development standard B, with a minimum width of 3,3 m apart from a few narrow points. Even though these are two-way cycle paths on important cycling routes next to heavily trafficked roads, there is no separate signal phase for cyclists at either location. An advanced green phase is also not present. Regarding visibility, the required sight distance of more than 25 m towards oncoming cyclists is available at Gaudenzdorfer Gürtel. At Parkring, however, only about 22 m are available because a historic public building blocks the view. Taken together, this means that the locations do not meet important RVS recommendations for managing this type of conflict.

HRL design implications

Regarding RVS sections **7.4**, and **9.2.6**, phase separation should be considered at these locations, as the cycle paths are of development standard B, form part of a main cycling route, and run next to roads with high traffic volumes. If a separate phase is not implemented, an advanced green phase for cyclists would still likely improve safety. This would make cyclists visible to turning drivers earlier and could reduce the conflict risk at the start of the green phase.

RVS design implication: Left-turning motor vehicles



As with "turning conflicts in the same direction of travel", the RVS mainly refers to right-turning motor vehicles. In this accident group as well, however, accidents at both analysed intersections were primarily involving left-turning motor vehicles. This suggests that the guideline does not yet address this conflict type clearly enough. Situations with two-way cycle paths next to heavily trafficked roads should also consider separate signal phases or turning lanes for entering motor vehicles. Such turning lanes could allow drivers to slow down earlier and look more carefully for approaching cyclists before completing the turn.

Figure 62: Left-turning motor vehicles

5.5 Group 5: Right-angle collisions

The identified issues regarding "right-angle collisions" are:

- motorists not yielding to crossing cyclists at non-signalised intersections,
- additional warning measures, such as speed bumps and road markings, do not seem to have the desired effect,
- cyclists are likely to travel at higher speeds due to downhill gradients.

HRL compliance to current relevant RVS criteria

The RVS names one frequent cause of accidents on cycling facilities as motor vehicle drivers in crossing traffic who fail to give way to cyclists (FSV, 2022, section 4.1). For unsignalised cyclist crossings, it stresses that drivers are more willing to stop if approaching cyclists are visible early enough. The speed-dependent sight field (see Figure 63, distance l) must therefore always be kept clear. For cyclists approaching at 10 km/h, the approach distance (see Figure 63, distance c) is assumed to be 10 m (FSV, 2022, section 7.4).

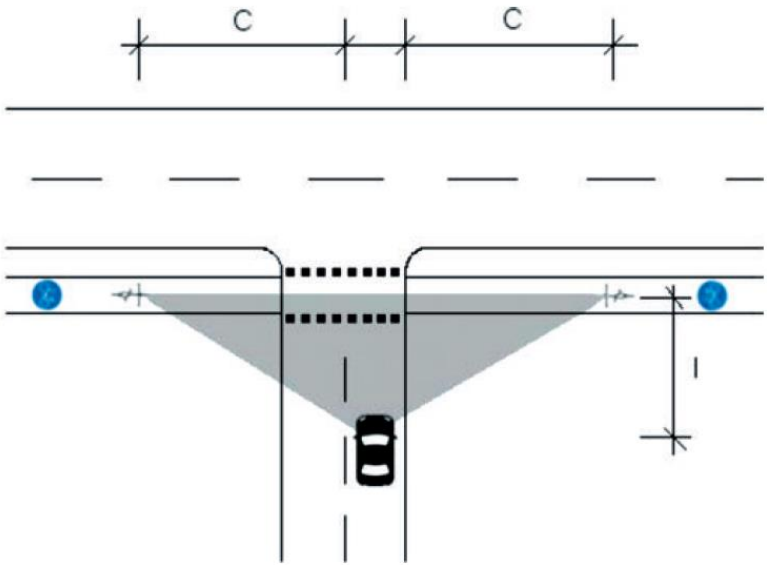


Figure 63: Required fields of vision when cyclists are crossing a intersection (FSV, 2022)

If sight conditions are not sufficient, the RVS states that it should be examined whether a structural redesign of the street could reduce motor vehicle speeds (FSV, 2022, section 7.4). It also notes that on downhill sections clearly higher cycling speeds must be taken into account in the design, for example 30 km/h at a gradient of 3 % (FSV, 2022, section 7.3). For crossings with minor side streets, the RVS recommends raised cycle crossings, as these force motor vehicles to cross via ramps, reduce their speed, and make the right-of-way relationship clearer. At unclear approaches, a different surface treatment or coloured conflict area is also recommended to increase attention (FSV, 2022, section 9.2.1).

Table 40: Assessment of analysed HRLs against measurable RVS criteria for "right-angle collisions"

RVS Section	**Section-Title**	**HRL Hasnerstraße**	**HRL Untere Donaustraße**
7.4	Design elements – Sight distances		
9.2.1	Nodes – Nodes in built-up areas – Cycle path		

Legend

	does comply
	does partly comply
	does not comply
	not applicable

HRL Hasnerstraße **complies partly** and HRL Untere Donaustraße **complies fully** with the RVS. At Hasnerstraße, the sight conditions do not comply (see Figure 64, left). From Sulmgasse, which was the approach direction of motorists in every accident involving a cyclist at this location, the visible distance to the right is about 19 m under free conditions. This would be enough if cyclists approach uphill at around 15 km/h, which would mean about 15 m within the 3,6 s reaction time specified in the RVS. However, perpendicular parking spaces reduce this visibility to around 13 m when occupied. The left side also does not comply, as only about 15 m are visible instead of around 30 m, which is the assumed approach distance for cyclists travelling downhill at around 30 km/h. At the time when the accidents happened, visibility on the left side was even worse, because there was also a perpendicular parking space there. This was removed only after 2024 (Google Street View, 2024). At Untere Donaustraße, by contrast, the sight conditions are sufficient (see Figure 64, right). From Franzensbrückenstraße, which was the direction from which motorists arrived in every cyclist accident at this location, at least 10 m are visible on both sides. This corresponds to the expected approach distance for cyclists travelling at the legal speed of 10 km/h before cyclist crossings. However, actual cyclist speeds may be higher, as it is unclear how many cyclists comply with this limit.

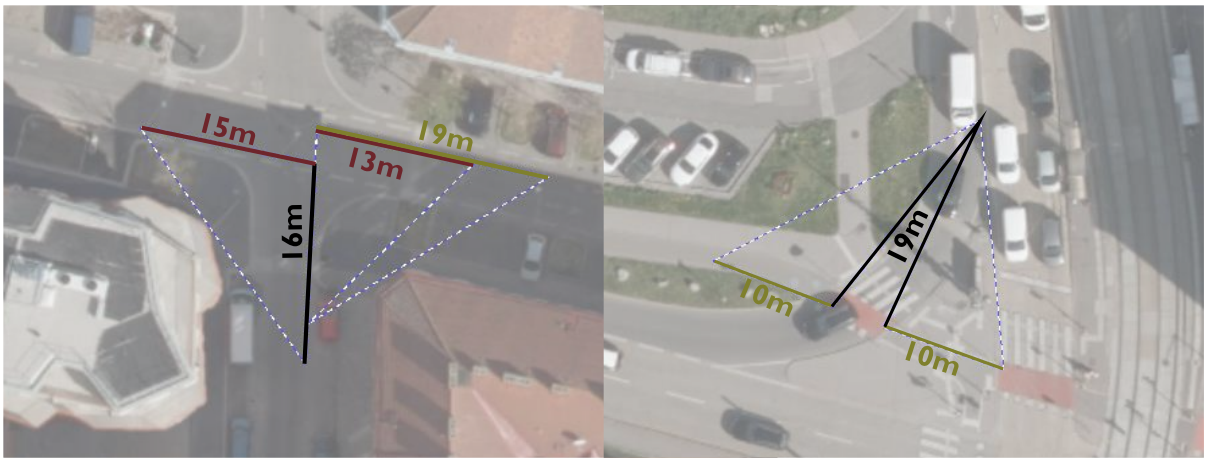


Figure 64: Measurements of sight conditions at HRL Hasnerstraße (left) and Untere Donaustraße (right)

Both HRLs comply with the RVS regarding the raised cycle crossing. However, only Untere Donaustraße also complies regarding conspicuous design, as the cycle path is paved red and there is a large warning marking on the carriageway before the intersection. At Hasnerstraße, there is only a small cyclist crossing sign, and there is not even a stop line for cars at the stop sign.

HRL design implications

Regarding RVS sections **7.4**, and **9.2.1**, HRL Untere Donaustraße's current layout complies with the RVS. At Hasnerstraße, however, the main priority should be to improve visibility and reduce motor vehicle speeds. In line with the RVS, a structural redesign should be examined to slow down approaching motor vehicles where sight conditions are not sufficient. In addition, a clearer stop line and a more conspicuous design of the crossing area, for example through red paving, would likely improve safety.

RVS design implication: Signalizing right-turning lanes at high-volume intersections

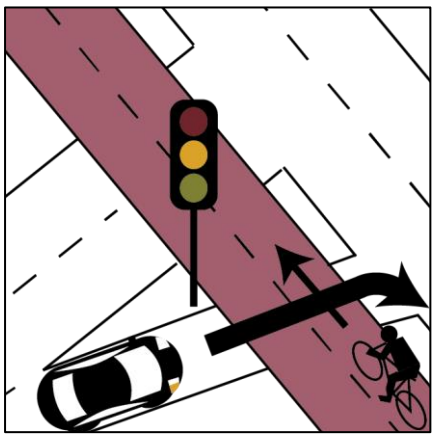


Figure 65: Signalizing right-turning lanes

As one of the analysed HRLs complies with the current RVS but still recorded five cyclist accidents within three years, the guideline framework may not be sufficient in all cases. Signalised intersections with cyclist crossings, especially where traffic volumes are high, should be designed so that right-turning motor vehicles are also signal-controlled, rather than remaining unsignalised. Otherwise, drivers may focus on motor traffic coming from the left, to which they must give way, and fail to notice cyclists approaching from the right, who also have priority. An alternative measure could be to require a stop sign for motorists before the cyclist crossing.

5.6 Group 7: Conflicts with parked vehicles

The identified issues regarding "conflicts with parked vehicles" are:

- absence of separate cycling infrastructure and downhill gradients on secondary street segments with parallel on-street parking on both sides,
- stated accident circumstances of "opening car door" and motorists' "inattention / distraction", pointing towards dooring accidents.

HRL compliance to current relevant RVS criteria

The RVS identifies conflicts with parked vehicles as one of the most frequent accident causes on carriageways with motor traffic. This includes both dooring and conflicts during parking manoeuvres. It also lists inattention and distraction by motor vehicle drivers as an important contributing factor (FSV, 2022, section 4.2). In addition, the RVS states that on downhill sections clearly higher cyclist speeds must be expected, which also means longer reaction distances. For this reason, fast downhill cycling should preferably be done in mixed traffic (FSV, 2022, section 7.3). At the same time, the RVS notes that this can become hazardous where the carriageway is narrow and parking is present on both sides, as the risk of dooring increases strongly (FSV, 2022, section 8.3.4). The RVS further describes lane widths between 3,0 m and 3,75 m as critical, because they can encourage overtaking with too little side distance. If there is not enough space for safe cycling infrastructure, the RVS allows reducing other uses, for example parking spaces, in order to create safer conditions (FSV, 2022, section 8.2.1). For parking next to cycling facilities, it requires a safety clearance of at least 0,75 m. Painted cycle lanes including this safety clearance must have a minimum width of 2,0 m. (FSV, 2022, section 8.1.1).

Table 41: Assessment of analysed HRLs against measurable RVS criteria for "conflicts with parked vehicles"

RVS Section	Section-Title	HRL Landstraßer Hauptstr. I	HRL Wallensteinstraße
7.3	Design elements – Travel speed		
8.1.1	Route area – Cycle facilities – Cycle lanes		
8.2.1	Route area – Mixed traffic – Cycling in mixed traffic without special measures		

Legend

	does comply
	does partly comply
	does not comply
	not applicable

The analysed HRLs **only partly comply** with the RVS. Both locations follow the RVS principle of cycling downhill in mixed traffic. However, the carriageway widths are critical at both locations. At Landstraßer Hauptstraße, the carriageway width is 3,3 m, at Wallensteinstraße, the carriageway width is 3,2 m. Both HRLs lie exactly within the width range that the RVS describes as critical for mixed traffic. This means that the current layout increases the risk of close passing and makes dooring even more likely. In addition, the uphill painted cycle lane at Landstraßer Hauptstraße has a total width of only 1,5 m and is therefore too narrow.

HRL design implications

Regarding RVS sections **7.3**, **8.1.1** and **8.2.1**, a safer street design would likely require converting at least one side of parking space into space for cycling infrastructure, as the carriageway widths are critical at

both HRLs and the painted cycle lane at Landstraßer Hauptstraße I is too narrow. This could create space for (wider) cycling infrastructure uphill and wider carriageway space downhill.

RVS design implication: No further recommendations

From an RVS perspective, the two analysed HRLs are sufficiently covered by the current guideline framework. The RVS already provides clear guidance on the relevance of parking-related risks and minimum width requirements for cycling infrastructure. If these principles were applied more consistently at the two locations, the infrastructure for cyclists would likely be safer.

5.7 Group 8: Conflicts with pedestrians

The identified issues regarding "conflicts with pedestrians" are:

- stated accident circumstances of "improper / unlawful behaviour" at and around signalised intersections,
- proximity to tram stops, and therefore also the presence of tram tracks, with tram stops inducing pedestrian frequency

HRL compliance to current relevant RVS criteria

The RVS identifies pedestrian-cyclist conflicts as a frequent source of accidents on cycling facilities, especially on mixed-use areas and at crossing points. It also explicitly names the disregard of traffic rules by road users as an important accident cause (FSV, 2022, section 4.1). Where both pedestrian and cyclist volumes are high, the RVS suggests a clear separation between walking and cycling space. It recommends a tactile separation and explicitly mentions a level difference of 3 cm, for example through a sloped kerb or paving strip (FSV, 2022, section 8.1.3). Before pedestrian crossings, the RVS also requires suitable markings and stop or holding lines in order to reduce conflicts between waiting cyclists and crossing pedestrians. At particularly unclear or hazardous points, additional coloured surface treatment is recommended (FSV, 2022, section 9.1.1).
The RVS further states that high pedestrian volumes and frequent crossings over cycle paths can strongly affect cycling traffic. In such cases, for example near public transport stops, cycle lanes or multi-use lanes on the carriageway may sometimes be the better option (FSV, 2022, section 6.4). In public transport stop areas, the RVS strongly recommends guiding the cycle path behind the waiting area so that direct conflicts between cyclists and boarding or waiting passengers are avoided (FSV, 2022, section 8.3.1). For streets with tram tracks, it warns of the increased fall risk and requires either separated cycling infrastructure or markings that keep cyclists at least 0,4 m away from the rails (FSV, 2022, section 8.3.3). Finally, where a high hazard to pedestrians cannot otherwise be avoided, the RVS allows speed-reducing measures for cyclists, such as ramps or changes in surface structure (FSV, 2022, chapter 10).

Table 42: Assessment of analysed HRLs against measurable RVS criteria for "conflicts with pedestrians"

RVS Section	Section-Title	HRL Parkring	HRL Spitalgasse
6.4	Criteria for the use of cycle facilities – Other criteria		
8.1.3	Route area – Cycle facilities – Cycle paths		

8.3.1	Route area – Special forms and routing in specific local situations – Public transport stops		
8.3.3	Route area – Special forms and routing in specific local situations – Cycling on streets with rail tracks		
9.1.1	Nodes – General recommendations – Safety and comfort		
10	Speed reduction measures on cycle facilities		

Legend

	does comply
	does partly comply
	does not comply
	not applicable

The two analysed HRLs **comply partly** with the RVS. At HRL Spitalgasse, there is a clear separation between cycle and pedestrian space. At HRL Parkring, this is not the case, as the separation is only made by surface markings and not by a tactile or vertical difference. However, at Parkring there is an additional coloured surface treatment at the intersection area. The RVS criterion that cycle lanes or multi-use lanes on the carriageway may sometimes be the better option in situations with high pedestrian volumes applies to HRL Spitalgasse, where painted cycle lanes are the current form of cycling infrastructure. At HRL Parkring, however, this would not be advisable, as the street has very high motorised traffic volumes. At both locations, the cycle path is guided behind the public transport waiting area and therefore complies with this RVS principle. The criterion on tram tracks is only relevant for HRL Spitalgasse. There, the painted cycle lane keeps the required distance of 0,4 m to the rails on the left side, but at the same time the available space is constrained by on-street parking on the right. Speed-reducing measures for cyclists are not present at either HRL.

HRL design implications

Regarding the listed RVS criteria (see Table 42), at HRL Parkring, the main implication is a clearer separation between cycle and pedestrian traffic. A tactile or level-based separation would likely reduce pedestrian–cyclist conflicts more effectively than markings alone. In addition, speed-reducing measures for cyclists, such as ramps or a changed surface structure, could be considered.

At HRL Spitalgasse, the location broadly complies with the RVS in relation to the issues discussed in this subsection. As most accidents there involved cyclists running a red light, the signalisation and possible waiting times should be examined more closely.

RVS design implication: Separation measures of cyclists and pedestrians

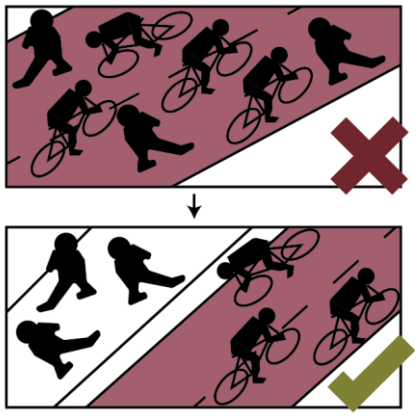


Figure 66: Separation measures of cyclists and pedestrians

From an RVS perspective, the two analysed HRLs are broadly covered by the current guideline framework. The RVS already provides clear guidance on the separation of pedestrian and cyclist space, the treatment of public transport stop areas, and tram-track safety. If these principles were applied more consistently at HRL Parkring, the infrastructure for both cyclists and pedestrians would likely be safer. At the same time, some parts of the RVS remain too weak in their wording. In particular, the recommendation that a tactile or level-based separation between walking and cycling space "should be aimed for" is not strong enough. The same applies to the guidance that routing the cycle path behind the waiting area is "strongly recommended". Both should be made more binding in the guideline framework.

5.8 Group 9: Other conflicts

As this accident group only has one HRL, the identified issues regarding "other conflicts" are specific to the situation at Museumplatz:

- motorists' right-of-way violation turning right into the driveway of a parking garage and colliding with cyclists travelling in the same direction,
- the high motorised traffic volumes and average speeds,
- motorists not having a separate turning lane or green phase.

HRL compliance to current relevant RVS criteria

The RVS names restricted visibility at driveways, such as garages or parking entrances, as a specific cause of accidents on cycling facilities. It also mentions right-turning motorists who fail to give way to cyclists going straight ahead (FSV, 2022, section 4.1). To reduce such conflicts, the RVS requires good visibility and close spatial proximity between the cycling facility and the parallel traffic lane (FSV, 2022, section 9.1.1). For crossings at driveways, it recommends a right-angled design, a continuous cycle path without lowering it, ramps for motor vehicles, and a conspicuous design of the conflict area, for example through red colouring (FSV, 2022, section 9.2.1). The RVS also states that where there is a dense sequence of heavily used driveways, cycle lanes may be preferable to cycle paths, because cyclists on the carriageway are more visible to motorists (FSV, 2022, section 6.3). At the same time, separated cycling infrastructure may already be necessary where motor traffic speeds are high, even at lower traffic volumes (see Figure 2; FSV, 2022, section 6.1). For particularly crash-prone turning conflicts, signal phase separation should in any case be examined, and safety should take priority over motor traffic capacity (FSV, 2022, section 9.2.6).

Table 43: Assessment of analysed HRLs against measurable RVS criteria for "other conflicts"

RVS Section	Section-Title	HRL Spitalgasse
6.1	Criteria for the use of cycle facilities – Motor vehicle criterion	

6.3	Criteria for the use of cycle facilities – Node criterion	
9.1.1	Nodes – General recommendations – Safety and comfort	
9.2.1	Nodes – Nodes in built-up areas – Cycle path	
9.2.6	Nodes – Nodes in built-up areas – Signal-controlled nodes	

Legend

	does comply
	does partly comply
	does not comply
	not applicable

The analysed HRL **only partly complies** with the RVS. Good visibility and close spatial proximity are given, as the cycle path runs directly next to the carriageway. The crossing at the driveway is also right-angled and marked in red. However, the cycle path is lowered, while the motor vehicles are not guided over a ramp, which does not follow the RVS recommendation. Although the RVS generally prefers cycle lanes instead of cycle paths at heavily used driveways, this would not be a good solution here because of the high motorised traffic volume and speed (see Figure 2). At present, the conflict is not signal-controlled, although a signalised pedestrian crossing is located about 5 m further ahead.

HRL design implications

Regarding the listed RVS criteria (see Table 43), the cycle path should be continued across the driveway without lowering it. This would make cyclist priority clearer and likely reduce the crossing speed of motor vehicles. In addition, it would make sense to create a signal-controlled right-turn lane for cars. This could be coordinated with the nearby signalised pedestrian crossing, especially as cyclists already have to give way to crossing pedestrians there.

RVS design implication: Turning motorists crossing cycle paths into driveways

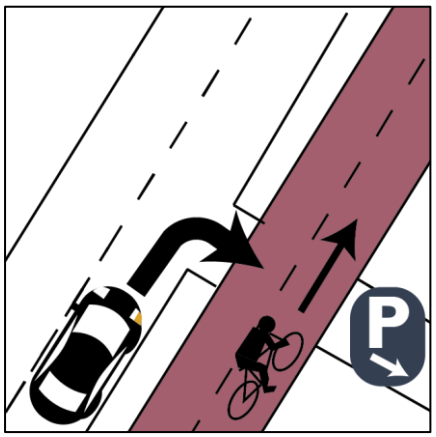


Figure 67: Turning motorists crossing cycle paths into driveways

It is difficult to define general RVS design implications for the group of "other conflicts". In cases of heavily used driveways like this one, however, the same basic conclusion applies as for Groups 3 and 4 (see sections 5.3 and 5.4): where traffic volumes and speeds are high, separate green phases or turning lanes should be considered more strongly. This would help to reduce conflicts between turning motor vehicles and cyclists in situations where visibility alone is not enough.

6 Discussion

The goal of this research was to identify hazardous road locations and analysing their recurring accident patterns in relation to infrastructural characteristics. Consequently, the goal is also to contribute practical guidance for the design of urban streets in Austria in order to improve cyclist safety. The results showed that cyclist accidents were spatially clustered and that several hazardous road locations had recurring accident patterns that could be linked to specific street characteristics.

However, this research moved beyond identifying hazardous road locations (HRL) and describing their characteristics. By combining quantitative hot spot analysis with qualitative analysis of selected locations, it was possible to understand how different street characteristics contributed to recurring cyclist accident patterns. This allowed the research to relate the findings to previous literature and to discuss where current planning guidelines, especially the RVS *Bicycle Traffic*, may need clearer or more binding criteria.

The following section builds on the results to discuss how the findings contribute to the understanding of cyclist safety in urban street environments. First, the findings are discussed in relation to accident clustering, street characteristics, and recurring cyclist accident patterns. Then, the practical implications for the RVS are considered. Lastly, the limitations of the research and recommendations for future studies are discussed.

6.1 Spatial concentration of cyclist accidents and meaning of HRLs

The results of the quantitative analysis indicate that cyclist accidents cluster spatially as 91 HRLs were identified. This is in line with previous research showing that cycling accidents are not randomly distributed across urban space, but tend to cluster at particular locations (Bassani et al., 2020; Kaygisiz & Hauger, 2017; Loidl et al., 2016; Schuurman et al., 2020; Toraldo et al., 2025). The main distances at which clustering was strongest were 250 m and 375 m. The first distance is especially relevant, as it matches the spatial definition of accident black spots in the RVS (FSV, 2014). This supports the use of this distance also in an urban cycling context.

At the same time, the identified clusters need to be interpreted carefully. Many HRLs were located on important cycling routes and higher-level roads. This means that the clusters may partly be explained by higher exposure, as more cyclists and more motor vehicles are likely to be present at these locations. Since the analysis was not exposure-adjusted, the results cannot show whether these locations are more hazardous per cyclist. The use of absolute accident counts is still relevant for planning, as they indicate where the most accidents happen absolutely, and therefore, the most accidents could be prevented.

6.2 Street characteristics as an interpretive framework

Traffic environment, intersection and conflict-point design, street layout and space allocation, and surface and topography are the four concepts used to organise the street characteristics identified in the literature. These factors informed the analysis of HRLs and enabled a better understanding of which indicators influenced safety issues at a specific HRL.

Overall, the four factors were useful for interpreting the HRLs. Traffic environment, intersection and conflict-point design, and street layout and space allocation were especially relevant, as these appear to relate to an increase in conflicts between cyclists and other road users. High motorised traffic volumes and speeds, complex intersections, the presence of different mode users, limited cycling space, and on-street parking all contributed to situations where conflicts became more likely. In this sense, the findings support the basic assumption that cyclist safety is strongly influenced by street characteristics (Aldred et al., 2018). At the same time, they also confirm the relevance of the individual characteristics identified in

the literature, as these factors repeatedly appeared in connection with recurring cyclist accident patterns (Aldred et al., 2021; Asadi et al., 2022; Bassani et al., 2020; De Rome et al., 2014; Dozza & Werneke, 2014; Harris et al., 2013; Kapousizis et al., 2021; Kaygisiz & Hauger, 2017; Reynolds et al., 2009; Van Petegem et al., 2021).

The selected factors were sufficient to cover the main street-related aspects of cyclist safety. However, some interrelations between the indicators were also quite clear. For example, primary roads often had high motorised traffic volumes and high speeds. In these cases, it may not have been necessary to collect all three variables separately, as traffic volume and speed might already have captured the main effect. More complete cyclist count data would have been useful, not only to adjust the analysis for exposure, but also to examine the safety-in-numbers effect. This effect describes a relationship where the number of cyclist accidents does not increase linearly with the number of cyclists, meaning that the individual risk for cyclists may decrease as cycling volumes increase.

Another important reflection concerns the spatial focus of the qualitative analysis. In many cases, the focus group cluster (FGC) was used as the main point of interpretation within the wider 250 m HRL diameter. This was necessary because not all accidents within the HRL were equally related to the same infrastructural situation. While some nearby accidents shared similar street characteristics, others appeared to be connected to a different part of the location. Using the FGC as the main point of analysis therefore made the interpretation more precise and helped to avoid assigning street characteristics to accident patterns that were only weakly related.

The usefulness of some indicators also depended strongly on the local context. For example, high motorised traffic volume or speed was less directly relevant where the focus group cluster was located on a two-way cycle path with little interaction with the adjacent carriageway. A similar issue applied to tram tracks that ran parallel to a cycle path without directly crossing the cyclists' movement path. These characteristics cannot be considered irrelevant, as they may still influence the wider traffic situation. However, their direct relevance was lower than in situations where cyclists moved in mixed traffic, crossed tram tracks, or interacted more closely with motorised traffic.

6.3 Recurring cyclist accident patterns

6.3.1 Intersections

Ten of the 13 distinct HRLs were located at intersections, which is consistent with studies that identify intersections as important locations for cyclist crashes (Harris et al., 2013; Kaygisiz & Hauger, 2017; Reynolds et al., 2009). Six of these ten intersections were signalized. However, this does not mean that signalized intersections are necessarily more hazardous. They are often signalized because traffic volumes, speeds, and turning movements are already high. The results suggest that the complexity of the intersection context is more important than signalization itself.

Turning conflicts in the same or opposite direction (Group 3 and Group 4), as well as turning conflicts into driveways (Group 9), are mainly linked to intersections where motorists did not yield, often on one-way streets with high motor traffic volumes and speeds. These intersections are either unsignalized or signalized in a way that turning motorists have the same green phase as crossing cyclists. Additionally, those turning motorists do not have separate turning lanes at all four signalized cases. Right-angle collisions (Group 5) also involve right-of-way violations. Both analysed HRLs, however, are located at non-signalised intersections.

6.3.2 Street layout and space allocation

Street layout and space allocation also played an important role. Many HRLs were located close to primary or higher-level roads, which is consistent with research linking major roads to cyclist crash occurrence (Aldred et al., 2021; Asadi et al., 2022; Bassani et al., 2020; Minikel, 2012; Reynolds et al., 2009; Van Petegem et al., 2021). On-street parking was not present at all HRLs, but where it was present, it was sometimes directly related to the recurring accident pattern. This was especially visible in conflicts with parked vehicles (Group 7), where dooring accidents occurred with no separated cycling infrastructure was present. Tram tracks were present at 8 of the 13 HRLs, which confirms that tram tracks are a relevant risk factor for cyclists (Harris et al., 2013; Van Petegem et al., 2021). However, tram tracks should not be understood as an isolated cause. In Vienna, they are often part of large transport corridors, which also have high traffic volumes, important cycling routes, and complex intersections.

A more careful interpretation is needed for cycling infrastructure type. Several HRLs were located on two-way separated cycle paths, even though exposure-adjusted studies often identify separated infrastructure as safer than mixed traffic or multi-use cycle paths (De Rome et al., 2014; Harris et al., 2013; Kapousizis et al., 2021; Lusk et al., 2011; Reynolds et al., 2009; Thomas & DeRobertis, 2013; Van Petegem et al., 2021; Von Stülpnagel & Binnig, 2022). This does not contradict the literature, because this thesis does not compare accident risk per cyclist. Instead, the findings show that even separated cycling infrastructure can produce recurring accident patterns when it interacts with complex intersections, poor visibility, or turning conflicts. In this research, conflicts in same-direction traffic (Group 1) and conflicts with parked vehicles (Group 7) could be linked to on-street parking and limited and non-separated cycling space.

6.3.3 Public transport and local visibility problems

Many HRLs were located close to public transport stops or bicycle-sharing stations (cf. Kaygisiz & Hauger, 2017). For pedestrian conflicts, this proximity seems directly relevant. Pedestrian conflicts appeared especially near public transport and were often linked to stated accident circumstances such as unlawful behaviour. However, these conflicts should not only be interpreted as behavioural problems. Public transport stops create locations with high pedestrian frequencies, where people enter and exit the transport hub and cross or wait close to cycling infrastructure. In these situations, the design of the street space can influence whether conflicts between cyclists and pedestrians become more likely.

In addition, local visibility problems also played a role in some cases. Conflicts in opposing traffic (Group 2) mainly occurred between cyclists or e-scooter riders, often with obstacles reducing visibility. While this was not one of the strongest findings across all HRLs, it shows that small-scale design elements can still contribute to recurring accident patterns where they block sight lines or are located directly after turns.

6.4 Implications for clearer or more binding RVS criteria

Among the analysed HRLs, all locations except Untere Donaustraße did not fully comply with the relevant RVS criteria assessed in this thesis. This shows, first, that several existing RVS criteria are not yet reflected in the current street design of the analysed HRLs. At the same time, the analysis also identified cases where the RVS itself could be clearer, more measurable, or more binding.

This is especially relevant in four areas. First, the option to reduce speed limits where separated cycling infrastructure cannot be provided could be formulated more clearly. The RVS could define more explicit conditions under which speed reduction should be used as a low-cost safety measure. Second, the treatment of obstacles on cycling infrastructure should be more specific. Instead of only stating that trees, poles, construction sites, and similar problem points should be assessed separately, the RVS should more clearly state that such obstacles create unfavourable conditions where they block sight lines, are located

directly after turns, or reduce the usable cycling space. Third, the guidance on pedestrian-cyclist separation should be more binding. In areas with high pedestrian and cyclist demand, tactile or level-based separation should not only be aimed for, but required where space allows. The same applies to the routing of cycle paths behind public transport waiting areas, which should be treated as a stronger requirement in locations with high passenger flows.

The analysis also showed conflict types that are not addressed clearly enough in the current RVS. This includes left-turn conflicts on one-way streets and turning conflicts where high-volume roads cross cycling infrastructure at signalised intersections. For these situations, the RVS could provide clearer guidance on when separate signal phases, advanced green phases, or signal-controlled turning lanes should be examined.

6.5 Research limitations and recommendations

The most important limitation of this study is that the analysis could not account for exposure. This means that the identified HRLs are the locations with high absolute numbers of cyclist accidents, but not necessarily the locations with the highest accident risk per cyclist. A full exposure-adjusted analysis would require reliable cyclist volume data for all locations, which was not available. However, the aim of this thesis was not to identify the relatively most hazardous locations per cyclist, but to analyse locations where many cyclist accidents happened and where serious safety problems therefore become visible. It is important to acknowledge that this research design affected the results, overrepresenting certain characteristics, such as two-way cycle paths, primary roads, and proximity to public transport stations.

The analysis also relies on police-reported accident data, which is a limitation because many cycling accidents are not reported (Kaygisiz & Hauger, 2017). However, this limitation is manageable for the focus of this thesis, as police-reported data are more likely to include accidents involving injuries and therefore cover the incidents that are most relevant from a Safe System perspective.

A further limitation is that the available data does not cover all dimensions that may influence cyclist accidents. While this thesis focuses on street characteristics and infrastructure, factors such as environmental, vehicle-related, driver-related, cyclist-related, and crash-related factors (Scarano et al., 2023) could not be analysed systematically. The findings should therefore be understood as an infrastructure-focused interpretation of cyclist accident patterns, rather than a complete explanation of all contributing factors.

A final limitation concerns the definition of bicycle-related accidents in the data. In 2022, e-scooters were still included in the bicycle+ category, while they were recorded separately from 2023 onwards (see section 3.1.1). This may have influenced the interpretation of some accident patterns, as bicycles and e-scooters have different riding characteristics. However, this limitation is relatively small for this research. The two modes are similar enough for the purpose of identifying infrastructure-related conflict patterns, and the issue only affects one year of the three-year accident period.

These limitations also show where further research is needed. Future studies of cyclist safety in Austria should include cyclist exposure data in order to distinguish between locations with many accidents and locations with high accident risk per cyclist. They should also look more closely at factors beyond street characteristics, such as behaviour, vehicle, or environmental conditions. In addition, other data sources, such as near-misses, video-based conflict analysis, or time-to-collision indicators[3], could help to analyse dangerous situations that do not appear in police-reported accident data.

[3] Time to collision (TTC) is a widely used surrogate safety indicator that predicts the time remaining before a collision if the involved road users keep their current speed and trajectory (Arun et al., 2021).

7 Conclusion

This thesis aimed to identify hazardous road locations for cyclists in Vienna and to analyse how recurring accident patterns relate to infrastructural characteristics. By doing so, it aimed to support safer urban street design and provide recommendations for the further development of the Austrian RVS guidelines.

The results show that cyclist accidents are not randomly distributed, but cluster spatially at specific locations. Many of these hazardous road locations also showed recurring accident patterns, which means that similar types of accidents happened repeatedly at the same location. These patterns were often connected to specific street characteristics, especially complex intersections, street layout and space allocation, public transport-related conflict points, and visibility conditions. The findings therefore indicate that cyclist safety is strongly influenced by how different elements of street design interact at a specific location.

A key contribution of this thesis is that it connects accident type, stated accident circumstances, infrastructure, and RVS relevance at the level of specific hazardous road locations. This made it possible to better understand how recurring cyclist accident patterns are linked to local street design. The findings also show that separated cycling infrastructure is not automatically safe in every context. It can still create safety problems when it is combined with complex intersections, poor visibility, unclear priority, or turning motor vehicles.

The RVS already provides a strong basis for safe cycling infrastructure, but the findings show that some parts could be made clearer, more measurable, and more binding. This is especially relevant where current wording leaves too much room for interpretation, for example regarding speed reductions, obstacles on cycling infrastructure, pedestrian-cyclist separation, and signalisation at complex crossings. As a practical reflection from working with the RVS, a simpler structure or digital support tool could also make the guidelines easier to apply. However, the main contribution of this thesis is the identification of specific areas where the content of the RVS could be further developed to better address recurring cyclist accident patterns.

Overall, the thesis shows that improving cyclist safety requires more than identifying accident hot spots. It also requires understanding the recurring accident patterns behind these hot spots and relating them to the specific street characteristics at each location. For planning practice, this means that hazardous road locations should not only be treated as points with many accidents, but as places where infrastructure, traffic conditions, and road user interactions need to be assessed together.

References

Abid, R. I. (2024). Identifying Spatial Patterns of Road Accidents in Madaba City by Applying Getis-Ord Gi* Spatial Statistic. *International Journal of Engineering and Advanced Technology*. https://doi.org/10.35940/ijeat.c4387.13040424

Aldred, R., Goodman, A., Gulliver, J., & Woodcock, J. (2018). Cycling injury risk in London: A case-control study exploring the impact of cycle volumes, motor vehicle volumes, and road characteristics including speed limits. *Accident Analysis & Prevention*, *117*, 75–84. https://doi.org/10.1016/j.aap.2018.03.003

Aldred, R., Kapousizis, G., & Goodman, A. (2021). Association of Infrastructure and Route Environment Factors with Cycling Injury Risk at Intersection and Non-Intersection Locations: A Case-Crossover Study of Britain. *International Journal of Environmental Research and Public Health*, *18*(6), 3060. https://doi.org/10.3390/ijerph18063060

Arun, A., Haque, M. M., Bhaskar, A., Washington, S., & Sayed, T. (2021). A systematic mapping review of surrogate safety assessment using traffic conflict techniques. *Accident Analysis & Prevention*, *153*, 106016. https://doi.org/10.1016/j.aap.2021.106016

Asadi, M., Ulak, M. B., Geurs, K. T., Weijermars, W., & Schepers, P. (2022). A comprehensive analysis of the relationships between the built environment and traffic safety in the Dutch urban areas. *Accident Analysis & Prevention*, *172*, 106683. https://doi.org/10.1016/j.aap.2022.106683

Austrian Standards Institute. (2025, January 1). *Informationen zu Normen*. Informationen zu Normen. https://www.oesterreich.gv.at/de/themen/gesetze_und_recht/oenormen-und-standards/Seite.2560001

Bassani, M., Rossetti, L., & Catani, L. (2020). Spatial analysis of road crashes involving vulnerable road users in support of road safety management strategies. *Transportation Research Procedia*, *45*, 394–401. https://doi.org/10.1016/j.trpro.2020.03.031

BMIMI. (n.d.). *Richtlinien und Vorschriften (RVS) für den Straßenbau*. Verkehrswege. Retrieved 18 May 2026, from https://www.bmimi.gv.at/themen/verkehr/strasse/infrastruktur/planung/rvs.html

BMK. (2021). *Austrian Road Safety Strategy 2021–2030*. https://www.bmimi.gv.at/verkehrssicherheit/publikationen/vs-strategie/vss2030.html

BMK. (2024). *Masterplan Radfahren 2030*.

BMVIT. (2016). *Österreich unterwegs 2013/2014*.

Council of the European Union. (2024). *European Declaration on Cycling* (Official Journal of the European Union C/2024/2377). Publications Office of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:C_202402377

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (Third Edition). SAGE.

De Rome, L., Boufous, S., Georgeson, T., Senserrick, T., Richardson, D., & Ivers, R. (2014). Bicycle Crashes in Different Riding Environments in the Australian Capital Territory. *Traffic Injury Prevention*, *15*(1), 81–88. https://doi.org/10.1080/15389588.2013.781591

Dozza, M., & Werneke, J. (2014). Introducing naturalistic cycling data: What factors influence bicyclists' safety in the real world? *Transportation Research Part F: Traffic Psychology and Behaviour*, *24*, 83–91. https://doi.org/10.1016/j.trf.2014.04.001

Esri. (n.d.-a). *Best practices for selecting a fixed distance band value*. Retrieved 29 April 2026, from https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/choosingdistanceband.htm

Esri. (n.d.-b). *Spatial Autocorrelation (Global Moran's I)*. Retrieved 15 June 2026, from https://pro.arcgis.com/en/pro-app/3.4/tool-reference/spatial-statistics/spatial-autocorrelation.htm

Esri. (n.d.c). *How Hot Spot Analysis (Getis-Ord Gi*) works*. https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/h-how-hot-spot-analysis-getis-ord-gi-spatial-stati.htm

European Commission. (2020). *Next steps towards 'Vision Zero': EU road safety policy framework 2021 2030*. Publications Office. https://doi.org/10.2832/391271

FSV. (n.d.). *Richtlinien und Vorschriften für das Straßenwesen*. Richtlinien Und Vorschriften Für Das Straßenwesen. Retrieved 18 May 2026, from https://www.fsv.at/cms/default.aspx?ID=9815dd09-f5a8-41a8-9fb5-b1197ffb1cd2

FSV. (2014). *Guidelines for Planning, Construction and Maintenance of Roads: Road Safety Analysis* (02.02.21).

FSV. (2022). *Guidelines for Planning, Construction and Maintenance of Roads: Bicycle Traffic* (03.02.13).

Fürthner, C. (2024). *Bicycle Street Argentinierstraße* [Photograph].

Fyhri, A., Sundfør, H. B., Bjørnskau, T., & Laureshyn, A. (2017). Safety in numbers for cyclists—Conclusions from a multidisciplinary study of seasonal change in interplay and conflicts. *Accident Analysis & Prevention*, *105*, 124–133. https://doi.org/10.1016/j.aap.2016.04.039

Getis, A., & Ord, J. K. (1992). The Analysis of Spatial Association by Use of Distance Statistics. *Geographical Analysis*, *24*(3), 189–206. https://doi.org/10.1111/j.1538-4632.1992.tb00261.x

Google Street View. (2021). *Google Street View* [Computer software].

Google Street View. (2024). *Google Street View* [Computer software].

Google Street View. (2025). *Google Street View* [Computer software].

Grigorev, A., Lillo-Trynes, D., & Mihaita, A.-S. (2025). Spatial Association Between Near-Misses and Accident Blackspots in Sydney, Australia: A Getis-Ord Gi* Analysis. *ArXiv*, *abs/2506.03356*. https://doi.org/10.48550/arxiv.2506.03356

Habib, M. F., Bridgelall, R., Motuba, D., & Rahman, B. (2023). Exploring the Robustness of Alternative Cluster Detection and the Threshold Distance Method for Crash Hot Spot Analysis: A Study on Vulnerable Road Users. *Safety*. https://doi.org/10.3390/safety9030057

Harris, M. A., Reynolds, C. C. O., Winters, M., Cripton, P. A., Shen, H., Chipman, M. L., Cusimano, M. D., Babul, S., Brubacher, J. R., Friedman, S. M., Hunte, G., Monro, M., Vernich, L., & Teschke, K. (2013). Comparing the effects of infrastructure on bicycling injury at intersections and non-intersections using a case–crossover design. *Injury Prevention*, *19*(5), 303–310. https://doi.org/10.1136/injuryprev-2012-040561

ITF. (2016). *Zero Road Deaths and Serious Injuries*. OECD Publishing. https://www.oecd.org/en/publications/zero-road-deaths-and-serious-injuries_9789282108055-en.html

Jacobsen, P. L. (2003). Safety in numbers: More walkers and bicyclists, safer walking and bicycling. *Injury Prevention*, *9*(3), 205–209. https://doi.org/10.1136/ip.9.3.205

Kapousizis, G., Goodman, A., & Aldred, R. (2021). Cycling injury risk in Britain: A case-crossover study of infrastructural and route environment correlates. *Accident Analysis & Prevention*, *154*, 106063. https://doi.org/10.1016/j.aap.2021.106063

Kaygisiz, Ö., & Hauger, G. (2017). Network-Based Point Pattern Analysis of Bicycle Accidents to Improve Cyclist Safety. *Transportation Research Record*, *2659*(1), 106–116. https://doi.org/10.3141/2659-12

Knappinger, M. (2026). *Young cyclist* [Photograph].

Land Niederösterreich. (2013). *Mobilitätserhebung Niederösterreich 2013*.

Land Niederösterreich. (2018). *Mobilitätserhebung Niederösterreich 2018*.

Land Oberösterreich. (2012). *Mobilitätserhebung Oberösterreich 2012*.

Land Oberösterreich. (2022). *Mobilitätserhebung Oberösterreich 2022*.

Land Salzburg. (2012). *Mobilitätserhebung Salzburg 2012*.

Land Salzburg. (2022). *Mobilitätserhebung Salzburg 2022*.

Land Vorarlberg. (2013). *Mobilitätserhebung Vorarlberg 2013*.

Land Vorarlberg. (2017). *Mobilitätserhebung Vorarlberg 2017*.

Land Vorarlberg. (2023). *Mobilitätserhebung Vorarlberg 2023*.

Loidl, M., Traun, C., & Wallentin, G. (2016). Spatial patterns and temporal dynamics of urban bicycle crashes—A case study from Salzburg (Austria). *Journal of Transport Geography*, *52*, 38–50. https://doi.org/10.1016/j.jtrangeo.2016.02.008

Lusk, A. C., Furth, P. G., Morency, P., Miranda-Moreno, L. F., Willett, W. C., & Dennerlein, J. T. (2011). Risk of injury for bicycling on cycle tracks versus in the street. *Injury Prevention*, *17*(2), 131–135. https://doi.org/10.1136/ip.2010.028696

Mesquitela, J., Elvas, L., Ferreira, J., & Nunes, L. (2022). Data Analytics Process over Road Accidents Data—A Case Study of Lisbon City. *ISPRS Int. J. Geo Inf.*, *11*, 143. https://doi.org/10.3390/ijgi11020143

Millard-Ball, A., Reginald, M., Yusuf, Y., & Bian, C. (2025). Global health and climate benefits from walking and cycling infrastructure. *Proceedings of the National Academy of Sciences*, *122*(24), e2422334122. https://doi.org/10.1073/pnas.2422334122

Minikel, E. (2012). Cyclist safety on bicycle boulevards and parallel arterial routes in Berkeley, California. *Accident Analysis & Prevention*, *45*, 241–247. https://doi.org/10.1016/j.aap.2011.07.009

Moran, P. A. P. (1950). NOTES ON CONTINUOUS STOCHASTIC PHENOMENA. *Biometrika*, *37*(1–2), 17–23. https://doi.org/10.1093/biomet/37.1-2.17

Muduli, K., Sahu, D., & Ghosh, I. (2025). An Adaptable Framework for Identifying and Prioritising Road Traffic Accident Hotspots. *Promet - Traffic&Transportation*. https://doi.org/10.7307/ptt.v37i2.751

Nader, A. (2023). *Multi-use lane in Hagenberg* [Photograph].

Neubauer, D. (2025, November 26). *Hoher Sanierungsbedarf auf Österreichs Straßennetz—Mobilität mit Zukunft*. https://vcoe.at/news/details/hoher-sanierungsbedarf-auf-oesterreichs-strassennetz

Odijk, M. J. M. (2023). *Analysis of cyclists' safety on "bicycle streets" and other facilities in four large Dutch municipalities: A crash and conflict study*. University of Twente, Department of Civil Engineering.

OGD Austria. (2025a). *Geländemodell Raster Wien* [Data set]. https://www.data.gv.at/datasets/1eda4b16-05e3-43c3-b5b0-ef8276df0701?locale=de

OGD Austria. (2025b). *Graph Integration Platform Vienna* [Data set]. https://www.data.gv.at/datasets/1039ed7e-97fb-435f-b6cc-f6a105ba5e09?locale=de

OGD Austria. (2025c). *Öffentliches Verkehrsnetz Haltestellen Wien* [Data set]. https://www.data.gv.at/datasets/f1f6f15d-2faa-4b62-b78b-80599dd1c66e?locale=de

OGD Austria. (2025d). *Wien Mobil Räder Wien* [Data set]. https://www.data.gv.at/datasets/a5fe8bd9-8629-4459-b8fb-45c439080aa2?locale=de

OGD Austria. (2026). *Main cycle network Vienna* [Data set]. https://www.data.gv.at/datasets/1ea3d3e8-fa07-4c37-af68-eb588d439de2?locale=de

OpenGIS. (n.d.). *Get started—QField Ecosystem Documentation*. Retrieved 29 April 2026, from https://docs.qfield.org/get-started/

Ord, J. K., & Getis, A. (1995). Local Spatial Autocorrelation Statistics: Distributional Issues and an Application. *Geographical Analysis*, *27*(4), 286–306. https://doi.org/10.1111/j.1538-4632.1995.tb00912.x

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research. *Administration and Policy in Mental Health and Mental Health Services Research*, *42*(5), 533–544. https://doi.org/10.1007/s10488-013-0528-y

Reynolds, C. C., Harris, M. A., Teschke, K., Cripton, P. A., & Winters, M. (2009). The impact of transportation infrastructure on bicycling injuries and crashes: A review of the literature. *Environmental Health*, *8*, 47. https://doi.org/10.1186/1476-069X-8-47

Scarano, A., Aria, M., Mauriello, F., Riccardi, M. R., & Montella, A. (2023). Systematic literature review of 10 years of cyclist safety research. *Accident Analysis & Prevention*, *184*, 106996. https://doi.org/10.1016/j.aap.2023.106996

Schepers, P., Hagenzieker, M., Methorst, R., Van Wee, B., & Wegman, F. (2014). A conceptual framework for road safety and mobility applied to cycling safety. *Accident Analysis & Prevention*, *62*, 331–340. https://doi.org/10.1016/j.aap.2013.03.032

Schuurman, N., Walker, B. B., Swanlund, D., Amram, O., & Yanchar, N. L. (2020). Qualitative Field Observation of Pedestrian Injury Hotspots: A Mixed-Methods Approach for Developing Built- and Socioeconomic-Environmental Risk Signatures. *International Journal of Environmental Research and Public Health*, *17*(6), 2066. https://doi.org/10.3390/ijerph17062066

Stadt Wien. (2025, March 16). *Archivmeldung: Modal Split 2024: Weitere Zunahme bei Öffis und Radfahren, Zu-Fuß-Gehen nach wie vor auf Rekordniveau*. Presseservice der Stadt Wien. https://presse.wien.gv.at/presse/2025/03/16/modal-split-2024-weitere-zunahme-bei-oeffis-und-radfahren-zu-fuss-gehen-nach-wie-vor-auf-rekordniveau

Statistik Austria. (2025). *Unfälle 2025*.

Statistik Austria. (2026). *Unfalldatenmanagement UDM* [Data set].

Thomas, B., & DeRobertis, M. (2013). The safety of urban cycle tracks: A review of the literature. *Accident Analysis & Prevention*, *52*, 219–227. https://doi.org/10.1016/j.aap.2012.12.017

TomTom. (n.d.). *TomTom MOVE. FAQ*. Retrieved 23 April 2026, from https://www.tomtom.com/products/tomtom-move/

TomTom. (2026). *Traffic Data & Traffic Stats* [Data set]. https://www.tomtom.com/products/traffic-stats/

Toraldo, E., Novati, N., Rossi, D., & Ketabdari, M. (2025). A Novel Methodology for Planning Urban Road Safety Interventions. *Applied Sciences*, *15*(4), 1993. https://doi.org/10.3390/app15041993

United Nations. (2020). *Improving global road safety* (Resolution 74/299).

United Nations Environment Programme. (2016). *Global Outlook on Walking and Cycling: Policies & Realities from Around the World* (G. Jennings, Trans.). https://wedocs.unep.org/handle/20.500.11822/17030

Van Petegem, J. H., Schepers, P., & Wijlhuizen, G. J. (2021). The safety of physically separated cycle tracks compared to marked cycle lanes and mixed traffic conditions in Amsterdam. *European Journal of Transport and Infrastructure Research*. https://doi.org/10.18757/EJTIR.2021.21.3.5283

Von Stülpnagel, R., & Binnig, N. (2022). How safe do you feel? – A large-scale survey concerning the subjective safety associated with different kinds of cycling lanes. *Accident Analysis & Prevention*, *167*, 106577. https://doi.org/10.1016/j.aap.2022.106577

Werneke, J., Dozza, M., & Karlsson, M. (2015). Safety–critical events in everyday cycling – Interviews with bicyclists and video annotation of safety–critical events in a naturalistic cycling study. *Transportation Research Part F: Traffic Psychology and Behaviour*, *35*, 199–212. https://doi.org/10.1016/j.trf.2015.10.004

WHO. (2022). *Walking and cycling, latest evidence to support policy-making and practice*. WHO.

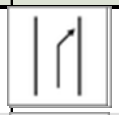
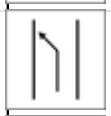
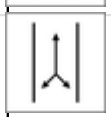
Wolf, S. (2025, November 26). *Rückbau von Straßen als Chance—Mobilität mit Zukunft*. https://vcoe.at/news/details/rueckbau-von-strassen-als-chance

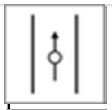
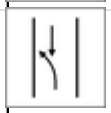
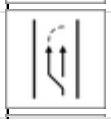
WUR Student Support. (2025, July 14). *WUR – Rules and Guidelines for Student Use of GenAI*.

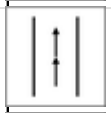
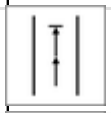
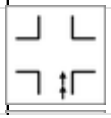
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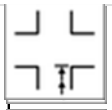
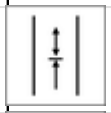
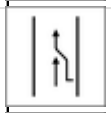
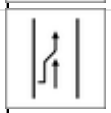
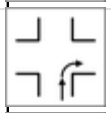
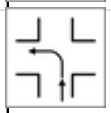
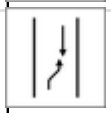
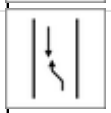
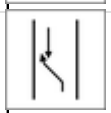
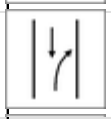
A Appendix - RVS Accident Groups and Accident Types

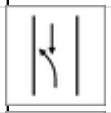
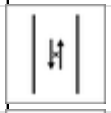
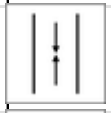
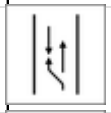
Table 44: RVS Accident Groups and Accident Types including icons

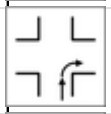
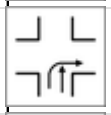
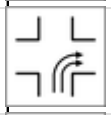
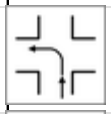
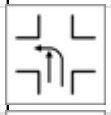
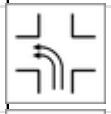
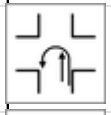
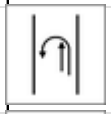
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0	Single-bicyde accident		11	Leaving the road to the right on a straight stretch of road
0	Single-bicyde accident		12	Leaving the road to the right on a right-hand bend
0	Single-bicyde accident		13	Leaving the road to the right on a left-hand bend
0	Single-bicyde accident		21	Leaving the road to the left on a straight stretch of road
0	Single-bicyde accident		22	Leaving the road to the left on a right-hand bend
0	Single-bicyde accident		23	Leaving the road to the left on a left-hand bend
0	Single-bicyde accident		31	Leaving the road at an intersection, road fork or exit
0	Single-bicyde accident		41	Reversing or making a U-turn
0	Single-bicyde accident		51	Falling from the vehide

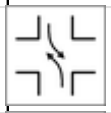
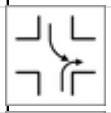
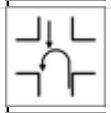
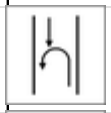
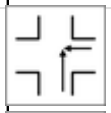
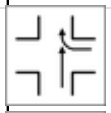
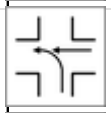
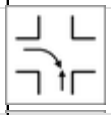
0	Single-bicyde accident		52	Falling inside the vehide
0	Single-bicyde accident		61	Collision with obstades or roadworks protection on the road
0	Single-bicyde accident		91	Other single-bicyde accident
0	Single-bicyde accident		221	Leaving the road to the right caused by an oncoming vehide on a straight stretch of road
0	Single-bicyde accident		222	Leaving the road to the right caused by an oncoming vehide on a right-hand bend
0	Single-bicyde accident		223	Leaving the road to the right caused by an oncoming vehide on a left-hand bend
0	Single-bicyde accident		224	Leaving the road to the left caused by an oncoming vehide on a straight stretch of road
0	Single-bicyde accident		225	Leaving the road to the left caused by an oncoming vehide on a right-hand bend
0	Single-bicyde accident		226	Leaving the road to the left caused by an oncoming vehide on a left-hand bend
1	Conflicts in same-direction traffic		111	Overtake on the right
1	Conflicts in same-direction traffic		112	Overtake on the left

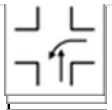
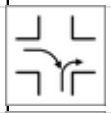
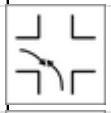
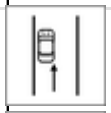
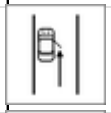
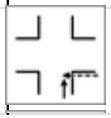
1	Conflicts in same-direction traffic		121	Changing lane to the right
1	Conflicts in same-direction traffic		122	Changing lane to the right with leaving the road to the right
1	Conflicts in same-direction traffic		123	Changing lane to the left
1	Conflicts in same-direction traffic		124	Changing lane to the left with leaving the road to the left
1	Conflicts in same-direction traffic		131	Rear-ending a moving vehide on a straight stretch of road
1	Conflicts in same-direction traffic		132	Rear-ending a moving vehide on a right-hand bend
1	Conflicts in same-direction traffic		133	Rear-ending a moving vehide on a left-hand bend
1	Conflicts in same-direction traffic		141	Rear-ending a vehide stopped due to traffic on a straight stretch of road
1	Conflicts in same-direction traffic		142	Rear-ending a vehide stopped due to traffic on a right-hand bend
1	Conflicts in same-direction traffic		143	Rear-ending a vehide stopped due to traffic on a left-hand bend
1	Conflicts in same-direction traffic		151	Rear-ending a moving vehide in an intersection area

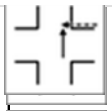
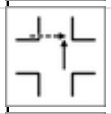
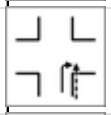
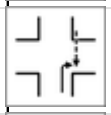
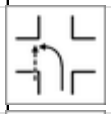
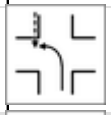
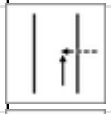
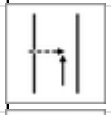
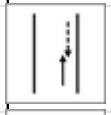
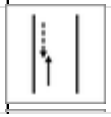
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1	Conflicts in same-direction traffic		172	Collision whilst reversing
1	Conflicts in same-direction traffic		181	Collision when merging from the right
1	Conflicts in same-direction traffic		182	Collision when merging from the left
1	Conflicts in same-direction traffic		191	Other accident in same-direction traffic
1	Conflicts in same-direction traffic		311	Rear-ending a vehide turning right
1	Conflicts in same-direction traffic		321	Rear-ending a vehide turning left
2	Conflicts in opposing traffic		211	Collision when merging from the left
2	Conflicts in opposing traffic		212	Collision when merging from the right
2	Conflicts in opposing traffic		213	Collision when moving towards the left edge of the road
2	Conflicts in opposing traffic		221	Leaving the road to the right caused by an oncoming vehide on a straight stretch of road

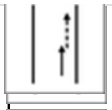
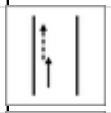
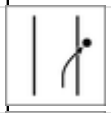
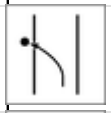
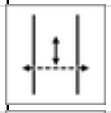
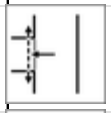
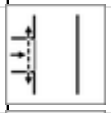
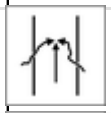
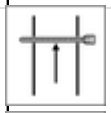
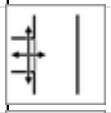
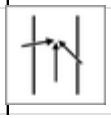
2	Conflicts in opposing traffic		222	Leaving the road to the right caused by an oncoming vehide on a right-hand bend
2	Conflicts in opposing traffic		223	Leaving the road to the right caused by an oncoming vehide on a left-hand bend
2	Conflicts in opposing traffic		224	Leaving the road to the left caused by an oncoming vehide on a straight stretch of road
2	Conflicts in opposing traffic		225	Leaving the road to the left caused by an oncoming vehide on a right-hand bend
2	Conflicts in opposing traffic		226	Leaving the road to the left caused by an oncoming vehide on a left-hand bend
2	Conflicts in opposing traffic		231	Side-on collision on the straight
2	Conflicts in opposing traffic		232	Side-on collision on a bend
2	Conflicts in opposing traffic		241	Head-on collision on the straight
2	Conflicts in opposing traffic		242	Head-on collision on a bend
2	Conflicts in opposing traffic		264	Head-on or side-on collision whilst overtaking on a straight stretch of road
2	Conflicts in opposing traffic		265	Head-on or side-on collision whilst overtaking on a right-hand bend

2	Conflicts in opposing traffic		266	Head-on or side-on collision whilst overtaking on a left-hand bend
2	Conflicts in opposing traffic		291	Other accident in opposing traffic
3	Turning conflicts in the same direction of travel		311	Rear-ending a vehide turning right
3	Turning conflicts in the same direction of travel		312	Vehides turning right and vehides going straight ahead
3	Turning conflicts in the same direction of travel		313	Collision between vehides turning right
3	Turning conflicts in the same direction of travel		321	Rear-ending a vehide turning left
3	Turning conflicts in the same direction of travel		322	Vehides turning left and vehides going straight ahead
3	Turning conflicts in the same direction of travel		323	Collision between vehides turning left
3	Turning conflicts in the same direction of travel		331	Collision whilst making a U-turn at an intersection
3	Turning conflicts in the same direction of travel		332	Collision whilst making a U-turn along a road section
3	Turning conflicts in the same direction of travel		391	Other accident whilst turning or making a U-turn in the same direction of travel

4	Turning conflicts in the opposite direction of travel		411	Collision whilst turning left
4	Turning conflicts in the opposite direction of travel		421	Collision where both vehides turn left
4	Turning conflicts in the opposite direction of travel		431	Collision whilst turning at the same time
4	Turning conflicts in the opposite direction of travel		451	Turning right where there is separated oncoming traffic
4	Turning conflicts in the opposite direction of travel		461	Collision whilst making a U-turn at an intersection
4	Turning conflicts in the opposite direction of travel		462	Collision whilst making a U-turn along a road section
5	Right-angle collisions		511	Collision at an intersection
5	Right-angle collisions		591	Other right-angle collision whilst crossing
5	Right-angle collisions		611	Collision with a vehide turning right whilst travelling in the same direction
5	Right-angle collisions		612	Collision with a vehide turning left whilst travelling in the same direction
5	Right-angle collisions		621	Collision with a vehide turning right whilst driving in the opposite direction

5	Right-angle collisions		622	Collision with a vehide turning left whilst driving in the opposite direction
5	Right-angle collisions		631	Collision between vehides turning right
5	Right-angle collisions		632	Collision between vehides turning left
5	Right-angle collisions		633	Collision between vehides turning right and left
5	Right-angle collisions		691	Other right-angle collision whilst turning
5	Right-angle collisions		951	Collision with cydists crossing the road
7	Conflicts with parked vehides		711	vehide is stopping or parking on the right
7	Conflicts with parked vehides		721	vehide is stopping or parking on the left
7	Conflicts with parked vehides		741	Drive past on the left of the parking vehide
7	Conflicts with parked vehides		742	Drive past on the right of the parking vehide
8	Conflicts with pedestrians		811	Before the crossroad, pedestrians coming from the right

8	Conflicts with pedestrians		812	After the crossroad, pedestrians coming from the right
8	Conflicts with pedestrians		813	Before the crossroad, pedestrians coming from the left
8	Conflicts with pedestrians		814	After the crossroad, pedestrians coming from the left
8	Conflicts with pedestrians		821	Collision with a pedestrian whilst turning right, pedestrian has the same direction of approach
8	Conflicts with pedestrians		822	Collision with a pedestrian whilst turning right, pedestrian has the opposite direction of approach
8	Conflicts with pedestrians		823	Collision with a pedestrian whilst turning left, pedestrian has the same direction of approach
8	Conflicts with pedestrians		824	Collision with a pedestrian whilst turning left, pedestrian has the opposite direction of approach
8	Conflicts with pedestrians		851	Pedestrian coming from the right
8	Conflicts with pedestrians		852	Pedestrian coming from the left
8	Conflicts with pedestrians		871	Pedestrian walking on the right-hand side of the lane in the opposite direction
8	Conflicts with pedestrians		872	Pedestrian walking on the left-hand side of the lane in the opposite direction

8	Conflicts with pedestrians		873	Pedestrian walking on the right-hand side of the lane
8	Conflicts with pedestrians		874	Pedestrian walking on the left-hand side of the lane
8	Conflicts with pedestrians		881	Pedestrian to the right of the road
8	Conflicts with pedestrians		882	Pedestrian to the left of the road
8	Conflicts with pedestrians		883	Pedestrian crossing the road whilst reversing
8	Conflicts with pedestrians		884	Collision with a pedestrian when entering a driveway
8	Conflicts with pedestrians		885	Collision with a pedestrian when exiting a driveway
9	Other		921	Animal on the road
9	Other		931	Accident with railway
9	Other		948	Collision when entering or exiting the driveway
9	Other		951	Collision with cydists crossing the road

B Appendix - Data Action Model Quantitative Analysis

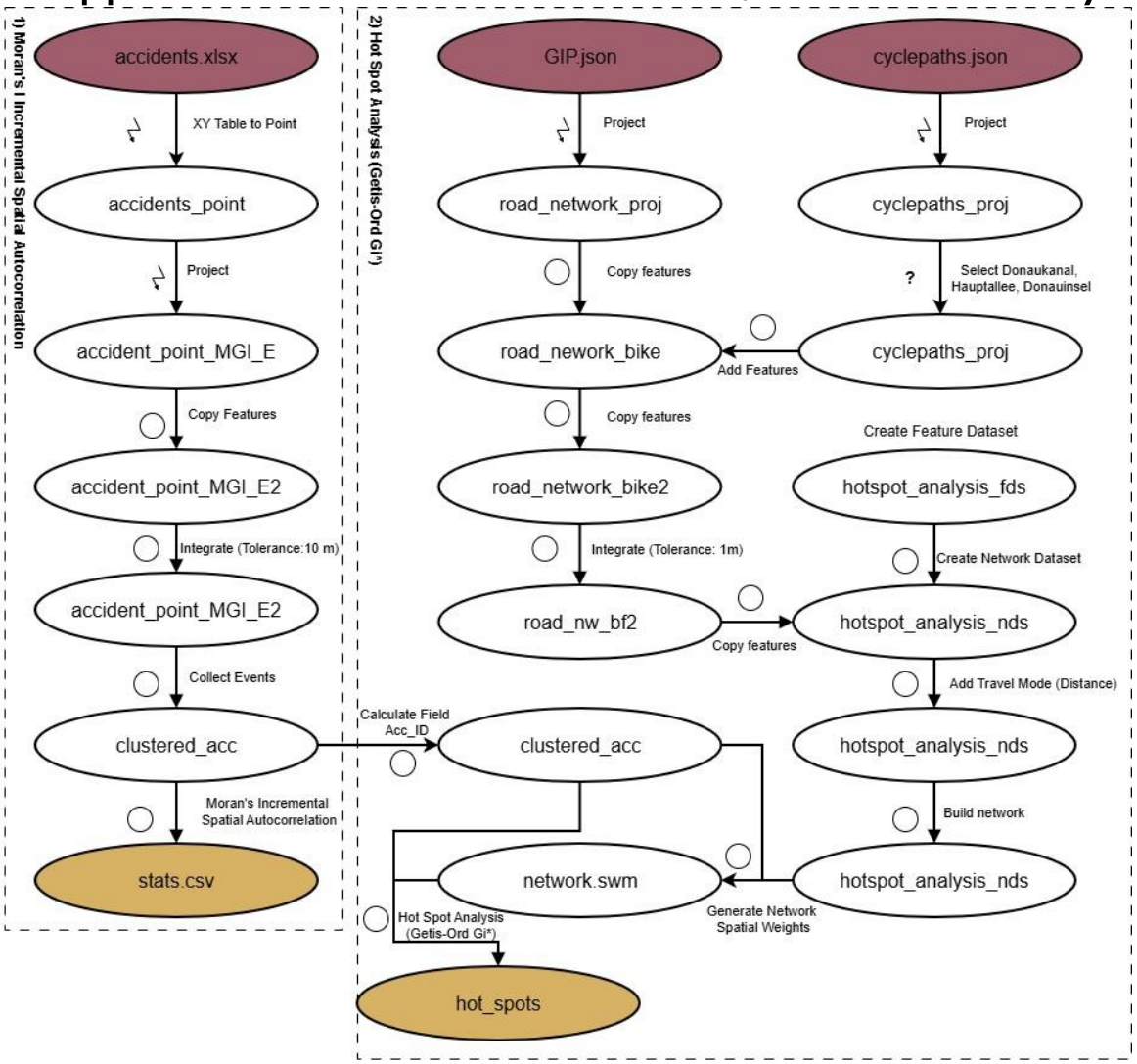


Figure 68: Data Action Model for the quantitative analysis

The figure shows the data action model for the whole analysis process of hot spot identification. The classes of data handling operators are represented by a ray (transformation), question mark (query) and circle (process). In red colour are depicted the input datasets and in yellow the output datasets.

C Appendix - Use of Generative AI Statement

Different Generative AI (GenAI) models were used in this thesis as a supplement, not a substitute for academic skills. While using GenAI ethical implications I adhered to the WUR rules and guidelines for student use of GenAI (WUR Student Support, 2025).

ChatGPT 5.5 was used for the refinement of text (see Figure 69), for digitizing sketches (see Figure 70), and for translating large amounts of data (see Figure 71).

Consensus Pro was used for literature review (see Figure 72) in addition to the non-AI database Scopus. All articles cited in this thesis were also read to verify claims.

NotebookLM was used for the analysing large policy documents for relevant information in chapter 5 (see Figure 73). All outputs were also read to verify claims.

Grammarly for Windows was used for grammar checks.

Examples for inputs and outputs

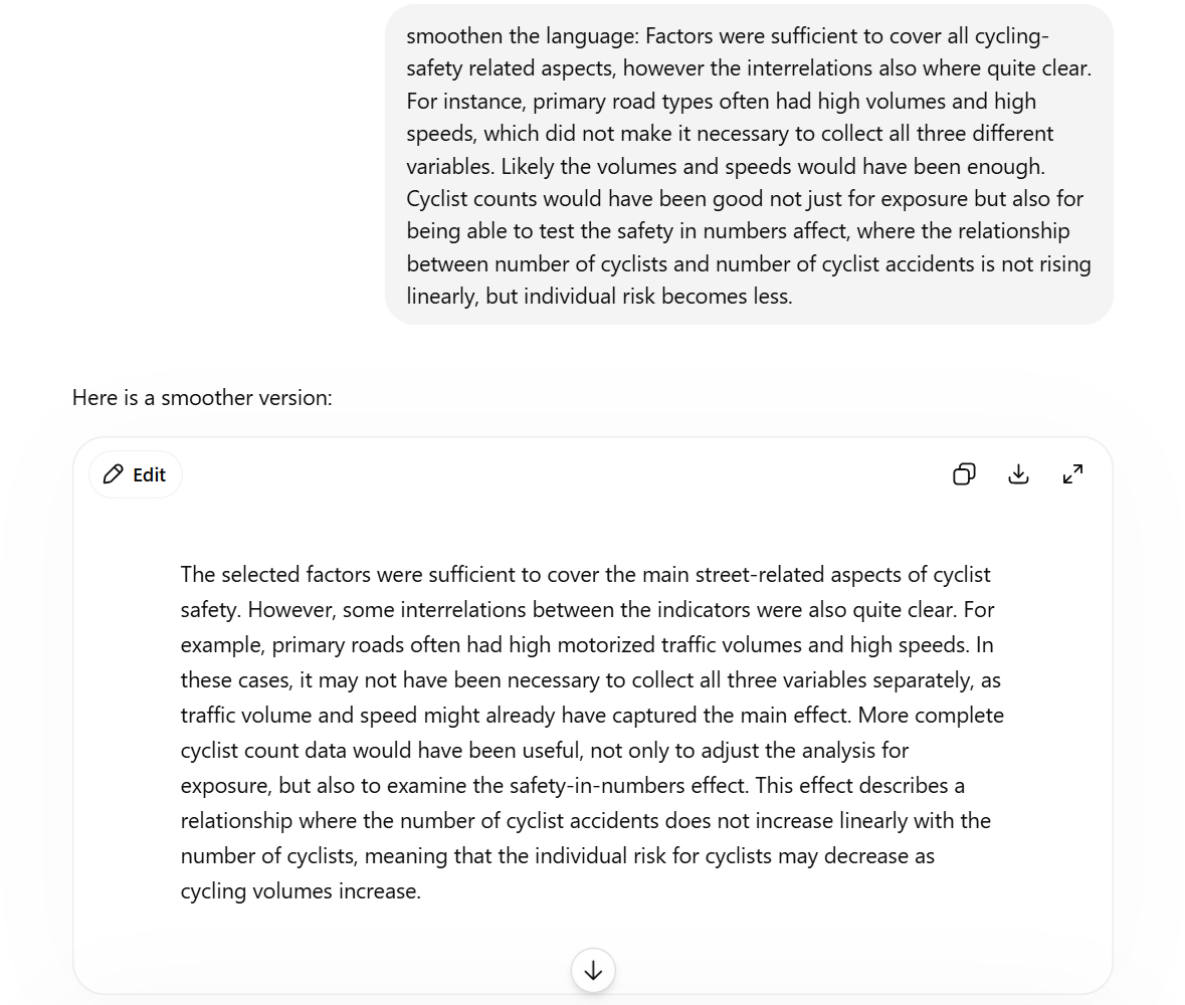


Figure 69: Example of the use of ChatGPT 5.5 for the refinement of text

i have a data action model hand drawn. can you transform it into a file that i can use in either draw.io or lucidchart or any other of these programs

Thought for 8s ›

Yes — upload a clear photo or scan of the hand-drawn model, and I can turn it into a usable diagram file.

Best output options:

- `.drawio` for diagrams.net / draw.io



only use what is written in black. and make it for drawio

Thought for 5m 10s ›

Done — I recreated it as a draw.io file using only the black text/content from your sketch.

Download the draw.io file

A couple of labels were hard to read, so I transcribed them as best as possible.

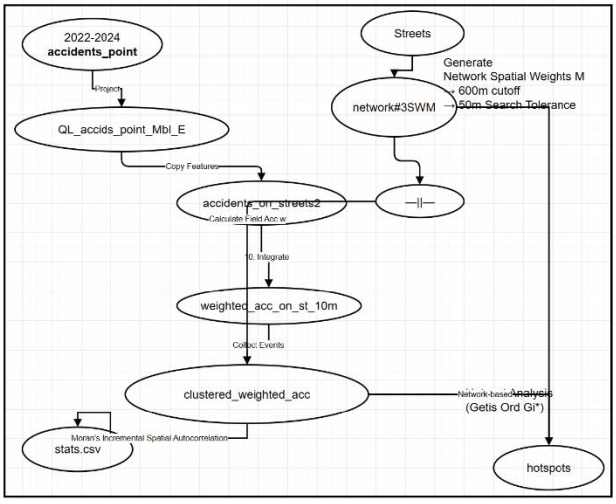


Figure 70: Example of the use of ChatGPT 5.5 for the digitalization of sketches

unfalltypenkatalog r_strassenverkehrs...
PDF

Lookup Table RVS Obergruppen And Accident Name

Unable to display visualization

I need your help with adding addtional translations in the second coloumn. I translated some of them already and they have to stay the same. This is the baseline for your translations - use the same vocabulary for the other ones. especially accident types that are very similar in german should be translated in the same way in english. some accident type numbers are double, make sure that they have the same translation when they are double. don't change anything in cells that already have text

Nachgedacht für 1m 44s

Done — I filled the empty cells in the second column using the German accident-type catalogue as reference, kept all existing translations unchanged, and made duplicate accident type numbers consistent.

unfalltypenkatalog r_strassenve...

You can download the completed CSV here:

lookup%20table%20RVS%20Obergruppen%20and%20accident%20name_t...

	A	B	C	D	E	F	G	H
1	Accidenttype_ID;Accidenttype_Name;RVS_Group;RVS_Group_Name							
2	11;Leaving the road to the right on a straight stretch of road;0;Single-bicycle accident							
3	12;Leaving the road to the right on a right-hand bend;0;Single-bicycle accident							
4	13;Leaving the road to the right on a left-hand bend;0;Single-bicycle accident							
5	21;Leaving the road to the left on a straight stretch of road;0;Single-bicycle accident							
6	22;Leaving the road to the left on a right-hand bend;0;Single-bicycle accident							
7	23;Leaving the road to the left on a left-hand bend;0;Single-bicycle accident							
8	31;Leaving road fork or exit;0;Single-bicycle accident							
9	41;Reversing or making a U-turn;0;Single-bicycle accident							
10	51;Falling from the vehicle;0;Single-bicycle accident							
11	52;Falling inside the vehicle;0;Single-bicycle accident							
12	61;Collision with obstacles or roadworks protection on the road;0;Single-bicycle accident							
13	91;Other single-bicycle accident;0;Single-bicycle accident							
14	221;Leaving the road to the right caused by an oncoming vehicle on a straight stretch of road;0;S							

Sheet1

Sources

Figure 71: Example of the use of ChatGPT 5.5 for translating large amounts of data

Perform a literature review on street characteristics contributing to cycling accidents. Tell me which factors play a role in enhancing the likelihood of accident occurance and give me the source as well. as well as that try to tell me how they measured it as well, so I can use it for my operationalization

Pro · 2 steps · 20 sources >

Street characteristics that increase cycling crash likelihood

Below is a literature-based overview of key street and built-environment factors linked to higher bicycle crash risk, plus how they were operationalized so you can reuse similar measures.

1. Road type, function and width

- **Primary / main roads vs. residential**
  - Main (Class A/primary) roads have about double the injury odds of residential roads for commuter cycling in Britain 8.
  - In London, primary roads and non-residential streets also show higher injury odds than residential and 20 mph streets 6.
- **High streets / retail corridors**
  - High streets (clusters of retail premises) increase injury odds by 32% 8.
- **Road width**
  - Greater carriageway width is consistently associated with higher injury odds 5 8.

Figure 72: Example of the use of Consensus Pro for literature review

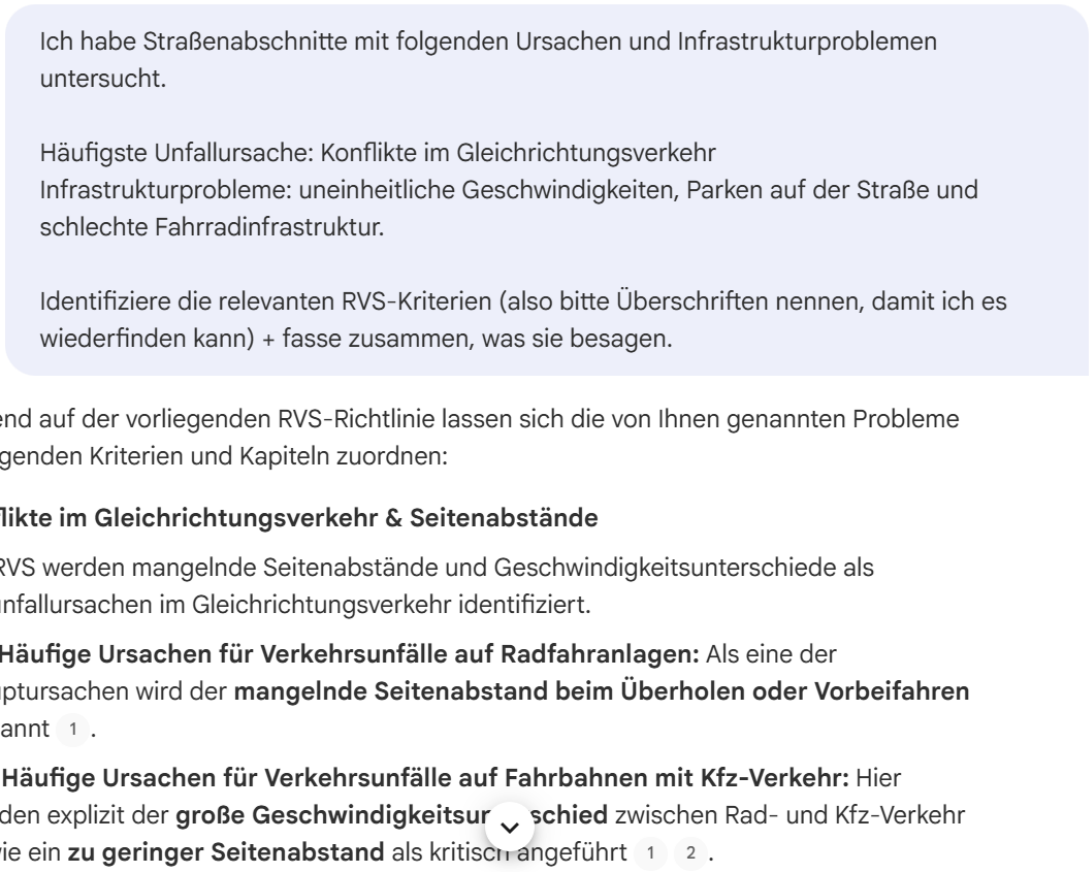


Figure 73: Example of the use of Consensus Pro for analysing large policy documents

Input:

"I have examined road sections with the following causes and infrastructure issues.

Most common cause of accidents: conflicts in two-way traffic

Infrastructure issues: inconsistent speed limits, on-street parking and poor cycling infrastructure.

Identify the relevant RVS criteria (please list the headings so that I can find them again) and summarise what they mean."

Output:

"Based on the current RVS guidelines, the issues you have raised can be categorised under the following criteria and sections:

1. Conflicts in two-way traffic & lateral spacing

The RVS identifies insufficient lateral spacing and differences in speed as the main causes of accidents in two-way traffic.

4.1 Common causes of traffic accidents on cycle facilities: **Insufficient lateral distance when overtaking or passing** is cited as one of the main causes.

4.2 Common causes of traffic accidents on carriageways with motor vehicle traffic: Here, the **significant difference in speed** between cyclists and motor vehicles, as well as **insufficient lateral distance**, are explicitly cited as critical factors [...]"

Reflection on AI use

I chose to use GenAI in this thesis for several reasons. Firstly, it supported time-intensive tasks such as digitising sketches, translating larger datasets, and assisting with literature and policy review. These uses helped to speed up the research process while maintaining quality through critical review, verification, and adaptation of the outputs. Secondly, GenAI was used to refine text, support grammar checks, and improve the clarity and consistency of the writing. In this way, it contributed to the overall quality and usability of the thesis, while remaining transparent about where and how it was used. Overall, I conclude that a thesis with this workload would have been difficult to complete within the five-month timeframe without the support of GenAI. I therefore regard its responsible and ethical use as a valuable technological advancement.

At the same time, I recognise the implications and limitations of using GenAI. Key concerns include data privacy, limited transparency, reliability of outputs, and environmental impact. To address these concerns, I did not upload confidential or sensitive information to GenAI tools. Where copyrighted material was used, this was limited to publicly available sources and only for research-related support, such as understanding, summarising, or reviewing content, without reproducing the material as original work. In addition, I disabled the use of my ChatGPT data for training. To account for the limited transparency and possible inaccuracy of GenAI outputs, I never relied on them without critical assessment, but checked claims, verified sources, and adapted the results where necessary. I was also mindful of the environmental impact of AI tools and used less energy-intensive alternatives where possible, relying on GenAI only when it provided a clear benefit to the research process or my learning.

D Appendix - Full Case Selection Map

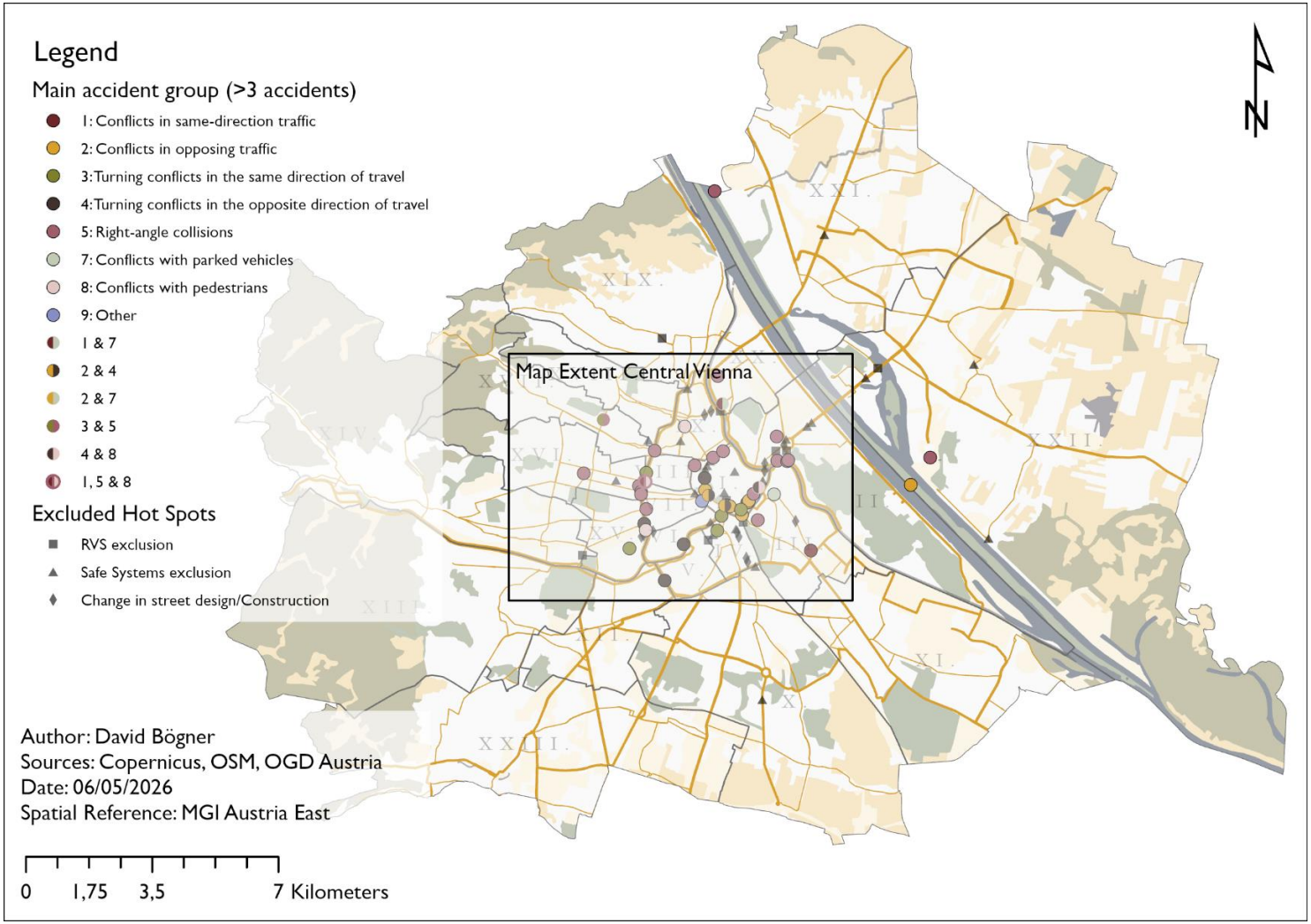


Figure 74: Full Case Selection Map of Vienna