Appendices

Investigation of Urban Rail Crossing Safety in The Netherlands

Master Thesis - Civil Engineering & Management
Specialization: Transport Engineering & Management
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Overview Abbreviations

AHOB: Automatic Half Barrier (*Dutch: Automatische Halve Overweg Bomen*)

CBA: Cost-Benefit Analysis

CMF: Crash Modification Factor

DO: Damage Only

EBM: Empirical Bayes Method

IF: Injury/Fatality

LC(S): Level Crossing

NB: Negative Binomial

SPF: Safety Performance Function

VOS: Safety Support Barriers (*Dutch: Veiligheidsondersteunende Slagbomen*)

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Appendix I – Extensive Literature Review

I.1. Definition of Urban Rail

For urban rail, there are many different options available. Traditionally, the tram (also called streetcar) and the metro (also called subway) do exist (Mohan, 2008) (Babalik-Sutcliffe, 2010). The tram is often integrated within the city, while the metro has a more exclusive environment. Furthermore, the metro has very few level crossings and always has a signalling system (van Es, 2020). In contrast, tram systems have many crossings and only in a few cases do tram crossings have a signalling system, for example, in tunnel sections (van der Bijl & van Oort, 2014).

In recent years, the term 'light rail' has gained popularity. Light rail can be positioned between tram and metro (de Bruijn & Veeneman, 2009). In some parts of the light rail network, the system integrates within the city and can share public space with other means of transport (van der Bijl et al., 2018). On other parts of the network, the system can have its own right of way and have a separated track and can be considered as a metro. The number of level crossings differs per section; more level crossings are present on integrated parts of the line than on separated parts (van der Bijl & van Oort, 2014). The average speed of light rail is higher compared to conventional tram lines. In this research, the term 'urban rail' will be applied, and for urban rail vehicles, the term 'tram' since most of the urban rail vehicles are a tram.

The advantage of urban rail is integrating within the city, which offers many opportunities for optimal public transport connections of a city with the suburbs (Topp, 1999). However, the integration also means that big and heavy vehicles mix with other traffic in certain places. Furthermore, different types of environments apply to urban rail lines. For example, lines can be located in the middle of the city centre and in quiet suburbs (van der Bijl & van Oort, 2014). Also, in the city, many on-grade level crossings are present. Also, urban rail vehicles have a higher crash risk at level crossings than busses (Cheung, 2008).

I.2. Law and Regulations

The Law and the Decree on Local Rail apply for urban rail in the Netherlands. The law describes the requirements for urban rail systems (Dutch Government, 2021). It describes that a system must be reliable, available, suitable for use and may not cause danger or damage to people or property. Also, a safety management system must be applied so that risks are recognized and matching measures are taken to control them. The safety level should also be continuously improved based on experience, deviations, and incidents. The Decree further specifies the requirements (Dutch Government, 2015). There is no maximum speed for urban rail; the speed limit is determined after advice from the infrastructure manager. Protection by means of signals should only be applied at speeds higher than 80 km/h or in situations without appropriate visibility. At level crossings, it is not necessary to install signals if traffic lights are used. Trams have priority over other traffic, except when road signs or traffic lights are applied (Dutch Government, 2021).

The law states that each system is responsible for its own safety management in the Netherlands. The law designates three city regions' tram, light rail, and metro networks as local rail (CROW-KpVV, 2015). These city-regions are Rotterdam-The Hague, Amsterdam, and Utrecht. The transport authority is responsible for the management and safety of the networks. However, the transport authority differs per city, and it can be either the metropolitan region or the province. For Amsterdam, this is the Transport region Amsterdam; for Rotterdam and The Hague, the Metropolis region Rotterdam Den Haag (MRDH) and for Utrecht, the Province of Utrecht. The transport authority works together with the manager and the transport operator. In Amsterdam, The Hague and Rotterdam, the manager and the transport operator are one company. However, Utrecht is an exception as the manager is part of the province (Heijgele, 2015). In conclusion, it

can be stated that there are several stakeholders responsible for urban rail safety and that each transport authority establishes its own policy related to safety management, which implies that no overarching policy on safety management for urban rail lines exists.

I.3. Crash Frequency Modelling

Instead of considering crash frequency modelling, it is possible to use an approach that considers the number of accidents per number of vehicles or the number of accidents per travelled kilometres. However, converting categorical data into continuous data can create problems with locations with no accidents. A Tobit regression model can be used to overcome this problem (Anastasopoulos et al., 2011). Another thing to consider is having many locations with zero accidents. Traditional models like the negative binomial model have limited performance when many zero counts exist in the data (Yu et al., 2019). A Hurdle model can be applied to deal with the zero issues. Such a model consists of two parts, the first part considers the count value as zero or positive, and the second part is applied with a count distribution (Cragg, 1971).

I.4. Risk Assessment Models

In the United Kingdom, the national rail operator has established a model for the qualitative risk assessment model of level crossing safety, the so-called ALCRM model (Network Rail Infrastructure Limited, 2019). In this model, the collective risk of the stakeholders is plotted against the money, time, and effort to avert the risk. If the risk is greater than the cost, it is worthwhile to take measures. This model uses a risk-based cost-benefit analysis to facilitate decision-making and considers measures' life cycle costs. The model also helps to prioritize unsafe crossings because different crossings can be compared.

Also, the Dutch railroad manager ProRail has applied risk assessment and risk ranking for regular railway level crossings in the Netherlands (Aalbers et al., 2018). The risk profile is determined based on the layout of the crossing, characteristics of the crossing and volumes of traffic. The updated register further discusses the use of a level crossing and the consequences of a possible collision. The risk classification model is based on the Kinney & Wiruth model (Kinney & Wiruth, 1976). Risk is determined by multiplying the 'probability' by 'consequence', in which probability is further defined as likelihood multiplied by exposure. 'Probability' is about the probability of a collision occurring at a crossing caused by the physical layout and design of the level crossing. 'Exposure' is about the probability that a crash occurs caused by the use of the crossing. 'Consequence' is about the 'damage' after a collision, such as casualties and other damage such as image loss.

Another assessment model is applied in Australia and New Zealand to prioritize level crossings based on safety risks, the so-called ALCAM model (NZ Transport Agency, 2012). It assists in decision-making for level crossings and supports the implementation of optimal safety measures for each level crossing. The model consists of an infrastructure, exposure, and consequence model. The infrastructure model consists of an algorithm in which properties and conditions of the infrastructure are filled in. In the exposure model, volumes of rail and road traffic are entered. In the consequence model, values are entered for the effects of a collision. Finally, the models are multiplied to determine the risk score. This risk score is the number of expected fatalities per year, and the model is validated with accident data.

In New Zealand, the ALCAM model is used for a more comprehensive risk assessment process of level crossings, called the Level Crossing Safety Impact Assessment (LCSIA) (Cook, 2021). In the LCSIA, a Level Crossing Safety Score (LCSS) is determined for every level crossing. LCSS uses the ALCAM model for a traditional risk model score, defining the theoretical risk for a specific level crossing. However, the LCSS also consists of three additional inputs: crash and incident data from the past, ratings of risks by engineers and train drivers and a Site Specific Safety Score (SSSS). For

crash and incident data, the history of crashes is analysed, and specific scores are provided concerning the extent and number of crashes for a particular level crossing. For the ratings of engineers and drivers, they are asked to assign scores to level crossings from their point of view. The Site Specific Safety Scores uses a scoring table to assess elements that are not incorporated within the ALCAM model. The LCSIA can be used to identify risk scores for current level crossings and evaluate the impact of proposed safety measures. Compared with the ALCAM model, ALCRM model and the model used in the Netherlands, the LCSIA consists of a more comprehensive assessment process. In addition, it is shown that ALCAM's risk model sometimes does not adequately measure the risk level and omits near misses (Turner et al., 2021). A more comprehensive risk assessment process could better inform decision-making since it has a broader perspective than traditional risk models (Cook, 2021). A drawback of the crash prediction models is that they need an extensive and complete set of data for all the level crossings and crash data. This data is needed to calibrate the prediction formula used in these models (Hu et al., 2012).

I.5. Safety Measures on Level Crossings

Also, studies have been conducted on the countermeasures which can be taken to improve safety on urban rail crossings. These measures differ in scope and costs; for example, relatively low-cost and straightforward measures like knockdown delineators at intersections or applying appropriate signing. Also, other measures could be taken, for example, ongoing education or standardization of the visual landscape at urban rail grade crossings (Coifman, 1997). The British rail authority went into detail about countermeasures for level crossings (Network Rail Infrastructure Limited, 2019). The safest option is to close level crossings; however, this has significant consequences for accessibility or major investments are required to build infrastructural structures in the form of bridges and tunnels. Another measure is to install security systems at unprotected level crossings. Another measure is installing barriers at level crossings, improving the signage, or improving the layout to make the level crossing easier to survey. Another solution is to install obstacle detection, which warns the driver when an obstacle is blocking the crossing.

I.6. Effects of Built Environment

Also, literature is explored to see how land use and built environment can be incorporated into the model as independent variables. (Heydari et al., 2020) showed that proximity to schools leads to more injuries at intersections for pedestrians. They considered a distance of 50 meters for the proximity of schools. In contrast, (Zahabi et al., 2011) found that schools within 400 meters lead to a lower risk of injury or fatality for pedestrians. They applied several buffers between 50 and 400 meters of intersections. Also, it was shown that commercial land use increases the probability of fatalities (KimJ. et al., 2010) (Kwigizile et al., 2011). (Xin et al., 2017) researched the effects of neighbourhood and built environment variables on pedestrian injury severity with an ordered probability model. They applied a school presence indicator when a school was located within 0.5 kilometres. The same they did for a supermarket. For a public transport stop, they used a buffer of 0.2 kilometres. They found that for close-located school areas, the number of fatal accidents was lower, but the number of injury accidents was higher. Both the fatal and injury accidents were lower for locations with bus stops. (Clifton et al., 2009) found that the presence of a school within 250 meters increases the probability of injuries and fatalities. So, in conclusion, it can be stated that the proximity of schools leads to different results.

A higher population density leads to a higher frequency of crashes, even when exposure is adjusted (Obelheiro et al., 2020). High land-use diversity, so areas with a high land-use index (MXI)) decrease crash frequency (Schepers et al., 2019). Also, it has been shown that proximity to facilities, such as schools and supermarkets leads to higher crash risk (Kim et al., 2010) (Schepers, 2021). Furthermore, research showed that neighbourhoods with a construction year before 1970

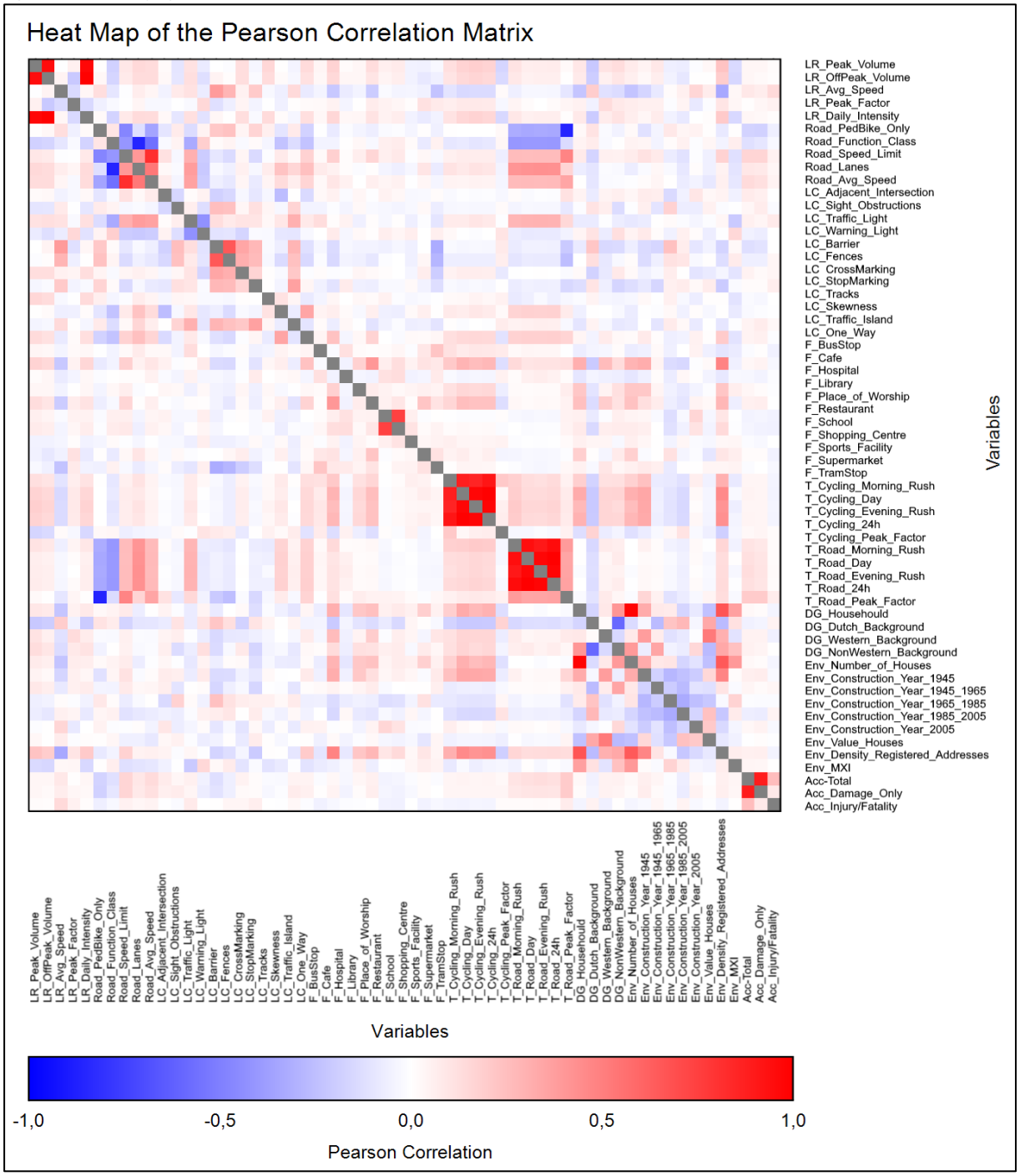
have a higher accident risk (Schepers, 2021). For the relation between accidents and the proximity of facilities, literature is examined to what extent the area of influence of these facilities extends. From the literature, it is not straightforward which distance needs to be considered. (Ulak et al., 2018) examined crashes involving ageing roadway users. They applied a distance of 0.1 miles (approximately 150 meters) for the distance to facilities such as hospitals, places of worship and supermarkets. (Vandenbulcke et al., 2014) investigated how infrastructure influences the safety of cyclists. They used a distance of 100 meters for the distance between accident locations and parking garages for predicting the accidents risk of cycling in Brussel. (Briz-Redón et al., 2019) looked in particular to accidents near school locations in the city of Valencia. They implemented values between 25 and 300 meters and found that a distance of 100 meters was optimal for defining buffer zones. Other research which investigated accidents near school areas incorporated a distance of 0.5 miles (approximately 800 meters) (Abdel-Aty et al., 2007) or 0.25 miles (approximately 400 meters) (Clifton & Kreamer-Fults, 2007) (Hwang et al., 2017).

Appendix II – Correlation Analysis

II.1. Pearson Correlation

In Figure 1, the heat map of the Pearson Correlation Matrix can be found.

Figure 1: Heat Map of Pearson Correlation Matrix



On the following page, the corresponding correlation tables can be found. Only correlated variables are shown.

		LR_Peak_Int
LR_Peak_Int	Pearson Correlation	
LR_OffPeak_Int	Pearson Correlation	0,948
	Sig. (2-tailed)	0,000

		LR_Peak_Int	LR_OffPeak_Int
LR_Daily_Int	Pearson Correlation	0,973	0,991
	Sig. (2-tailed)	0,000	0,000

		Road_Function_Class
Road_Lanes	Pearson Correlation	-0,858
	Sig. (2-tailed)	0,000

		Road_Speed_Limit
Road_Avg_Speed	Pearson Correlation	0,816
	Sig. (2-tailed)	0,000

		Road_PedBike_Only
T_Road_Peak_Factor	Pearson Correlation	-0,858
	Sig. (2-tailed)	0,000

		T_Cycling_MR_Int	T_Cycling_Day_Int	T_Cycling_ER_Int
T_Cycling_Day_Int	Pearson Correlation	0,884		
	Sig. (2-tailed)	0,000		
T_Cycling_ER_Int	Pearson Correlation	0,858	0,978	
	Sig. (2-tailed)	0,000	0,000	
T_Cycling_24h_Int	Pearson Correlation	0,918	0,996	0,981
	Sig. (2-tailed)	0,000	0,000	0,000

		T_Road_MR_Int	T_Road_Day_Int	T_Road_ER_Int
T_Road_MR_Int	Pearson Correlation			
	Sig. (2-tailed)			
T_Road_Day_Int	Pearson Correlation	0,945		
	Sig. (2-tailed)	0,000		
T_Road_ER_Int	Pearson Correlation	0,906	0,977	
	Sig. (2-tailed)	0,000	0,000	
T_Road_24h_Int	Pearson Correlation	0,957	0,999	0,981
	Sig. (2-tailed)	0,000	0,000	0,000

		DG_Households_x100
Env_CY_Houses_x1000	Pearson Correlation	0,984
	Sig. (2-tailed)	0,000

II.2. Tetrachoric Correlation

See Table 1 on the next page.

Table 1: Tetrachoric Correlation.

Tetrachoric Correlation *Dichotomous Variables*	Road_PedBike_Only	LC_Adj_Intersection	LC_Sight_Obstructions	LC_TrafficLight	LC_WarningLight	LC_Barrier	LC_Fences	LC_Cross_Marking	LC_Stop_Marking	LC_Skewness	LC_Traffic_Island	LC_One_Way	F_BusStop_150m	F_Cafe_150m	F_Hospital_150m	F_Place_of_Worship_150m	F_Restaurant_150m	F_School_150m	F_Shopping_Centre_150m	F_Sport_Facility_150m	F_Supermarket_150m	F_TramStop_150m
Road_PedBike_Only	-																					
LC_Adj_Intersection	-0,285	-																				
LC_Sight_Obstructions	-0,216	-0,411	-																			
LC_TrafficLight	-0,276	0,041	0,147	-																		
LC_WarningLight	0,097	0,137	-0,263	-0,639	-																	
LC_Barrier	0,530	-0,519	0,616	0,352	-0,292	-																
LC_Fences	0,481	-0,412	0,529	0,169	-0,205	**0,991**	-															
LC_Cross_Marking	0,108	-0,105	0,116	0,217	-0,329	0,724	0,598	-														
LC_Stop_Marking	0,317	-0,251	0,247	0,169	-0,037	0,675	0,503	0,331	-													
LC_Skewness	-0,278	-0,590	-0,076	0,180	-0,178	-0,273	-0,441	-0,065	-0,094	-												
LC_Traffic_Island	0,164	0,016	0,358	0,518	-0,178	0,664	0,460	0,418	0,587	-0,166	-											
LC_One_Way	-0,779	-0,415	-0,148	0,190	-0,059	**-1,000**	-0,659	-0,034	0,090	0,664	-0,306	-										
F_BusStop_150m	-0,004	0,077	-0,081	0,206	0,002	-0,104	-0,036	0,031	-0,094	0,090	0,033	0,097	-									
F_Cafe_150m	-0,217	0,207	-0,012	0,022	0,166	**-0,805**	-0,497	-0,030	-0,244	0,152	-0,169	0,509	-0,037	-								
F_Hospital_150m	-0,162	-0,198	**-1,000**	0,396	-0,273	**-1,000**	**-1,000**	-0,096	0,549	0,161	0,244	**-1,000**	**-1,000**	**-1,000**	-							
F_Place_of_Worship_150m	-0,141	0,167	0,107	-0,148	0,072	-0,241	-0,210	0,121	-0,165	-0,086	-0,009	0,106	0,052	0,428	**-1,000**	-						
F_Restaurant_150m	-0,171	-0,032	-0,051	0,022	0,019	-0,190	-0,276	0,061	-0,147	0,143	-0,261	0,390	0,026	0,690	**-1,000**	0,200	-					
F_School_150m	-0,049	0,216	-0,081	-0,073	0,153	-0,272	-0,034	0,029	-0,060	-0,166	-0,127	-0,002	0,032	0,171	0,669	0,155	0,138	-				
F_Shopping_Centre_150m	0,435	-0,086	0,404	-0,035	-0,077	**0,791**	**0,726**	0,617	0,484	-0,291	0,269	**-1,000**	-0,355	0,275	**-1,000**	0,299	0,571	**-1,000**	-			
F_Sport_Facility_150m	-0,101	-0,090	-0,065	-0,131	0,139	-0,236	-0,163	-0,104	0,042	0,060	-0,159	0,069	-0,024	0,118	**-1,000**	0,128	0,043	0,156	**-1,000**	-		
F_Supermarket_150m	0,022	-0,094	0,098	-0,029	0,003	0,005	0,099	0,186	-0,132	0,163	-0,158	0,064	0,215	0,269	**-1,000**	0,184	0,484	-0,041	0,578	0,098	-	
F_TramStop_150m	-0,118	0,050	-0,164	-0,160	0,100	**-0,821**	-0,543	-0,387	-0,213	0,008	-0,178	0,082	0,369	0,186	**-1,000**	0,120	0,230	0,007	-0,274	0,109	0,289	-

Appendix III – Descriptive Statistics

III.1. Overview Variables & Descriptive Statistics

Table 2: Candidate variables & descriptive statistics.

Variable	*Definition*	*Data Source*	*Min*	*Max*	*Mean*	*St.D.*
Accidents						
Accidents Total	Total number of accidents	(ViaStat, 2021)	0	8	0,40	0,84
Accidents Damage Only (DO)	Number of accidents with damage only	(ViaStat, 2021)	0	7	0,28	0,67
Accidents Injury	Number of accidents with injury	(ViaStat, 2021)	0	2	0,10	0,33
Accidents Fatality	Number of accidents with fatality	(ViaStat, 2021)	0	1	0,02	0,13
Proximity Facilities						
Bus Stop	Indicator whether there is a bus stop within 150m of LC; 0: no, 1: yes	(OSM, 2021)	0	1	0,42	0,49
Café	Indicator whether there is a cafe within 150m of LC; 0: no, 1: yes	(OSM, 2021)	0	1	0,20	0,40
Hospital	Indicator whether there is a hospital within 150m of LC; 0: no, 1: yes	(OSM, 2021)	0	1	0,01	0,10
Place of Worship (POW)	Indicator whether there is a POW within 150m of LC; 0: no, 1: yes	(OSM, 2021)	0	1	0,12	0,32
Restaurant	Indicator whether there is a restaurant within 150m of LC; 0: no, 1: yes	(OSM, 2021)	0	1	0,20	0,40
School	Indicator whether there is a school within 150m of LC; 0: no, 1: yes	(OSM, 2021)	0	1	0,15	0,36
Shopping Centre	Indicator whether there is a shopping centre within 150m of LC; 0: no, 1: yes	(OSM, 2021)	0	1	0,01	0,12
Sport Facility	Indicator whether there is a sports facility within 150m of LC; 0: no, 1: yes	(OSM, 2021)	0	1	0,19	0,40
Supermarket	Indicator whether there is a supermarket within 150m of LC; 0: no, 1: yes	(OSM, 2021)	0	1	0,14	0,34
Tram Stop	Indicator whether there is a tram stop within 150m of LC; 0: no, 1: yes	(OSM, 2021)	0	1	0,62	0,49
Demographics						
Background Dutch	% with Dutch background	(CBS, 2020)	0	1	0,48	0,20
Background Western	% with Western background	(CBS, 2020)	0	0,5	0,15	0,09
Background Non-Western	% with Non-Western background	(CBS, 2020)	0	0,8	0,34	0,19
Households (x1000)	Number of households	(CBS, 2020)	0	26,3	9,66	5,77
Environment						
Construction Year (<1945)	% of houses with construction year before 1945.	(CBS, 2020)	0	1	0,16	0,28
Construction Year (1945-1965)	% of houses with construction year between 1945 and 1965.	(CBS, 2020)	0	1	0,14	0,25
Construction Year (1965-1985)	% of houses with construction year between 1965 and 1985.	(CBS, 2020)	0	1	0,24	0,32
Construction Year (1985-2005)	% of houses with construction year between 1985 and 2005.	(CBS, 2020)	0	1	0,27	0,31
Construction Year (>2005)	% of houses with construction year after 2005.	(CBS, 2020)	0	1	0,14	0,24
Houses (x1k)	The number of houses.	(CBS, 2020)	0	2,36	0,92	0,54
MXI	Mixed Land Use Function Index	(PBL, 2020)	0	0,98	0,69	0,26
Registered Addresses (x1k)	Address Density	(PBL, 2020)	0,03	9,16	3,45	1,77
Value of Houses (x1m)	Average value of housing properties (x1M Euro)	(CBS, 2020)	0	1,36	0,27	0,15
Level Crossing Characteristics						
Adjacent Intersection	Adjacent to intersection (15m); 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,91	0,29
Barrier	Barrier present; 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,09	0,28
Cross Marking	Cross marking on tracks; 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,18	0,38
Fences	Fences present; 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,18	0,38
One-Way Traffic	One-way traffic; 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,14	0,34
Sight Obstructions	Obstruction of vision from road; 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,15	0,35
Skewness Road/Tracks	<90-degree: 1: yes / 90-degree: 0: no	(Cyclomedia, 2021)	0	1	0,21	0,41
Stop Marking	Stop marking in front of LC; 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,35	0,48
Tracks	Number of tracks	(Cyclomedia, 2021)	1	5	2	0,28
Traffic island	Traffic island present; 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,29	0,45
Traffic light (TL)	TL (red/yellow/(green)); 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,47	0,50
Warning light (TWL)	TWL (flashing red/yellow); 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,60	0,49
Rail Characteristics						
Average Speed	Avg. speed (km/h) of urban rail vehicles	(OSM, 2021) (OpenOV, 2021)	6	65	22,43	7,79
Frequency Peak	Frequency during peak (/hour)	(OpenOV, 2021)	2	41	7,92	3,84
Frequency Non-Peak	Frequency during non-peak (/hour)	(OpenOV, 2021)	0	34	7,22	3,51
Road Characteristics						
Average Speed	Avg. speed (km/h) based on floating car data	(HERE, 2021)	0	80	22,79	12,67
Function Class	Function class of the road	(HERE, 2021)	2	5	4,56	0,72
Lanes	Number of lanes	(HERE, 2021)	0	4	0,48	0,79
Pedestrian & Bike Only	Pedestrian & bike only; 0: no, 1: yes	(Cyclomedia, 2021)	0	1	0,20	0,40
Speed Limit	Speed limit of the road (km/h)	(HERE, 2021)	0	100	37,88	18,66
Traffic Characteristics						
Cycling volume morning rush	Volume cycling morning rush (07:00-09:00)	(Goudappel, 2021)	0	2684	350	381
Cycling volume day	Volume cycling day (other hours of the day)	(Goudappel, 2021)	0	9915	1365	1448
Cycling volume evening rush	Volume cycling evening rush (16:00-18:00)	(Goudappel, 2021)	0	2642	361	382
Cycling volume 24h	Volume cycling 24 hour period	(Goudappel, 2021)	0	14664	2075	2167
Traffic volume morning rush	Volume traffic morning rush (07:00-09:00)	(Goudappel, 2021)	0	4907	401	615
Traffic volume day	Volume traffic day (other hours of the day)	(Goudappel, 2021)	0	21945	1888	2789
Traffic volume evening rush	Volume traffic evening rush (16:00-18:00)	(Goudappel, 2021)	0	4691	436	657
Traffic volume 24h	Volume traffic 24 hour period	(Goudappel, 2021)	0	30085	2725	4018

LC: Level Crossing, Max: Maximum, Min: Minimum, St.D.: Standard Deviation, n = 666.

III.2. Definition of Additional Variables

A 'peak factor' was introduced for traffic volumes and urban rail frequencies. First, the cycling and traffic volumes were calculated by assuming that the morning and evening rush consists of two hours each (07.00 – 09.00) and (16.00 – 18.00). Then, the ratio of volumes between the two peak times and the 24-hour volume was calculated. Finally, the volumes for the morning, day and evening rush were removed from the analysis.

The 'peak factor' and '24-hour volumes' are implemented into the model for the cycling and traffic volumes. For the urban rail frequencies, a slightly different approach is applied. Here, the ratio of peak frequency to non-peak frequency was calculated. Also, the daily number of tram vehicles was calculated by assuming peak frequency between 07.00 – 09.00 and 16.00 – 18.00, no vehicles between 00.00 – 06.00 and the rest of the time non-peak frequency. Since the 'ratio of peak/non-peak' and 'daily volume' was added, the 'peak and non-peak frequency' of trams were removed from the analysis. For the variable 'background' within the demographics category, a 'western' and 'non-western' background were merged into a variable 'non-Dutch background', and the variables 'Dutch Background', 'Western Background' and 'Non-Western' background were removed from the analysis.

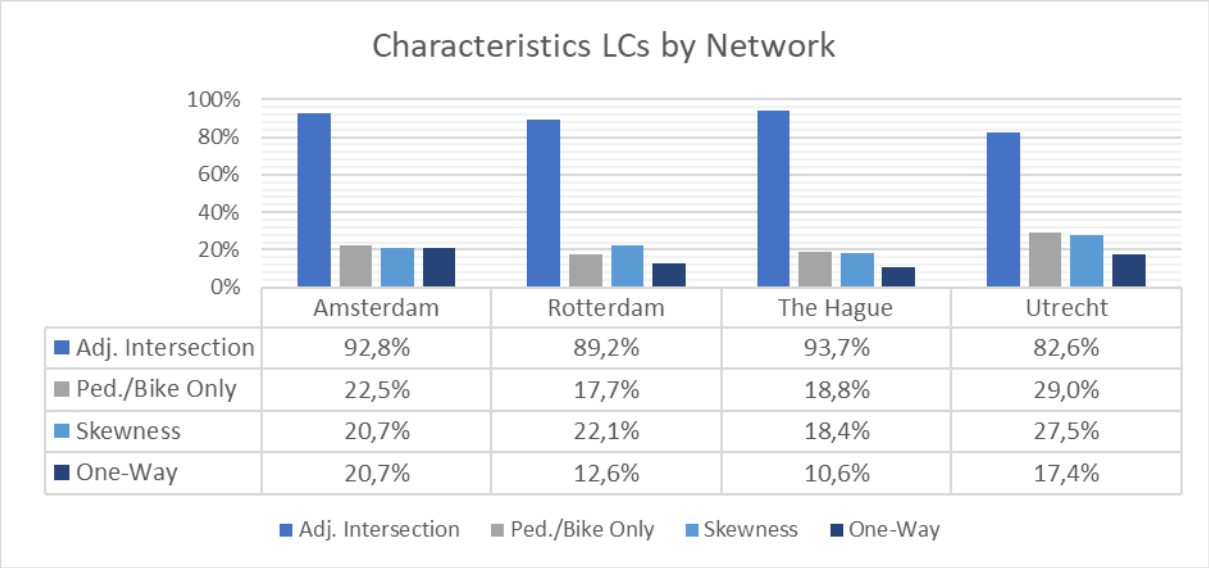
The variables 'Traffic Light' and 'Warning Light' are further specified in a new variable 'Warning System' for clarity. This variable considers if a crossing is equipped with a traffic light, warning light, a combination of a traffic and warning light or if no warning system is applied.

III.3. Extensive Descriptive Statistics

Level Crossing Characteristics

Other characteristics of level crossings are also collected, such as adjacent intersections, usage, skewness of a level crossing, and one-way traffic on a level crossing. Descriptive statistics in Figure 2 show that a majority (approximately 90%) of the level crossings are located adjacent to intersections. Only for the Utrecht network is this percentage slightly lower (82.6%). It can be seen that about 20% of the crossings in the analysis are pedestrian/bicycle only. The number of crossings that do not cross the tracks at 90 degrees is the same for all networks, about 20%. Some level crossings have one-way traffic; this is lowest in The Hague at 10.6% and highest in Amsterdam at 21.7%.

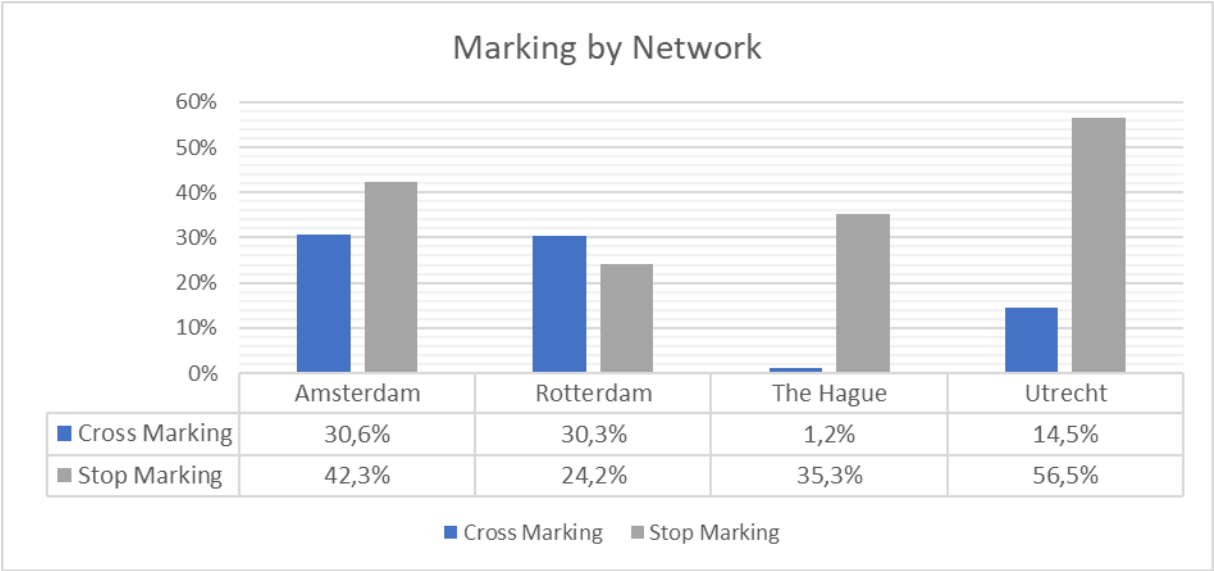
Figure 2: Characteristics by network.



	Amsterdam	Rotterdam	The Hague	Utrecht
Adj. Intersection	92,8%	89,2%	93,7%	82,6%
Ped./Bike Only	22,5%	17,7%	18,8%	29,0%
Skewness	20,7%	22,1%	18,4%	27,5%
One-Way	20,7%	12,6%	10,6%	17,4%

Markings on the road surface at level crossings were also specifically examined, as shown in Figure 3. The study examined cross markings on the road surface and stop markings (triangular markings and/or stop lines). There are significant differences between the different networks. Cross marking is almost non-existent at the Hague network and only at a few locations in Utrecht. In the network of Amsterdam and Rotterdam, this is around 15%. Stop marking is most common in the Utrecht network (44,9%) and least in Rotterdam (10,4%). There are also locations with cross marking and stop marking, almost non-existent in The Hague's network and around 15% for the other networks. Furthermore, there is no marking on a large proportion of level crossings. In the network of The Hague, 64.3% of the level crossings have no markings, and in Rotterdam, 59.3%. In the network of Amsterdam and Utrecht, this percentage is slightly lower, 44.1% and 40.6%, respectively.

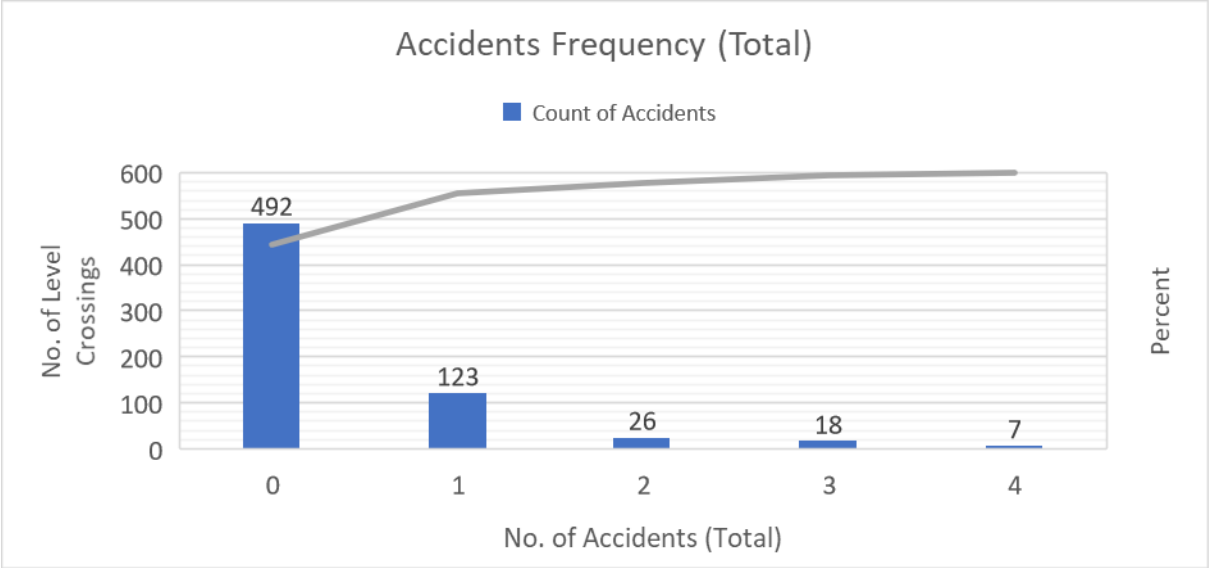
Figure 3: Marking by network.



Accident Characteristics

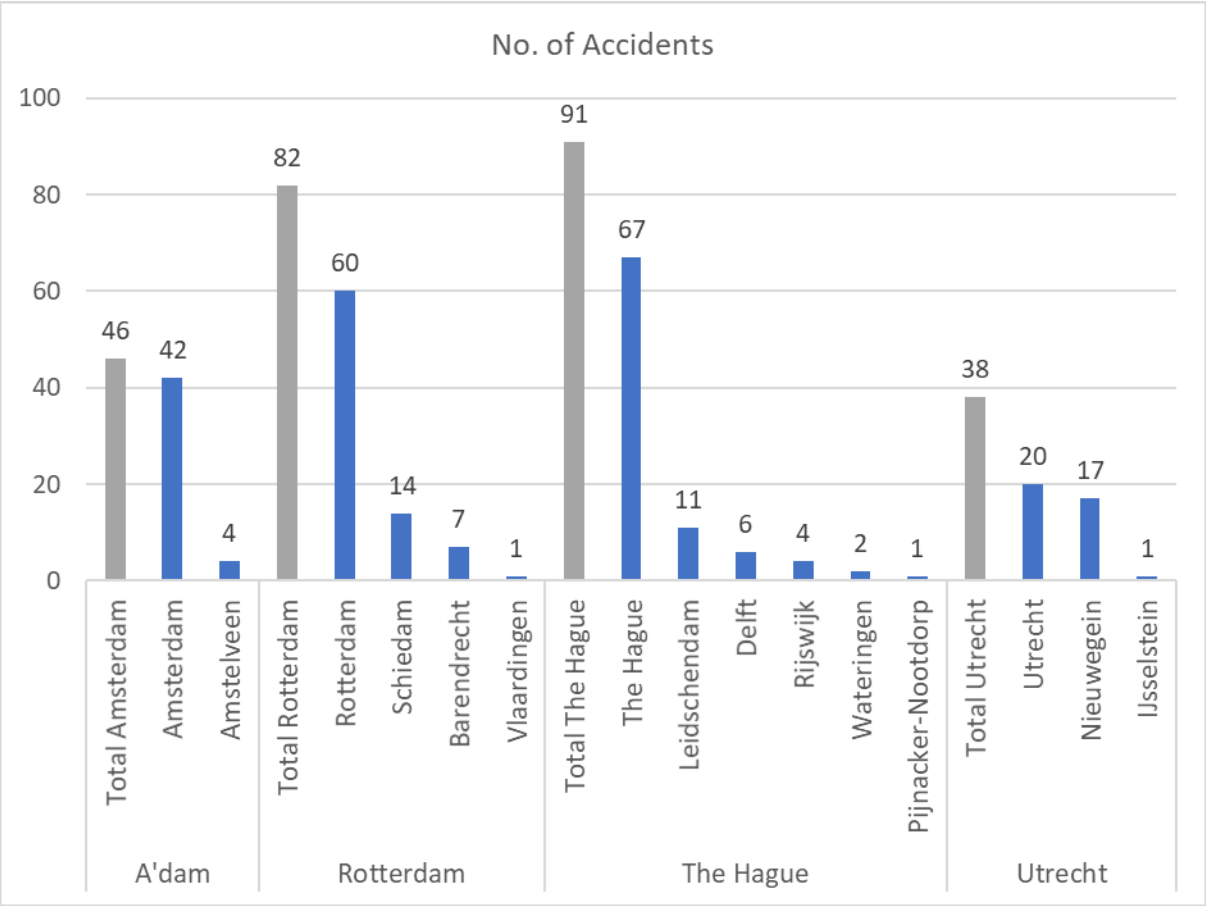
In Figure 4, it can be seen that 492 level crossings have no registered accidents. On 123 level crossings, one accident occurred during the observation period between 2014 and 2021. Twenty-six level crossings have an accident count of two accidents. Three accidents happened on eighteen crossings, and four accidents took place on seven level crossings.

Figure 4: Accident frequency (total accidents).



Furthermore, an analysis of the number of accidents per network and city was made. Figure 5 shows the number of accidents per network and city for the level crossings in the analysis. It can be seen that the numbers for Rotterdam and The Hague are higher compared to the other cities; however, the network size is also larger.

Figure 5: Number of accidents by network & cities



Appendix IV – Output Statistical Models

IV.1. Negative Binomial Model (Total Accidents)

Run Summary

Item	Value	Item	Value
Dependent Variable	Acc_Total	Rows Used	666
Exposure Variable	None	Sum of Frequencies	666
Frequency Variable	None	Iterations	20
Ind. Var's Available	27	Convergence Setting	1E-09
No. of X's in Model	29	Rel LogLike Change	0,0001305433
Log-Likelihood: Max Possible	-273,4412	Subset Method	None
Log-Likelihood: Model	-494,7192	Alpha	0,92615

Model Summary

Model	Model DF	Error DF	Log-Likelihood	Deviance	AIC(1)	Pseudo R^2
Intercept	1	665	-543,0956			
Model	30	636	-494,7192	442,5559	1049,4383	0,1794
Maximum	666		-273,4412			

Dependent Acc_Total

Regression Coefficients Report

Independent Variable	Regression Coefficient b(i)	Standard Error Sb(i)	Z Value H0: β = 0	Two-Sided P-Value	Lower 95,0% Confidence Limit	Upper 95,0% Confidence Limit
Alpha	0,92615	0,04069	22,76	0,0000	0,84641	1,00590
Intercept	-4,27674	0,96174	-4,45	0,0000	-6,16172	-2,39176
Env_Dens_Reg_Adress	0,09387	0,07327	1,28	0,2002	-0,04974	0,23748
Env_MXI	0,60532	0,38452	1,57	0,1154	-0,14832	1,35895
Env_No_Houses	-0,19167	0,22287	-0,86	0,3898	-0,62849	0,24515
Env_Value_Houses	-0,15808	0,52979	-0,30	0,7654	-1,19645	0,88029
LR_Avg_Speed	0,04141	0,01088	3,81	0,0001	0,02009	0,06272
LR_DI	0,00085	0,00136	0,62	0,5329	-0,00181	0,00350
LR_PF	-0,07912	0,34202	-0,23	0,8171	-0,74947	0,59124
T_C_PF	1,22493	0,53869	2,27	0,0230	0,16911	2,28074
T_C_24h	-0,00054	0,04084	-0,01	0,9895	-0,08059	0,07951
T_R_24h	0,02780	0,01965	1,41	0,1572	-0,01072	0,06632
DG_NDB	0,16325	0,47836	0,34	0,7329	-0,77431	1,10082
Road_Avg_Speed	0,01679	0,00797	2,11	0,0351	0,00117	0,03240
(LC_Adj=1)	0,55807	0,38736	1,44	0,1497	-0,20114	1,31728
(LC_SO=1)	0,44418	0,22213	2,00	0,0455	0,00882	0,87954
(LC_Barrier=1)	-2,39593	0,57044	-4,20	0,0000	-3,51397	-1,27789
(LC_CM=1)	0,48642	0,21819	2,23	0,0258	0,05876	0,91407
(F_Restaurant=1)	0,42803	0,20320	2,11	0,0352	0,02977	0,82630
(F_School=1)	-0,45493	0,23490	-1,94	0,0528	-0,91533	0,00546
(Road_PedBike_Only=1)	-0,95733	0,29881	-3,20	0,0014	-1,54299	-0,37167
(LC_StopMarking=1)	0,22446	0,18875	1,19	0,2344	-0,14549	0,59440
(LC_Skewness=1)	-0,30502	0,21354	-1,43	0,1532	-0,72354	0,11351
(LC_WarningSystem="TL")	-0,23119	0,29354	-0,79	0,4309	-0,80653	0,34415
(LC_WarningSystem="TLWL")	-0,34391	0,30652	-1,12	0,2619	-0,94467	0,25685
(LC_WarningSystem="WL")	-0,17580	0,26846	-0,65	0,5126	-0,70197	0,35038
(LC_TrafficIsland=1)	0,16302	0,19846	0,82	0,4114	-0,22595	0,55199
(F_BS=1)	0,03915	0,16452	0,24	0,8119	-0,28330	0,36161
(F_POW=1)	0,18777	0,23199	0,81	0,4183	-0,26693	0,64247
(F_SF=1)	-0,09888	0,20242	-0,49	0,6252	-0,49561	0,29785
(F_SuperMarket=1)	0,00245	0,23459	0,01	0,9917	-0,45733	0,46223

Variables, Model Tab	
-- Variables ----------	
Dependent Y:	Acc_Total
Exposure T:	<Empty>
Numeric X's:	Env_Dens_Reg_Adress; Env_MXI; Env_No_Houses; Env_Value_Houses; LR_Avg_Speed; LR_DI; LR_PF; T_C_PF; T_C_24h; T_R_24h; DG_NDB; Road_Avg_Speed
Categorical X's:	LC_Adj; LC_SO; LC_Barrier; LC_CM; F_Restaurant; F_School; Road_PedBike_Only; LC_StopMarking; LC_Skewness; LC_WarningSystem; LC_TrafficIsland; F_BS; F_POW; F_SF; F_SuperMarket
Default Recoding Scheme:	Binary
Default Reference Value:	First after Sorting
Frequencies:	<Empty>
-- Dispersion Parameter (α) ----------	
α Input Type:	Estimate α from the data
-- Regression Model ----------	
Terms:	1-Way
Remove Intercept	Unchecked
-- Subset Selection ----------	
Search Method:	None - No Search is Conducted
Iteration Tab	
-- Estimation Options ----------	
Maximum Iterations:	20
Convergence Setting:	1E-9
Reports Tab	
-- Alpha ----------	
Alpha Level:	0,050

IV.2. Negative Binomial Severity Model (Damage Only)

Run Summary

Item	Value	Item	Value
Dependent Variable	Acc_PDO	Rows Used	666
Exposure Variable	None	Sum of Frequencies	666
Frequency Variable	None	Iterations	20
Ind. Var's Available	27	Convergence Setting	1E-09
No. of X's in Model	29	Rel LogLike Change	0,0002220974
Log-Likelihood: Max Possible	-204,2731	Subset Method	None
Log-Likelihood: Model	-390,1117	Alpha	0,89225

Model Summary

Model	Model DF	Error DF	Log-Likelihood	Deviance	AIC(1)	Pseudo R^2
Intercept	1	665	-437,2572			
Model	30	636	-390,1117	371,6772	840,2233	0,2024
Maximum	666		-204,2731			

Dependent Acc_PDO

Regression Coefficients Report

Independent Variable	Regression Coefficient b(i)	Standard Error Sb(i)	Z Value H0: β = 0	Two-Sided P-Value	Lower 95,0% Confidence Limit	Upper 95,0% Confidence Limit
Alpha	0,89225	0,04504	19,81	0,0000	0,80397	0,98054
Intercept	-5,41476	1,12919	-4,80	0,0000	-7,62794	-3,20158
Env_Dens_Reg_Adress	0,15078	0,08320	1,81	0,0700	-0,01230	0,31386
Env_MXI	0,66089	0,44160	1,50	0,1345	-0,20464	1,52641
Env_No_Houses	-0,27461	0,25188	-1,09	0,2756	-0,76828	0,21906
Env_Value_Houses	0,00343	0,60173	0,01	0,9955	-1,17594	1,18280
LR_Avg_Speed	0,04312	0,01235	3,49	0,0005	0,01892	0,06732
LR_DI	0,00121	0,00149	0,81	0,4177	-0,00171	0,00412
LR_PF	0,19056	0,37612	0,51	0,6124	-0,54662	0,92774
T_C_PF	1,59472	0,65218	2,45	0,0145	0,31648	2,87296
T_C_24h	-0,00664	0,04643	-0,14	0,8862	-0,09764	0,08435
T_R_24h	0,01762	0,02296	0,77	0,4429	-0,02738	0,06262
DG_NDB	0,26341	0,55205	0,48	0,6333	-0,81859	1,34542
Road_Avg_Speed	0,01641	0,00959	1,71	0,0870	-0,00238	0,03520
(LC_Adj=1)	0,53004	0,43518	1,22	0,2232	-0,32289	1,38297
(LC_SO=1)	0,59135	0,24066	2,46	0,0140	0,11966	1,06303
(LC_Barrier=1)	-2,21624	0,64963	-3,41	0,0006	-3,48949	-0,94298
(LC_CM=1)	0,28984	0,25197	1,15	0,2500	-0,20402	0,78370
(F_Restaurant=1)	0,52307	0,22874	2,29	0,0222	0,07475	0,97139
(F_School=1)	-0,51124	0,27631	-1,85	0,0643	-1,05280	0,03032
(Road_PedBike_Only=1)	-1,53138	0,42082	-3,64	0,0003	-2,35617	-0,70660
(LC_StopMarking=1)	0,19326	0,21642	0,89	0,3719	-0,23092	0,61744
(LC_Skewness=1)	-0,20928	0,24010	-0,87	0,3834	-0,67987	0,26131
(LC_WarningSystem="TL")	-0,34000	0,32507	-1,05	0,2956	-0,97713	0,29713
(LC_WarningSystem="TLWL")	-0,71298	0,34836	-2,05	0,0407	-1,39576	-0,03021
(LC_WarningSystem="WL")	-0,25015	0,30275	-0,83	0,4087	-0,84354	0,34323
(LC_TrafficIsland=1)	0,41213	0,22278	1,85	0,0643	-0,02452	0,84878
(F_BS=1)	0,15100	0,18833	0,80	0,4227	-0,21812	0,52012
(F_POW=1)	0,04995	0,27199	0,18	0,8543	-0,48315	0,58305
(F_SF=1)	-0,18153	0,23789	-0,76	0,4454	-0,64778	0,28472
(F_SuperMarket=1)	0,06763	0,26565	0,25	0,7990	-0,45304	0,58830

Variables, Model Tab

-- Variables	
Dependent Y:	Acc_PDO
Exposure T:	<Empty>
Numeric X's:	Env_Dens_Reg_Adress; Env_MXI; Env_No_Houses; Env_Value_Houses; LR_Avg_Speed; LR_DI; LR_PF; T_C_PF; T_C_24h; T_R_24h; DG_NDB; Road_Avg_Speed
Categorical X's:	LC_Adj; LC_SO; LC_Barrier; LC_CM; F_Restaurant; F_School; Road_PedBike_Only; LC_StopMarking; LC_Skewness; LC_WarningSystem; LC_TrafficIsland; F_BS; F_POW; F_SF; F_SuperMarket
Default Recoding Scheme:	Binary
Default Reference Value:	First after Sorting
Frequencies:	<Empty>
-- Dispersion Parameter (α)	
α Input Type:	Estimate α from the data
-- Regression Model	
Terms:	1-Way
Remove Intercept	Unchecked
-- Subset Selection	
Search Method:	None - No Search is Conducted

Iteration Tab

-- Estimation Options	
Maximum Iterations:	20
Convergence Setting:	1E-9

Reports Tab

-- Alpha	
Alpha Level:	0,050

IV.3. Negative Binomial Severity Model (Injury/Fatality)

Run Summary

Item	Value	Item	Value
Dependent Variable	Acc_Inj_Fat	Rows Used	666
Exposure Variable	None	Sum of Frequencies	666
Frequency Variable	None	Iterations	20
Ind. Var's Available	27	Convergence Setting	1E-09
No. of X's in Model	29	Rel LogLike Change	0,0002017148
Log-Likelihood: Max Possible	-96,5166	Subset Method	None
Log-Likelihood: Model	-219,2473	Alpha	1,00736

Model Summary

Model	Model DF	Error DF	Log-Likelihood	Deviance	AIC(1)	Pseudo R^2
Intercept	1	665	-240,6660			
Model	30	636	-219,2473	245,4614	498,4946	0,1486
Maximum	666		-96,5166			

Dependent Acc_Inj_Fat

Regression Coefficients Report

Independent Variable	Regression Coefficient b(i)	Standard Error Sb(i)	Z Value H0: β = 0	Two-Sided P-Value	Lower 95,0% Confidence Limit	Upper 95,0% Confidence Limit
Alpha	1,00736	0,07360	13,69	0,0000	0,86310	1,15162
Intercept	-4,26350	1,59671	-2,67	0,0076	-7,39300	-1,13401
Env_Dens_Reg_Adress	-0,04539	0,12616	-0,36	0,7190	-0,29266	0,20188
Env_MXI	0,53433	0,65703	0,81	0,4161	-0,75343	1,82209
Env_No_Houses	0,12158	0,37695	0,32	0,7470	-0,61723	0,86039
Env_Value_Houses	-0,61166	0,94976	-0,64	0,5196	-2,47315	1,24984
LR_Avg_Speed	0,04373	0,01670	2,62	0,0088	0,01100	0,07646
LR_DI	0,00080	0,00246	0,33	0,7447	-0,00402	0,00562
LR_PF	-0,62140	0,64569	-0,96	0,3359	-1,88694	0,64413
T_C_PF	0,63813	0,84718	0,75	0,4513	-1,02231	2,29856
T_C_24h	0,01257	0,07001	0,18	0,8575	-0,12465	0,14978
T_R_24h	0,04755	0,03063	1,55	0,1205	-0,01248	0,10758
DG_NDB	-0,07100	0,78486	-0,09	0,9279	-1,60931	1,46730
Road_Avg_Speed	0,01585	0,01228	1,29	0,1970	-0,00823	0,03992
(LC_Adj=1)	0,52452	0,69781	0,75	0,4523	-0,84317	1,89220
(LC_SO=1)	-0,04166	0,44267	-0,09	0,9250	-0,90927	0,82596
(LC_Barrier=1)	-2,69714	1,08446	-2,49	0,0129	-4,82264	-0,57165
(LC_CM=1)	0,82319	0,35160	2,34	0,0192	0,13406	1,51232
(F_Restaurant=1)	0,03383	0,35586	0,10	0,9243	-0,66364	0,73129
(F_School=1)	-0,37015	0,38459	-0,96	0,3358	-1,12394	0,38364
(Road_PedBike_Only=1)	-0,10387	0,41091	-0,25	0,8004	-0,90924	0,70151
(LC_StopMarking=1)	0,31208	0,31774	0,98	0,3260	-0,31068	0,93484
(LC_Skewness=1)	-0,50037	0,37175	-1,35	0,1783	-1,22899	0,22824
(LC_WarningSystem="TL")	0,11356	0,53237	0,21	0,8311	-0,92986	1,15697
(LC_WarningSystem="TLWL")	0,54406	0,53076	1,03	0,3053	-0,49621	1,58434
(LC_WarningSystem="WL")	0,04007	0,47494	0,08	0,9328	-0,89079	0,97093
(LC_TrafficIsland=1)	-0,60709	0,35945	-1,69	0,0912	-1,31160	0,09741
(F_BS=1)	-0,33738	0,28086	-1,20	0,2297	-0,88786	0,21310
(F_POW=1)	0,48540	0,36454	1,33	0,1830	-0,22908	1,19988
(F_SF=1)	0,11521	0,31865	0,36	0,7177	-0,50934	0,73976
(F_SuperMarket=1)	0,06732	0,38565	0,17	0,8614	-0,68854	0,82318

Variables, Model Tab

-- Variables ----------	
Dependent Y:	Acc_Inj_Fat
Exposure T:	<Empty>
Numeric X's:	Env_Dens_Reg_Adress; Env_MXI; Env_No_Houses; Env_Value_Houses; LR_Avg_Speed; LR_DI; LR_PF; T_C_PF; T_C_24h; T_R_24h; DG_NDB; Road_Avg_Speed
Categorical X's:	LC_Adj; LC_SO; LC_Barrier; LC_CM; F_Restaurant; F_School; Road_PedBike_Only; LC_StopMarking; LC_Skewness; LC_WarningSystem; LC_TrafficIsland; F_BS; F_POW; F_SF; F_SuperMarket
Default Recoding Scheme:	Binary
Default Reference Value:	First after Sorting
Frequencies:	<Empty>
-- Dispersion Parameter (α) ----------	
α Input Type:	Estimate α from the data
-- Regression Model ----------	
Terms:	1-Way
Remove Intercept	Unchecked
-- Subset Selection ----------	
Search Method:	None - No Search is Conducted

Iteration Tab

-- Estimation Options ----------	
Maximum Iterations:	20
Convergence Setting:	1E-9

Reports Tab

-- Alpha ----------	
Alpha Level:	0,050

IV.4. Overview Negative Binomial models

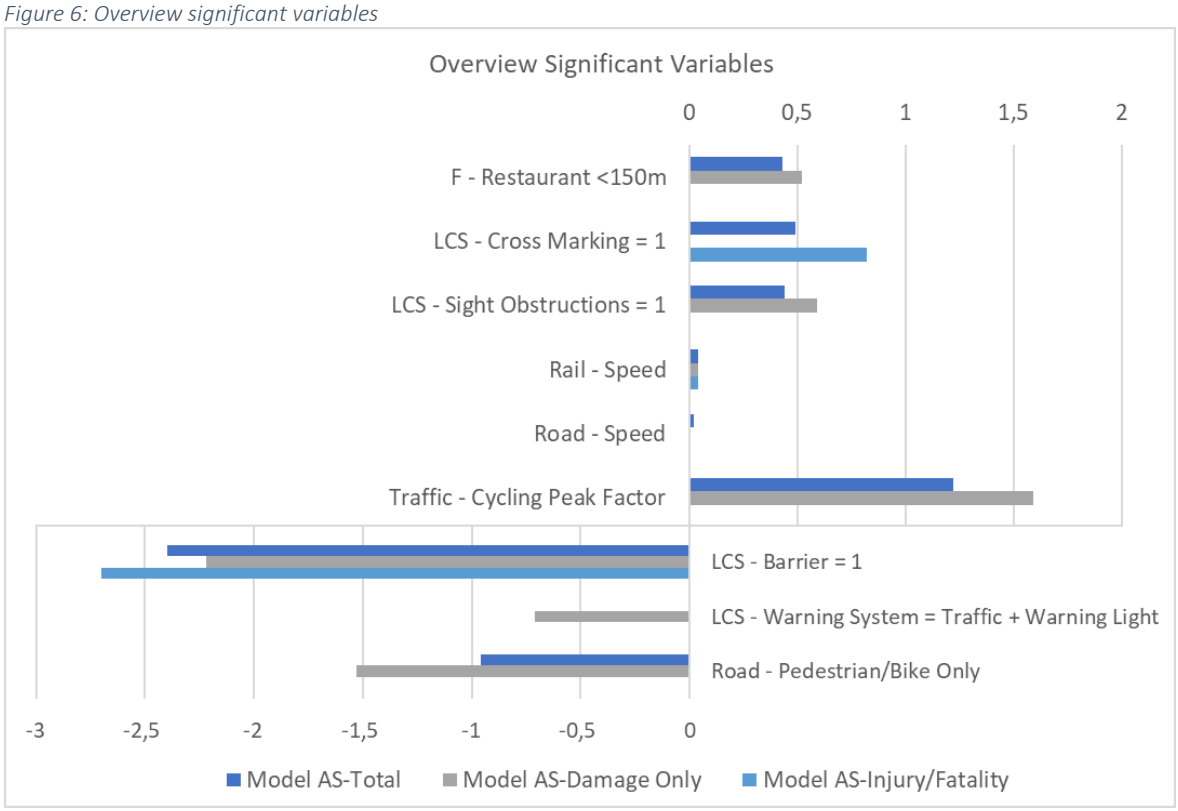
In Table 3, an overview of the different NB models can be seen. The first model is the Total Accidents model (AS-T), the second model Damage Only model (AS-DO) and the third Injury/Fatality model (AS-IF).

Table 3: Overview Negative Binomial models

Category	Variables	Model AS-T		Model AS-DO		Model AS-IF	
		NB Regression		NB Regression		NB Regression	
		Coeff.	Sig.	Coeff.	Sig.	Coeff.	Sig.
Intercept		*-4,28*	*0,00*	*-5,41*	*0,00*	*-4,26*	*0,01*
Demographics	Non-Dutch Background	0,16	0,73	0,26	0,63	-0,07	0,93
Environment	Density Registered Addresses	0,09	0,20	0,15	0,07	-0,05	0,72
Environment	MXI	0,61	0,12	0,66	0,13	0,53	0,42
Environment	Number of Houses	-0,19	0,39	-0,27	0,28	0,12	0,75
Environment	Value of Houses	-0,16	0,77	0,00	1,00	-0,61	0,52
Facility	Bus Stop <150m	0,04	0,81	0,15	0,42	-0,34	0,23
Facility	Place of Worship <150m	0,19	0,42	0,05	0,85	0,49	0,18
Facility	Restaurant <150m	0,43	**0,04**	0,52	**0,02**	0,03	0,92
Facility	School <150m	-0,45	0,05	-0,51	0,06	-0,37	0,34
Facility	Sport Facility <150m	-0,10	0,63	-0,18	0,45	0,12	0,72
Facility	Supermarket <150m	0,00	0,99	0,07	0,80	0,07	0,86
LCS[1] Characteristics	Adjacent Intersection = 1	0,56	0,15	0,53	0,22	0,52	0,45
LCS Characteristics	Barrier = 1	-2,40	**0,00**	-2,22	**0,00**	-2,70	**0,01**
LCS Characteristics	Cross Marking = 1	0,49	**0,03**	0,29	0,25	0,82	**0,02**
LCS Characteristics	Skewness = 1	-0,31	0,15	-0,21	0,38	-0,50	0,18
LCS Characteristics	Sight Obstructions = 1	0,44	**0,05**	0,59	**0,01**	-0,04	0,93
LCS Characteristics	Stop Marking = 1	0,22	0,23	0,19	0,37	0,31	0,33
LCS Characteristics	Traffic Island = 1	0,16	0,41	0,41	0,06	-0,61	0,09
LCS Characteristics	Warning System = Traffic Light	-0,23	0,43	-0,34	0,30	0,11	0,83
LCS Characteristics	Warning System = Traffic + Warning Light	-0,34	0,26	-0,71	**0,04**	0,54	0,31
LCS Characteristics	Warning System = Warning Light	-0,18	0,51	-0,25	0,41	0,04	0,93
Rail	Average Speed	0,04	**0,00**	0,04	**0,00**	0,04	**0,01**
Rail	Daily Volume	0,00	0,53	0,00	0,42	0,00	0,74
Rail	Peak Factor	-0,08	0,82	0,19	0,61	-0,62	0,34
Road	Average Speed	0,02	**0,04**	0,02	0,09	0,02	0,20
Road	Pedestrian/Bike Only	-0,96	**0,00**	-1,53	**0,00**	-0,10	0,80
Traffic	Cycling Volume 24h	0,00	0,99	-0,01	0,89	0,01	0,86
Traffic	Cycling Peak Factor	1,22	**0,02**	1,59	**0,01**	0,64	0,45
Traffic	Road Volume 24h	0,03	0,16	0,02	0,44	0,05	0,12
Alpha		*0,93*	*0,00*	*0,89*	*0,00*	*1,01*	*0,00*
Log-Likelihood		–494,7		–390,1		–219,2	

[1] LCS: Level Crossing

Figure 6: Overview significant variables



As shown in Figure 6, the effect for rail vehicles' speed and motorized vehicles' speed seems moderate; however, this is the effect for a 1 km/h increase in speed. So, when the speed is 10 km/h, this value should be multiplied by ten.

IV.5. Safety Performance Function Negative Binomial Model (Total Accidents)

Dependent Acc_Total

Run Summary

Item	Value	Item	Value
Dependent Variable	Acc_Total	Rows Used	666
Exposure Variable	None	Sum of Frequencies	666
Frequency Variable	None	Iterations	20
Ind. Var's Available	27	Convergence Setting	1E-09
No. of X's in Model	13	Rel LogLike Change	0,0001090646
Log-Likelihood: Max Possible	-274,8417	Subset Method	Forward
Log-Likelihood: Model	-498,5538	Alpha	0,94901

Model Summary

Model	Model DF	Error DF	Log-Likelihood	Deviance	AIC(1)	Pseudo R²
Intercept	1	665	-543,0956			
Model	14	652	-498,5538	447,4243	1025,1076	0,1660
Maximum	666		-274,8417			

Regression Coefficients Report

Independent Variable	Regression Coefficient b(i)	Standard Error Sb(i)	Z Value H0: β = 0	Two-Sided P-Value	Lower 95,0% Confidence Limit	Upper 95,0% Confidence Limit
Alpha	0,94901	0,04163	22,80	0,0000	0,86742	1,03061
Intercept	-4,21308	0,74265	-5,67	0,0000	-5,66864	-2,75752
Env_Dens_Reg_Adress	0,08001	0,04797	1,67	0,0953	-0,01401	0,17403
Env_MXI	0,48745	0,32381	1,51	0,1322	-0,14720	1,12210
LR_Avg_Speed	0,04446	0,01047	4,25	0,0000	0,02393	0,06499
T_C_PF	1,11851	0,51868	2,16	0,0310	0,10192	2,13510
Road_Avg_Speed	0,01807	0,00720	2,51	0,0121	0,00395	0,03219
(LC_Adj=1)	0,50165	0,37798	1,33	0,1844	-0,23917	1,24247
(LC_SO=1)	0,48952	0,21315	2,30	0,0216	0,07176	0,90728
(LC_Barrier=1)	-2,28100	0,55865	-4,08	0,0000	-3,37594	-1,18607
(LC_CM=1)	0,57033	0,20381	2,80	0,0051	0,17086	0,96979
(F_Restaurant=1)	0,36029	0,19076	1,89	0,0589	-0,01360	0,73417
(F_School=1)	-0,46496	0,23191	-2,00	0,0450	-0,91950	-0,01041
(Road_PedBike_Only=1)	-0,99589	0,28798	-3,46	0,0005	-1,56031	-0,43146
(LC_Skewness=1)	-0,28277	0,20657	-1,37	0,1710	-0,68764	0,12211

Table 4: Safety Performance Function – Total Accidents

Category	Variable	Regression Coefficient B	Sig.
Intercept		*-4,213*	*0,000*
Environment	Density Registered Addresses	0,080	0,095
Environment	MXI	0,487	0,132
Facility	Restaurant <150m = 1	0,360	0,059
Facility	School <150m = 1	-0,465	**0,045**
Level Crossing	Adjacent Intersection = 1	0,502	0,184
Level Crossing	Barrier = 1	-2,281	**0,000**
Level Crossing	Cross Marking = 1	0,570	**0,005**
Level Crossing	Skewness = 1	-0,283	0,171
Level Crossing	Sight Obstructions = 1	0,490	**0,022**
Rail	Average Speed	0,044	**0,000**
Road	Average Speed	0,018	**0,012**
Road	Pedestrian/Bike Only = 1	-0,996	**0,001**
Traffic	Cycling Peak Factor	1,119	**0,031**
Alpha		0,949	0,000

IV.6. Safety Performance Function Negative Binomial Model (Damage Only)

Dependent Acc_PDO

Run Summary

Item	Value	Item	Value
Dependent Variable	Acc_PDO	Rows Used	666
Exposure Variable	None	Sum of Frequencies	666
Frequency Variable	None	Iterations	20
Ind. Var's Available	27	Convergence Setting	1E-09
No. of X's in Model	14	Rel LogLike Change	0,0001689837
Log-Likelihood: Max Possible	-206,2037	Subset Method	Hierarchical Forward/Switching
Log-Likelihood: Model	-394,8326	Alpha	0,93327

Model Summary

Model	Model DF	Error DF	Log-Likelihood	Deviance	AIC(1)	Pseudo R²
Intercept	1	665	-437,2572			
Model	15	651	-394,8326	377,2579	819,6652	0,1836
Maximum	666		-206,2037			

Regression Coefficients Report

Independent Variable	Regression Coefficient b(i)	Standard Error Sb(i)	Z Value H0: β = 0	Two-Sided P-Value	Lower 95,0% Confidence Limit	Upper 95,0% Confidence Limit
Alpha	0,93327	0,04699	19,86	0,0000	0,84116	1,02537
Intercept	-4,45624	0,84920	-5,25	0,0000	-6,12064	-2,79184
Env_Dens_Reg_Adress	0,12362	0,05549	2,23	0,0259	0,01487	0,23236
LR_Avg_Speed	0,04491	0,01211	3,71	0,0002	0,02117	0,06865
T_C_PF	1,28690	0,60451	2,13	0,0333	0,10208	2,47172
Road_Avg_Speed	0,01683	0,00906	1,86	0,0632	-0,00093	0,03460
(LC_SO=1)	0,60370	0,23548	2,56	0,0104	0,14216	1,06523
(LC_Barrier=1)	-1,98901	0,62879	-3,16	0,0016	-3,22141	-0,75661
(F_Restaurant=1)	0,49035	0,21518	2,28	0,0227	0,06860	0,91209
(F_School=1)	-0,44923	0,27050	-1,66	0,0968	-0,97941	0,08094
(Road_PedBike_Only=1)	-1,62499	0,41162	-3,95	0,0001	-2,43175	-0,81823
(LC_WarningSystem="TL")	-0,33078	0,30610	-1,08	0,2799	-0,93073	0,26917
(LC_WarningSystem="TLWL")	-0,62865	0,32809	-1,92	0,0554	-1,27169	0,01440
(LC_WarningSystem="WL")	-0,15655	0,29035	-0,54	0,5898	-0,72562	0,41252
(LC_TrafficIsland=1)	0,52727	0,20131	2,62	0,0088	0,13271	0,92183
(LC_Adj=1)	0,61759	0,41745	1,48	0,1390	-0,20059	1,43577

Table 5: Safety Performance Function – Damage Only Accidents

Category	Variable	Regression Coefficient B	Sig.
Intercept		*-4,456*	*0,000*
Environment	Density Registered Addresses	0,124	**0,026**
Facility	Restaurant <150m = 1	0,490	**0,023**
Facility	School <150m = 1	-0,449	0,097
Level Crossing	Adjacent Intersection = 1	0,618	0,139
Level Crossing	Barrier = 1	-1,989	**0,002**
Level Crossing	Sight Obstructions = 1	0,604	**0,010**
Level Crossing	Traffic Island = 1	0,527	**0,009**
Level Crossing	Warning System = Traffic Light	-0,331	0,280
Level Crossing	Warning System = Traffic + Warning Light	-0,629	0,055
Level Crossing	Warning System = Warning Light	-0,157	0,590
Rail	Average Speed	0,045	**0,000**
Road	Average Speed	0,017	0,063
Road	Pedestrian/Bike Only = 1	-1,625	**0,000**
Traffic	Cycling Peak Factor	1,287	**0,033**
Alpha		0,933	0,000

IV.7. Safety Performance Function Negative Binomial Model (Injury/Fatality)

Dependent Acc_Inj_Fat

Run Summary

Item	Value	Item	Value
Dependent Variable	Acc_Inj_Fat	Rows Used	666
Exposure Variable	None	Sum of Frequencies	666
Frequency Variable	None	Iterations	20
Ind. Var's Available	27	Convergence Setting	1E-09
No. of X's in Model	7	Rel LogLike Change	0,0001249169
Log-Likelihood: Max Possible	-98,0124	Subset Method	Hierarchical Forward/Switching
Log-Likelihood: Model	-225,1524	Alpha	1,07920

Model Summary

Model	Model DF	Error DF	Log-Likelihood	Deviance	AIC(1)	Pseudo R²
Intercept	1	665	-240,6660			
Model	8	658	-225,1524	254,2799	466,3048	0,1088
Maximum	666		-98,0124			

Regression Coefficients Report

Independent Variable	Regression Coefficient b(i)	Standard Error Sb(i)	Z Value H0: β = 0	Two-Sided P-Value	Lower 95,0% Confidence Limit	Upper 95,0% Confidence Limit
Alpha	1,07920	0,07829	13,78	0,0000	0,92576	1,23265
Intercept	-3,83382	0,44960	-8,53	0,0000	-4,71501	-2,95263
LR_Avg_Speed	0,04425	0,01423	3,11	0,0019	0,01636	0,07214
T_R_24h	0,05036	0,02751	1,83	0,0672	-0,00356	0,10429
Road_Avg_Speed	0,01765	0,01074	1,64	0,1004	-0,00341	0,03871
(LC_Barrier=1)	-2,72735	1,04266	-2,62	0,0089	-4,77093	-0,68377
(LC_CM=1)	0,66368	0,30650	2,17	0,0304	0,06296	1,26440
(LC_Skewness=1)	-0,49466	0,34679	-1,43	0,1538	-1,17436	0,18504
(F_POW=1)	0,51353	0,34026	1,51	0,1312	-0,15336	1,18043

Table 6: Safety Performance Function – Injury/Fatality Accidents

Category	Variable	Regression Coefficient B	Sig.
Intercept		*-3,834*	*0,000*
Facility	Place of Worship <150m = 1	0,514	0,131
Level Crossing	Barrier = 1	-2,727	**0,009**
Level Crossing	Cross Marking = 1	0,664	**0,030**
Level Crossing	Skewness = 1	-0,495	0,154
Rail	Average Speed	0,044	**0,002**
Road	Average Speed	0,018	0,100
Traffic	Road Volume 24h	0,050	0,067
Alpha		1,079	0,000

Table 7: Safety Performance Functions - Overview

Category	Variable	SPF Total Accidents	SPF Damage Only Accidents	SPF Injury / Fatality Accidents
		Regression Coeff. B	Regression Coeff. B	Regression Coeff. B
Intercept		*-4,213*	*-4,456*	*-3,834*
Environment	Density Registered Addresses	0,080	0,124	-
Environment	MXI	0,487	-	-
Facility	Place of Worship <150m = 1	-	-	0,514
Facility	Restaurant <150m = 1	0,360	0,490	-
Facility	School <150m = 1	-0,465	-0,449	-
Level Crossing	Adjacent Intersection = 1	0,502	0,618	-
Level Crossing	Barrier = 1	-2,281	-1,989	-2,727
Level Crossing	Cross Marking = 1	0,570	-	0,664
Level Crossing	Skewness = 1	-0,283	-	-0,495
Level Crossing	Sight Obstructions = 1	0,490	0,604	-
Level Crossing	Traffic Island = 1	-	0,527	-
Level Crossing	Warning System = Traffic Light	-	-0,331	-
Level Crossing	Warning System = Traffic + Warning Light	-	-0,629	-
Level Crossing	Warning System = Warning Light	-	-0,157	-
Rail	Average Speed	0,044	0,045	0,044
Road	Average Speed	0,018	0,017	0,018
Road	Pedestrian/Bike Only = 1	-0,996	-1,625	-
Traffic	Cycling Peak Factor	1,119	1,287	-
Traffic	Road Motorized Vehicles 24h		-	0,050
Alpha		*0,949*	*0,933*	*1,079*

Appendix V – Sensitivity Analysis – Proximity of Facilities

If facilities are located within a specific area of influence of a level crossing, then the binary variable is 1. If no facility is situated in a given area of influence, the binary variable is 0. The initial modelling results showed that there might be some correlation between the binary variables/ Therefore, a tetrachoric correlation is applied to check possible multicollinearity among binary variables.

V.1. Facilities within 150 meters

First, the correlation between the variables was examined. As shown in Table 8 and 9, correlation was identified; therefore, the facilities 'café', 'hospital', 'shopping centre' and 'tram stop' were removed from the analysis. The facilities within the analysis are 'bus stop', 'place of worship', 'restaurant', 'school', 'sports facility' and 'supermarket'.

Table 8: Tetrachoric Correlation – Facilities within 150 meters.

Tetrachoric Correlation Dichotomous Variables	Road_PedBike_Only	LC_Adj_Intersection	LC_Sight_Obstructions	LC_TrafficLight	LC_WarningLight	LC_Barrier	LC_Fences	LC_Cross_Marking	LC_Stop_Marking	LC_Skewness	LC_Traffic_Island	LC_One_Way	F_BusStop_150m	F_Cafe_150m	F_Hospital_150m	F_Place_of_Worship_150m	F_Restaurant_150m	F_School_150m	F_Shopping_Centre_150m	F_Sport_Facility_150m	F_Supermarket_150m	F_TramStop_150m
Road_PedBike_Only	-																					
LC_Adj_Intersection	-0,285	-																				
LC_Sight_Obstructions	-0,216	-0,411	-																			
LC_TrafficLight	-0,276	0,041	0,147	-																		
LC_WarningLight	0,097	0,137	-0,263	-0,639	-																	
LC_Barrier	0,530	-0,519	0,616	0,352	-0,292	-																
LC_Fences	0,481	-0,412	0,529	0,169	-0,205	**0,991**	-															
LC_Cross_Marking	0,108	-0,105	0,116	0,217	-0,329	**0,724**	0,598	-														
LC_Stop_Marking	0,317	-0,251	0,247	0,169	-0,037	0,675	0,503	0,331	-													
LC_Skewness	-0,278	-0,590	-0,076	0,180	-0,178	-0,273	-0,441	-0,065	-0,094	-												
LC_Traffic_Island	0,164	0,016	0,358	0,518	-0,178	0,664	0,460	0,418	0,587	-0,166	-											
LC_One_Way	-0,779	-0,415	-0,148	0,190	-0,059	**-1,000**	-0,659	-0,034	0,090	0,664	-0,306	-										
F_BusStop_150m	-0,004	0,077	-0,081	0,206	0,002	-0,104	-0,036	0,031	-0,094	0,090	0,033	0,097	-									
F_Cafe_150m	-0,217	0,207	-0,012	0,022	0,166	**-0,805**	-0,497	-0,030	-0,244	0,152	-0,169	0,509	-0,037	-								
F_Hospital_150m	-0,162	-0,198	**-1,000**	0,396	-0,273	**-1,000**	**-1,000**	-0,096	0,549	0,161	0,244	**-1,000**	**-1,000**	**-1,000**	-							
F_Place_of_Worship_150m	-0,141	0,167	0,107	-0,148	0,072	-0,241	-0,210	0,121	-0,165	-0,086	-0,009	0,106	0,052	0,428	**-1,000**	-						
F_Restaurant_150m	-0,171	-0,032	-0,051	0,022	0,019	-0,190	-0,276	0,061	-0,147	0,143	-0,261	0,390	0,026	0,690	**-1,000**	0,200	-					
F_School_150m	-0,049	0,216	-0,081	-0,073	0,153	-0,272	-0,034	0,029	-0,060	-0,166	-0,127	-0,002	0,032	0,171	0,669	0,155	0,138	-				
F_Shopping_Centre_150m	0,435	-0,086	0,404	-0,035	-0,077	**0,791**	**0,726**	0,617	0,484	-0,291	0,269	**-1,000**	-0,355	0,275	**-1,000**	0,299	0,571	**-1,000**	-			
F_Sport_Facility_150m	-0,101	-0,090	-0,065	-0,131	0,139	-0,236	-0,163	-0,104	0,042	0,060	-0,159	0,069	-0,024	0,118	**-1,000**	0,128	0,043	0,156	**-1,000**	-		
F_Supermarket_150m	0,022	-0,094	0,098	-0,029	0,003	0,005	0,099	0,186	-0,132	0,163	-0,158	0,064	0,215	0,269	**-1,000**	0,184	0,484	-0,041	0,578	0,098	-	
F_TramStop_150m	-0,118	0,050	-0,164	-0,160	0,100	**-0,821**	-0,543	-0,387	-0,213	0,008	-0,178	0,082	0,369	0,186	**-1,000**	0,120	0,230	0,007	-0,274	0,109	0,289	-

Table 9: Output Negative Binomial model – Facilities within 150 meters.

Proximity Facilities		**b(i)**	**St. Error**	**St. Dev.**	**Sig.**
Bus Stop	**150m**	0,024	0,167	4,302	0,886
Café/Bar	**150m**	-	-	-	-
Hospital	**150m**	-	-	-	-
Place of Worship	**150m**	0,179	0,233	6,003	0,443
Restaurant	**150m**	0,434	0,203	5,249	**0,033**
School	**150m**	-0,448	0,235	6,069	0,057
Shopping Centre	**150m**	-	-	-	-
Sport Facility	**150m**	-0,097	0,202	5,224	0,632
Supermarket	**150m**	-0,003	0,235	6,064	0,991
Tram Stop	**150m**	-	-	-	-

V.2. Facilities within 250 meters

First, the correlation between the variables was examined. As shown in Table 10 and 11, correlation was identified; therefore, the facilities 'hospital', 'shopping centre' and 'tram stop' were removed from the analysis. The facilities within the analysis are 'bus stop', 'café', 'place of worship', 'restaurant', 'school', 'sports facility' and 'supermarket'.

Table 10: Tetrachoric Correlation – Facilities within 250 meters.

Tetrachoric Correlation Dichotomous Variables	Road_PedBike_Only	LC_Adj_Intersection	LC_Sight_Obstructions	LC_TrafficLight	LC_WarningLight	LC_Barrier	LC_Cross_Marking	LC_Stop_Marking	LC_Skewness	LC_Traffic_Island	F_BusStop_250m	F_Cafe_250m	F_Hospital_250m	F_Place_of_Worship_250m	F_Restaurant_250m	F_School_250m	F_Shopping_Centre_250m	F_Sport_Facility_250m	F_Supermarket_250m	F_TramStop_250m
Road_PedBike_Only	-																			
LC_Adj_Intersection	-0,285	-																		
LC_Sight_Obstructions	-0,216	-0,411	-																	
LC_TrafficLight	-0,276	0,041	0,147	-																
LC_WarningLight	0,097	0,137	-0,263	-0,639	-															
LC_Barrier	0,530	-0,519	0,616	0,352	-0,292	-														
LC_Cross_Marking	0,108	-0,105	0,116	0,217	-0,329	0,724	-													
LC_Stop_Marking	0,317	-0,251	0,247	0,169	-0,037	0,675	0,331	-												
LC_Skewness	-0,278	-0,590	-0,076	0,180	-0,178	-0,273	-0,065	-0,094	-											
LC_Traffic_Island	0,164	0,016	0,358	0,518	-0,178	0,664	0,418	0,587	-0,166	-										
F_BusStop_250m	0,002	0,086	-0,080	0,185	0,004	-0,127	0,048	-0,054	0,069	0,060										
F_Cafe_250m	-0,193	0,402	-0,097	0,085	0,005	-0,722	0,011	-0,274	0,068	-0,233	0,098									
F_Hospital_250m	-0,589	0,003	-0,217	0,505	-0,169	**-1,000**	0,131	0,179	0,226	0,145	0,676	-0,092								
F_Place_of_Worship_250m	-0,145	0,153	0,141	-0,125	0,130	-0,359	0,008	-0,171	-0,101	-0,135	-0,024	0,473	-0,229							
F_Restaurant_250m	-0,180	0,055	-0,127	0,030	-0,051	-0,219	0,056	-0,127	0,020	-0,138	0,110	0,641	0,107	0,289						
F_School_250m	-0,057	0,220	-0,078	-0,050	0,071	-0,085	-0,062	-0,048	-0,221	-0,120	0,038	0,065	0,240	0,121	0,158					
F_Shopping_Centre_250m	0,330	-0,381	0,464	0,183	-0,371	0,700	0,467	0,367	0,001	0,059	-0,161	0,556	0,196	0,290	**0,885**	-0,172				
F_Sport_Facility_250m	0,027	0,037	-0,047	-0,103	0,124	-0,057	-0,120	-0,080	0,086	-0,259	-0,051	0,196	-0,167	0,114	0,103	0,180	-0,158			
F_Supermarket_250m	0,045	-0,080	0,175	-0,100	0,054	-0,039	0,058	-0,124	0,104	-0,126	0,119	0,302	-0,466	0,251	0,526	0,106	**0,874**	-0,022		
F_TramStop_250m	-0,281	0,119	-0,217	-0,366	0,148	**-0,884**	-0,513	-0,447	0,070	-0,453	0,257	0,485	0,319	0,346	0,313	0,134	-0,369	0,033	0,292	

Table 11: Output Negative Binomial model – Facilities within 250 meters.

Proximity Facilities		**b(i)**	**St. Error**	**St. Dev.**	**Sig.**
Bus Stop	**250m**	0,155	0,172	4,449	0,370
Café/Bar	**250m**	0,302	0,203	5,243	0,137
Hospital	**250m**	-	-	-	-
Place of Worship	**250m**	0,071	0,194	5,003	0,715
Restaurant	**250m**	0,076	0,190	4,911	0,688
School	**250m**	-0,083	0,169	4,358	0,621
Shopping Centre	**250m**	-	-	-	-
Sport Facility	**250m**	-0,106	0,164	4,236	0,519
Supermarket	**250m**	-0,115	0,198	5,119	0,561
Tram Stop	**250m**	-	-	-	-

V.3. Facilities within 500 meters

First, the correlation between the variables was examined. As shown in Table 12 and Table 13, correlation was identified; therefore, the facility 'tram stop' is removed from the analysis. The facilities within the analysis are 'bus stop', 'café', 'hospital', 'place of worship', 'restaurant', 'school', 'shopping centre', 'sports facility' and 'supermarket'.

Table 12: Tetrachoric Correlation – Facilities within 500 meters.

Tetrachoric Correlation Dichotomous Variables	Road_PedBike_Only	LC_Adj_Intersection	LC_Sight_Obstructions	LC_TrafficLight	LC_WarningLight	LC_Barrier	LC_Cross_Marking	LC_Stop_Marking	LC_Skewness	LC_Traffic_Island	F_BusStop_500m	F_Cafe_500m	F_Hospital_500m	F_Place_of_Worship_500m	F_Restaurant_500m	F_School_500m	F_Shopping_Centre_500m	F_Sport_Facility_500m	F_Supermarket_500m	F_TramStop_500m
Road_PedBike_Only	-																			
LC_Adj_Intersection	-0,285	-																		
LC_Sight_Obstructions	-0,216	-0,411	-																	
LC_TrafficLight	-0,276	0,041	0,147	-																
LC_WarningLight	0,097	0,137	-0,263	-0,639	-															
LC_Barrier	0,530	-0,519	0,616	0,352	-0,292	-														
LC_Cross_Marking	0,108	-0,105	0,116	0,217	-0,329	0,724	-													
LC_Stop_Marking	0,317	-0,251	0,247	0,169	-0,037	0,675	0,331	-												
LC_Skewness	-0,278	-0,590	-0,076	0,180	-0,178	-0,273	-0,065	-0,094	-											
LC_Traffic_Island	0,164	0,016	0,358	0,518	-0,178	0,664	0,418	0,587	-0,166	-										
F_BusStop_500m	0,122	0,009	0,002	0,022	-0,068	0,126	0,192	0,056	0,104	0,168										
F_Cafe_500m	-0,236	0,209	-0,058	0,097	-0,125	-0,792	-0,117	-0,230	0,023	-0,150	0,255									
F_Hospital_500m	-0,362	-0,168	0,063	0,502	-0,209	-0,362	0,212	0,107	0,158	0,262	0,312	0,009								
F_Place_of_Worship_500m	-0,236	0,014	0,026	-0,134	0,073	-0,206	-0,056	-0,194	0,010	-0,163	0,300	0,531	-0,218							
F_Restaurant_500m	-0,151	0,078	-0,068	0,039	-0,147	-0,499	-0,025	-0,100	0,116	-0,121	0,161	0,662	-0,091	0,380						
F_School_500m	0,106	-0,095	-0,105	0,000	-0,062	0,122	0,232	0,044	-0,195	-0,100	0,080	0,084	0,086	0,277	0,200					
F_Shopping_Centre_500m	0,155	0,014	0,355	0,263	-0,406	0,538	0,426	0,206	-0,153	0,215	0,393	0,315	0,235	0,104	0,555	-0,167				
F_Sport_Facility_500m	0,044	0,172	-0,195	-0,187	0,209	-0,197	-0,160	-0,259	0,177	-0,306	-0,305	0,265	-0,280	0,072	0,091	0,097	-0,016			
F_Supermarket_500m	0,059	-0,036	0,139	-0,146	0,085	-0,091	0,009	-0,118	-0,017	-0,086	0,257	0,365	-0,355	0,462	0,484	0,279	0,499	-0,006		
F_TramStop_500m	-0,512	0,367	-0,492	-0,741	0,621	**-0,971**	**-0,845**	-0,584	0,235	**-0,845**	-0,017	0,654	0,098	0,211	0,435	0,106	-0,586	0,314	0,234	

Table 13: Output Negative Binomial model – Facilities within 500 meters.

Proximity Facilities		**b(i)**	**St. Error**	**St. Dev.**	**Sig.**
Bus Stop	**500m**	-0,105	0,248	6,394	0,671
Café/Bar	**500m**	-0,027	0,202	5,212	0,894
Hospital	**500m**	-0,032	0,296	7,649	0,914
Place of Worship	**500m**	0,182	0,193	4,984	0,346
Restaurant	**500m**	-0,020	0,202	5,212	0,922
School	**500m**	0,407	0,223	5,744	0,068
Shopping Centre	**500m**	0,335	0,319	8,226	0,294
Sport Facility	**500m**	-0,054	0,243	6,278	0,823
Supermarket	**500m**	-0,163	0,195	5,028	0,404
Tram Stop	**500m**	-	-	-	-

V.4. Facilities within 750 meters

First, the correlation between the variables was examined. As shown in Table 14 and Table 15, correlation was identified; therefore, the facilities 'bus stop', 'school', 'sports facility' and 'tram stop' are removed from the analysis. The facilities within the analysis are 'café', 'hospital', 'shopping centre', 'place of worship', 'restaurant', and 'supermarket'.

Table 14: Tetrachoric Correlation – Facilities within 750 meters.

Tetrachoric Correlation Dichotomous Variables	Road_PedBike_Only	LC_Adj_Intersection	LC_Sight_Obstructions	LC_TrafficLight	LC_WarningLight	LC_Barrier	LC_Cross_Marking	LC_Stop_Marking	LC_Skewness	LC_Traffic_Island	F_BusStop_750m	F_Cafe_750m	F_Hospital_750m	F_Place_of_Worship_750m	F_Restaurant_750m	F_School_750m	F_Shopping_Centre_750m	F_Sport_Facility_750m	F_Supermarket_750m	F_TramStop_750m
Road_PedBike_Only	-																			
LC_Adj_Intersection	-0,285	-																		
LC_Sight_Obstructions	-0,216	-0,411	-																	
LC_TrafficLight	-0,276	0,041	0,147	-																
LC_WarningLight	0,097	0,137	-0,263	-0,639	-															
LC_Barrier	0,530	-0,519	0,616	0,352	-0,292	-														
LC_Cross_Marking	0,108	-0,105	0,116	0,217	-0,329	0,724	-													
LC_Stop_Marking	0,317	-0,251	0,247	0,169	-0,037	0,675	0,331	-												
LC_Skewness	-0,278	-0,590	-0,076	0,180	-0,178	-0,273	-0,065	-0,094	-											
LC_Traffic_Island	0,164	0,016	0,358	0,518	-0,178	0,664	0,418	0,587	-0,166	-										
F_BusStop_750m	**1,000**	**-1,000**	**1,000**	0,106	0,166	**1,000**	0,254	0,294	0,335	0,471	-									
F_Cafe_750m	-0,179	0,166	-0,085	0,190	-0,175	-0,702	-0,059	-0,256	0,173	-0,142	0,163	-								
F_Hospital_750m	-0,083	-0,151	0,195	0,465	-0,176	0,062	0,279	0,090	0,032	0,286	**1,000**	-0,005	-							
F_Place_of_Worship_750m	-0,204	-0,108	0,093	-0,094	-0,013	0,006	-0,065	-0,209	0,007	-0,106	0,726	0,469	0,081	-						
F_Restaurant_750m	-0,217	0,174	0,074	0,214	-0,240	-0,392	0,127	0,038	0,085	0,044	-0,155	0,651	0,068	0,219	-					
F_School_750m	0,150	-0,094	-0,003	0,096	-0,180	0,072	0,603	0,097	-0,112	-0,022	0,626	-0,095	**1,000**	0,424	0,023	-				
F_Shopping_Centre_750m	0,148	0,125	0,263	0,282	-0,300	0,500	0,303	0,121	0,004	0,187	0,109	0,278	0,199	0,464	0,477	**1,000**	-			
F_Sport_Facility_750m	-0,184	-1,000	**1,000**	-0,401	0,604	-0,222	-0,639	-0,247	0,461	-0,355	**-1,000**	0,092	0,231	-0,020	0,202	0,238	-0,246	-		
F_Supermarket_750m	0,026	-0,221	0,048	-0,118	0,088	0,277	0,143	-0,183	-0,004	-0,152	0,325	0,236	-0,258	0,442	0,311	0,503	0,703	0,302	-	
F_TramStop_750m	-0,618	0,459	-0,592	**-1,000**	0,931	**-0,987**	**-0,979**	-0,673	0,263	**-1,000**	**-1,000**	0,602	-0,340	-0,338	0,335	**-1,000**	-0,673	0,598	-0,406	-

Table 15: Output Negative Binomial model – Facilities within 750 meters.

Proximity Facilities		**b(i)**	**St. Error**	**St. Dev.**	**Sig.**
Bus Stop	**750m**	-	-	-	-
Café/Bar	**750m**	-0,134	0,217	5,599	0,536
Hospital	**750m**	-0,102	0,255	6,589	0,690
Place of Worship	**750m**	0,421	0,213	5,492	**0,048**
Restaurant	**750m**	-0,116	0,264	6,809	0,661
School	**750m**	-	-	-	-
Shopping Centre	**750m**	0,518	0,230	5,943	**0,024**
Sport Facility	**750m**	-	-	-	-
Supermarket	**750m**	-0,155	0,247	6,364	0,529
Tram Stop	**750m**	-	-	-	-

V.5. Overview of sensitivity analysis facilities

In Table 16, an overview of the sensitivity analysis for the proximity of facilities can be found.

Table 16: Overview sensitivity analysis – distance of facilities.

Proximity Facilities		**b(i)**	**St. Error**	**St. Dev.**	**Sig.**
Bus Stop	**150m**	0,024	0,167	4,302	0,886
	250m	0,155	0,172	4,449	0,370
	500m	-0,105	0,248	6,394	0,671
	750m	-	-	-	-
Café/Bar	**150m**	-	-	-	-
	250m	0,302	0,203	5,243	0,137
	500m	-0,027	0,202	5,212	0,894
	750m	-0,134	0,217	5,599	0,536
Hospital	**150m**	-	-	-	-
	250m	-	-	-	-
	500m	-0,032	0,296	7,649	0,914
	750m	-0,102	0,255	6,589	0,690
Place of Worship	**150m**	0,179	0,233	6,003	0,443
	250m	0,071	0,194	5,003	0,715
	500m	0,182	0,193	4,984	0,346
	750m	0,421	0,213	5,492	**0,048**
Restaurant	**150m**	0,434	0,203	5,249	**0,033**
	250m	0,076	0,190	4,911	0,688
	500m	-0,020	0,202	5,212	0,922
	750m	-0,116	0,264	6,809	0,661
School	**150m**	-0,448	0,235	6,069	0,057
	250m	-0,083	0,169	4,358	0,621
	500m	0,407	0,223	5,744	0,068
	750m	-	-	-	-
Shopping Centre	**150m**	-	-	-	-
	250m	-	-	-	-
	500m	0,335	0,319	8,226	0,294
	750m	0,518	0,230	5,943	**0,024**
Sport Facility	**150m**	-0,097	0,202	5,224	0,632
	250m	-0,106	0,164	4,236	0,519
	500m	-0,054	0,243	6,278	0,823
	750m	-	-	-	-
Supermarket	**150m**	-0,003	0,235	6,064	0,991
	250m	-0,115	0,198	5,119	0,561
	500m	-0,163	0,195	5,028	0,404
	750m	-0,155	0,247	6,364	0,529
Tram Stop	**150m**	-	-	-	-
	250m	-	-	-	-
	500m	-	-	-	-
	750m	-	-	-	-

Some variables were excluded from the analyses because they showed a high correlation (>0,7). The facility tram stop showed a high correlation for all sizes of the influence area, so no results were observed.

It is found, for some facilities, that different sizes of the area of influence do not lead to significant results. Facilities without significant effects on every distance are 'bus stops', 'café', 'hospital', 'sports facilities', and 'supermarkets'.

Some facilities have a significant result for one specific area of influence. For the influence area of 750 meters, a place of worship ($p = 0,048$) and a shopping centre ($p = 0,024$) are significant variables. For the influence area of 150 meters, a restaurant is a significant variable ($p = 0,033$).

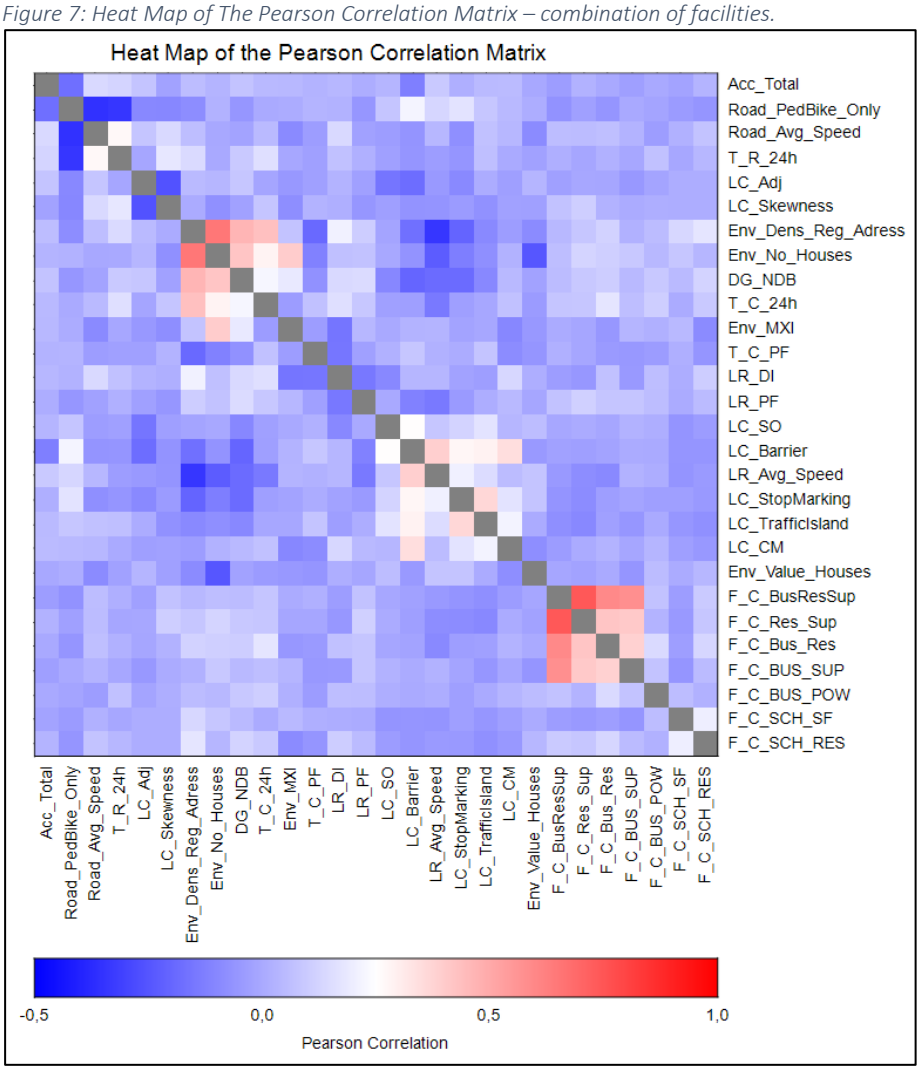
Appendix VI – Sensitivity Analysis – Combination of Facilities

For this sensitivity analysis, several combinations of facilities were created to examine the effect of combining facilities. The combination of facilities was made by considering which facilities were most frequently located close to each other. The combinations of facilities for the analysis are outlined below:

- Bus Stop, Restaurant & Supermarket;
- Bus Stop & Restaurant;
- Bus Stop & Supermarket;
- Bus Stop & Place of Worship;
- Restaurant & Supermarket;
- Restaurant & School;
- School & Sports Facility.

First, the correlation between the variables was examined. As shown in Figure 7, Bus Stop, Restaurant & Supermarket has a significant correlation (0,741) with Restaurant & Supermarket; therefore, the combination of Bus Stop, Restaurant & Supermarket was removed from the analysis.

Figure 7: Heat Map of The Pearson Correlation Matrix – combination of facilities.



Total Accidents

Table 17: Overview sensitivity analysis – combination of facilities – total accidents.

Combination of Facilities		b(i)	St. Error	St. Dev.	Sig.
Bus Stop & Restaurant	**150m**	-0,091	0,334	8,616	0,785
Bus Stop & Supermarket	**150m**	-0,453	0,362	9,346	0,211
Bus Stop & Place of Worship	**150m**	0,106	0,348	8,993	0,762
Restaurant & Supermarket	**150m**	0,494	0,373	9,622	0,185
Restaurant & School	**150m**	0,132	0,393	10,129	0,737
School & Sports Facility	**150m**	-0,405	0,453	11,688	0,371

Damage Only Accidents

Table 18: Overview sensitivity analysis – combination of facilities – damage only accidents.

Combination of Facilities		b(i)	St. Error	St. Dev.	Sig.
Bus Stop & Restaurant	**150m**	-0,066	0,379	9,780	0,862
Bus Stop & Supermarket	**150m**	-0,344	0,412	10,635	0,403
Bus Stop & Place of Worship	**150m**	0,072	0,399	10,299	0,857
Restaurant & Supermarket	**150m**	0,604	0,413	10,647	0,143
Restaurant & School	**150m**	0,232	0,431	11,115	0,590
School & Sports Facility	**150m**	-0,527	0,547	14,116	0,335

Injury/Fatality Accidents

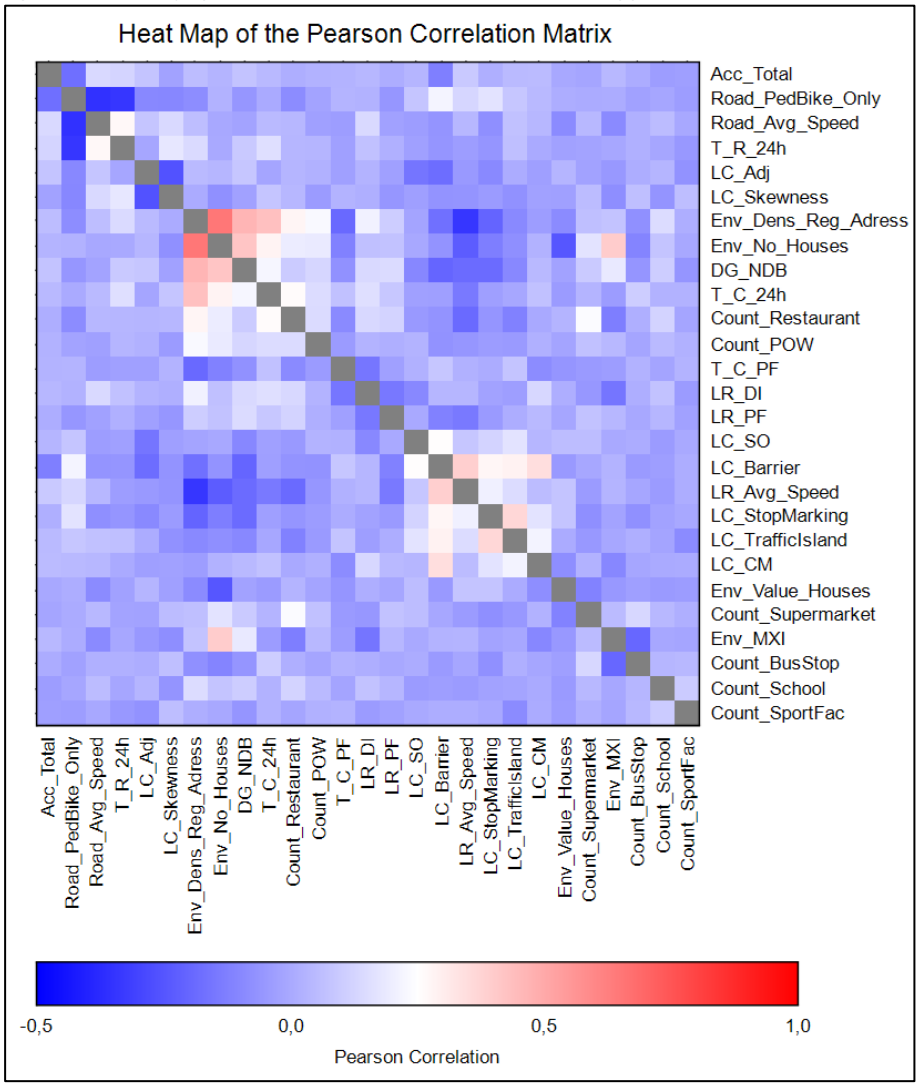
Table 19: Overview sensitivity analysis – combination of facilities – injury/fatality accidents.

Combination of Facilities		b(i)	St. Error	St. Dev.	Sig.
Bus Stop & Restaurant	**150m**	-0,814	0,716	18,479	0,256
Bus Stop & Supermarket	**150m**	-0,429	0,608	15,697	0,481
Bus Stop & Place of Worship	**150m**	0,211	0,576	14,869	0,715
Restaurant & Supermarket	**150m**	0,509	0,638	16,472	0,425
Restaurant & School	**150m**	-0,356	0,790	20,400	0,653
School & Sports Facility	**150m**	-0,010	0,666	17,177	0,988

Appendix VII – Sensitivity Analysis – Counts of Facilities

The facilities were loaded into GIS, and the number of facilities in the 150-meter area of influence was determined using spatial joins. Next, a correlation analysis was executed, which can be found in Figure 8. The correlation analyses showed no significant correlations (> 0,7).

Figure 8: Heat Map of The Pearson Correlation Matrix – counts of facilities.



Total Accidents

Table 20: Overview sensitivity analysis – counts of facilities – total accidents.

Counts of Facilities		**b(i)**	**St. Error**	**St. Dev.**	**Sig.**
Counts Bus Stop	**150m**	0,042	0,064	1,662	0,518
Counts Place of Worship	**150m**	0,056	0,161	4,152	0,729
Counts Restaurant	**150m**	0,016	0,061	1,573	0,798
Counts School	**150m**	-0,116	0,128	3,306	0,363
Counts Sports Facility	**150m**	-0,049	0,078	2,014	0,533
Counts Supermarket	**150m**	-0,071	0,152	3,913	0,641

Damage Only Accidents

Table 21: Overview sensitivity analysis – counts of facilities – damage only accidents.

Counts of Facilities		**b(i)**	**St. Error**	**St. Dev.**	**Sig.**
Counts Bus Stop	**150m**	0,116	0,069	1,782	0,093
Counts Place of Worship	**150m**	0,011	0,189	4,884	0,955
Counts Restaurant	**150m**	0,035	0,064	1,652	0,583
Counts School	**150m**	-0,215	0,157	4,054	0,171
Counts Sports Facility	**150m**	-0,106	0,104	2,690	0,308
Counts Supermarket	**150m**	-0,038	0,171	4,401	0,825

Injury/Fatality Accidents

Table 22: Overview sensitivity analysis – counts of facilities – injury/fatality accidents.

Counts of Facilities		**b(i)**	**St. Error**	**St. Dev.**	**Sig.**
Counts Bus Stop	**150m**	-0,204	0,134	3,468	0,128
Counts Place of Worship	**150m**	0,183	0,244	6,294	0,454
Counts Restaurant	**150m**	-0,063	0,143	3,691	0,658
Counts School	**150m**	0,046	0,197	5,087	0,817
Counts Sports Facility	**150m**	0,011	0,109	2,802	0,921
Counts Supermarket	**150m**	0,019	0,260	6,697	0,943

Appendix VIII – Sensitivity Analysis – Density of Level Crossings

Table 23: Overview sensitivity analysis – density of level crossings.

Level Crossing Density		**b(i)**	**St. Error**	**St. Dev.**	**Sig.**
The number of level crossings within the influence area of x meters.	**150m**	0,054	0,100	2,587	0,593
	250m	0,017	0,065	1,680	0,800
	500m	0,002	0,040	1,036	0,952
	750m	0,021	0,025	0,642	0,391

Appendix IX – Sensitivity Analysis – Traffic Volumes

IX.1. Traffic Volumes +/- 15%

It is shown that the model with a slight deviation, out of 100 models, was not significant 100 times ($p < 0,05$), which can be seen in Table 24. So, traffic volume is not significant at +/- 15% deviation.

Table 24: Sensitivity analysis – traffic volumes – +/- 15%.

TI-Sens	b(i)	St. Error	Z-Value	P-Value	St. Dev.
15-T1	0,027	0,019	1,370	0,171	0,502
15-T2	0,025	0,019	1,310	0,189	0,500
15-T3	0,025	0,019	1,310	0,190	0,496
15-T4	0,026	0,019	1,370	0,171	0,498
15-T5	0,02009	0,0192	1,05	0,2953	0,495
15-T6	0,02549	0,01881	1,36	0,1752	0,485
15-T7	0,02272	0,01869	1,22	0,224	0,482
15-T8	0,03192	0,02026	1,58	0,1152	0,523
15-T9	0,02252	0,01965	1,15	0,2516	0,507
15-T10	0,02679	0,01944	1,38	0,1682	0,502
15-T11	0,0235	0,01967	1,19	0,2322	0,508
15-T12	0,02451	0,01966	1,25	0,2125	0,507
15-T13	0,02964	0,02001	1,48	0,1385	0,516
15-T14	0,02228	0,01879	1,19	0,2357	0,485
15-T15	0,02553	0,01847	1,38	0,1668	0,477
15-T16	0,0238	0,02034	1,17	0,2419	0,525
15-T17	0,0305	0,01959	1,56	0,1195	0,506
15-T18	0,02847	0,01882	1,51	0,1305	0,486
15-T19	0,02594	0,02035	1,27	0,2024	0,525
15-T20	0,02759	0,02089	1,32	0,1867	0,539
15-T21	0,02989	0,01974	1,51	0,1298	0,509
15-T22	0,02921	0,01964	1,49	0,1368	0,507
15-T23	0,02556	0,01935	1,32	0,1866	0,499
15-T24	0,02635	0,01872	1,41	0,1593	0,483
15-T25	0,02753	0,01915	1,44	0,1506	0,494
15-T26	0,02966	0,0194	1,53	0,1263	0,501
15-T27	0,02772	0,02008	1,38	0,1675	0,518
15-T28	0,02072	0,01939	1,07	0,2854	0,500
15-T29	0,02077	0,01964	1,06	0,2903	0,507
15-T30	0,02503	0,01974	1,27	0,2049	0,509
15-T31	0,02626	0,01871	1,4	0,1605	0,483
15-T32	0,02674	0,01964	1,36	0,1735	0,507
15-T33	0,02784	0,01924	1,45	0,1479	0,497
15-T34	0,02261	0,01982	1,14	0,2539	0,511
15-T35	0,01867	0,01977	0,94	0,3452	0,510
15-T36	0,02765	0,01855	1,49	0,1362	0,479
15-T37	0,01973	0,0206	0,96	0,3382	0,532
15-T38	0,02387	0,01932	1,23	0,2168	0,499
15-T39	0,02351	0,01923	1,22	0,2216	0,496
15-T40	0,02852	0,01984	1,44	0,1506	0,512
15-T41	0,02531	0,01918	1,32	0,1869	0,495
15-T42	0,0244	0,01938	1,26	0,208	0,500
15-T43	0,02904	0,02022	1,44	0,151	0,522
15-T44	0,02607	0,01997	1,31	0,1918	0,515
15-T45	0,02447	0,01994	1,23	0,2197	0,515
15-T46	0,02967	0,01969	1,51	0,1318	0,508
15-T47	0,02752	0,01971	1,4	0,1626	0,509
15-T48	0,02191	0,01982	1,11	0,2689	0,511
15-T49	0,02496	0,01878	1,33	0,184	0,485
15-T50	0,02586	0,01893	1,37	0,1719	0,489
15-T51	0,02544	0,02023	1,26	0,2084	0,522
15-T52	0,02968	0,019	1,56	0,1183	0,490
15-T53	0,02335	0,02	1,17	0,2431	0,516
15-T54	0,0281	0,01968	1,43	0,1534	0,508
15-T55	0,0308	0,01994	1,54	0,1224	0,515
15-T56	0,02744	0,01984	1,38	0,1665	0,512
15-T57	0,02183	0,01913	1,14	0,2538	0,494
15-T58	0,02649	0,01906	1,39	0,1645	0,492
15-T59	0,02581	0,01941	1,33	0,1836	0,501
15-T60	0,02794	0,01954	1,43	0,1527	0,504
15-T61	0,02668	0,0197	1,35	0,1755	0,508
15-T62	0,02683	0,01918	1,4	0,1618	0,495
15-T63	0,02289	0,01997	1,15	0,2516	0,515
15-T64	0,02743	0,01898	1,44	0,1485	0,490
15-T65	0,02131	0,0196	1,09	0,2769	0,506
15-T66	0,02417	0,02116	1,14	0,2534	0,546
15-T67	0,02439	0,01906	1,28	0,2008	0,492
15-T68	0,02585	0,01937	1,33	0,182	0,500
15-T69	0,02833	0,01919	1,48	0,1399	0,495
15-T70	0,02755	0,02038	1,35	0,1763	0,526
15-T71	0,02341	0,0192	1,22	0,2227	0,495
15-T72	0,01927	0,01991	0,97	0,3331	0,514
15-T73	0,02722	0,01999	1,36	0,1734	0,516
15-T74	0,02763	0,01906	1,45	0,1472	0,492
15-T75	0,02907	0,01927	1,51	0,1314	0,497
15-T76	0,02632	0,01933	1,36	0,1733	0,499
15-T77	0,02812	0,01886	1,49	0,136	0,487
15-T78	0,02338	0,0189	1,24	0,2162	0,488
15-T79	0,02655	0,02015	1,32	0,1877	0,520
15-T80	0,02615	0,02018	1,3	0,1949	0,521
15-T81	0,02879	0,019	1,52	0,1297	0,490
15-T82	0,02702	0,01935	1,4	0,1625	0,499
15-T83	0,02816	0,01913	1,47	0,1411	0,494
15-T84	0,02744	0,01983	1,38	0,1664	0,512
15-T85	0,02716	0,01998	1,36	0,174	0,516
15-T86	0,03011	0,01904	1,58	0,1137	0,491
15-T87	0,02666	0,01914	1,39	0,1637	0,494
15-T88	0,02522	0,01888	1,34	0,1817	0,487
15-T89	0,02851	0,01893	1,51	0,132	0,489
15-T90	0,02846	0,02012	1,41	0,1572	0,519
15-T91	0,02728	0,01968	1,39	0,1657	0,508
15-T92	0,02804	0,01936	1,45	0,1476	0,500
15-T93	0,02739	0,02005	1,37	0,1719	0,517
15-T94	0,03536	0,01879	1,88	0,0598	0,485
15-T95	0,02903	0,01957	1,48	0,1379	0,505
15-T96	0,02736	0,01981	1,38	0,1672	0,511
15-T97	0,02505	0,01994	1,26	0,2091	0,515
15-T98	0,02285	0,01869	1,22	0,2217	0,482
15-T99	0,03024	0,01929	1,57	0,1169	0,498
15-T100	0,0255	0,01885	1,35	0,1762	0,486

IX.2. Traffic Volumes +/- 50%

It is shown that the model with a large deviation, out of 100 models, was not significant 94 times and significant six times ($p < 0,05$), which can be seen in Table 25.

Table 25: Sensitivity analysis – traffic volumes – +/- 50%.

TI-Sens	b(i)	St. Error	Z-Value	P-Value	St. Dev.
50-T1	0,011	0,017	0,680	0,499	0,433
50-T2	0,025	0,016	1,580	0,113	0,408
50-T3	0,003	0,018	0,140	0,889	0,470
50-T4	0,018	0,016	1,110	0,266	0,407
50-T5	0,01395	0,01426	0,98	0,3279	0,368
50-T6	0,01862	0,0152	1,23	0,2205	0,392
50-T7	0,01136	0,01779	0,64	0,5233	0,459
50-T8	0,00229	0,01646	0,14	0,8895	0,425
50-T9	0,00602	0,01631	0,37	0,7121	0,421
50-T10	0,02501	0,01431	1,75	0,0805	0,369
50-T11	0,02267	0,01488	1,52	0,1275	0,384
50-T12	0,00226	0,01873	0,12	0,9041	0,483
50-T13	0,02375	0,01544	1,54	0,1238	0,398
50-T14	0,014	0,0171	0,82	0,4131	0,441
50-T15	0,02753	0,01508	1,83	0,068	0,389
50-T16	0,013	0,0157	0,83	0,4077	0,405
50-T17	0,01766	0,01637	1,08	0,2806	0,422
50-T18	0,02108	0,01732	1,22	0,2234	0,447
50-T19	0,02527	0,01542	1,64	0,1013	0,398
50-T20	0,01515	0,01596	0,95	0,3425	0,412
50-T21	0,02065	0,01645	1,26	0,2094	0,425
50-T22	0,02435	0,01591	1,53	0,1258	0,411
50-T23	0,01988	0,01864	1,07	0,286	0,481
50-T24	0,02873	0,01639	1,75	0,0796	0,423
50-T25	0,01847	0,01676	1,1	0,2704	0,433
50-T26	0,02518	0,01659	1,52	0,1291	0,428
50-T27	0,03091	0,01567	1,97	**0,0484**	0,404
50-T28	0,01602	0,01695	0,94	0,3447	0,437
50-T29	0,02036	0,01882	1,08	0,2794	0,486
50-T30	0,02745	0,01599	1,72	0,086	0,413
50-T31	0,0315	0,01488	2,12	**0,0342**	0,384
50-T32	0,01097	0,01519	0,72	0,47	0,392
50-T33	0,01912	0,01571	1,22	0,2236	0,405
50-T34	0,01768	0,01625	1,09	0,2765	0,419
50-T35	0,01716	0,01477	1,16	0,2452	0,381
50-T36	0,00894	0,01739	0,51	0,6074	0,449
50-T37	0,00826	0,01989	0,42	0,6778	0,513
50-T38	0,02154	0,01393	1,55	0,1219	0,359
50-T39	0,02475	0,01611	1,54	0,1244	0,416
50-T40	0,01379	0,01629	0,85	0,3973	0,420
50-T41	0,01848	0,01703	1,08	0,278	0,439
50-T42	0,0222	0,01522	1,46	0,1447	0,393
50-T43	-0,0024	0,01606	-0,15	0,8814	0,414
50-T44	0,00713	0,01611	0,44	0,6579	0,416
50-T45	0,0211	0,01575	1,34	0,1804	0,406
50-T46	0,0323	0,01611	2	**0,045**	0,416
50-T47	0,03103	0,01628	1,91	0,0567	0,420
50-T48	0,01724	0,01501	1,15	0,2506	0,387
50-T49	0,02224	0,01612	1,38	0,1677	0,416
50-T50	0,02395	0,01628	1,47	0,1412	0,420
50-T51	0,02789	0,01572	1,77	0,0761	0,406
50-T52	0,02552	0,01498	1,7	0,0885	0,387
50-T53	0,00454	0,01614	0,28	0,7787	0,417
50-T54	0,02577	0,01629	1,58	0,1136	0,420
50-T55	0,01937	0,01602	1,21	0,2265	0,413
50-T56	0,01253	0,01761	0,71	0,4765	0,454
50-T57	0,02318	0,01592	1,46	0,1453	0,411
50-T58	0,01695	0,01451	1,17	0,2426	0,374
50-T59	0,02623	0,01626	1,61	0,1068	0,420
50-T60	0,02111	0,01432	1,47	0,1403	0,370
50-T61	0,00317	0,01927	0,16	0,8692	0,497
50-T62	0,00734	0,01696	0,43	0,665	0,438
50-T63	0,01994	0,01625	1,23	0,2196	0,419
50-T64	-0,00534	0,01783	-0,3	0,7643	0,460
50-T65	-0,00394	0,01752	-0,22	0,8222	0,452
50-T66	0,01462	0,01566	0,93	0,3506	0,404
50-T67	0,03377	0,01342	2,52	**0,0118**	0,346
50-T68	0,02405	0,01586	1,52	0,1293	0,409
50-T69	0,0178	0,01514	1,18	0,2399	0,391
50-T70	0,01541	0,01521	1,01	0,3109	0,393
50-T71	0,02041	0,0157	1,3	0,1934	0,405
50-T72	0,01352	0,01569	0,86	0,389	0,405
50-T73	0,01115	0,01822	0,61	0,5407	0,470
50-T74	0,02769	0,01304	2,12	**0,0337**	0,337
50-T75	0,02724	0,01658	1,64	0,1004	0,428
50-T76	0,02754	0,01738	1,58	0,113	0,449
50-T77	0,02903	0,01796	1,62	0,106	0,463
50-T78	0,01096	0,01697	0,65	0,5184	0,438
50-T79	0,00499	0,01724	0,29	0,7723	0,445
50-T80	0,02367	0,01785	1,33	0,1848	0,461
50-T81	0,01344	0,01553	0,87	0,3869	0,401
50-T82	0,02221	0,01768	1,26	0,209	0,456
50-T83	0,03377	0,01747	1,93	0,0532	0,451
50-T84	0,01315	0,01612	0,82	0,4145	0,416
50-T85	0,02543	0,01755	1,45	0,1474	0,453
50-T86	0,01926	0,01684	1,14	0,2529	0,435
50-T87	0,02041	0,01719	1,19	0,2351	0,444
50-T88	0,00743	0,01565	0,47	0,6349	0,404
50-T89	0,0348	0,01481	2,35	**0,0188**	0,382
50-T90	0,01013	0,01544	0,66	0,512	0,398
50-T91	0,01016	0,02045	0,5	0,6193	0,528
50-T92	0,02267	0,01742	1,3	0,1931	0,450
50-T93	0,0269	0,0168	1,6	0,1093	0,434
50-T94	0,01438	0,01556	0,92	0,3555	0,402
50-T95	0,02297	0,01598	1,44	0,1505	0,412
50-T96	-0,003	0,01782	-0,17	0,8664	0,460
50-T97	0,00793	0,01739	0,46	0,6482	0,449
50-T98	0,01861	0,01813	1,03	0,3047	0,468
50-T99	0,01897	0,01506	1,26	0,2076	0,389
50-T100	0,0159	0,01538	1,03	0,301	0,397

Appendix X – Residual Analysis

X.1. Residuals – All Level Crossings

Table 26: Observed accidents subtracted from predicted means.

LCS	NB Total Accidents			NB DO[2]			NB IF[3]		
No.	**Predicted Mean of Response (P) Total**	**Actual Value (A) Total**	**P-A Total**	**Predicted Mean of Response (P) DO**	**Actual Value (A) DO**	**P-A DO**	**Predicted Mean of Response (P) IF**	**Actual Value (A) IF**	**P-A IF**
1	0,33101	0	0,3	0,18075	0	0,2	0,13480	0	0,1
2	0,35933	2	-1,6	0,29794	2	-1,7	0,06334	0	0,1
3	0,27719	0	0,3	0,12475	0	0,1	0,10569	0	0,1
4	0,52167	1	-0,5	0,43685	1	-0,6	0,08988	0	0,1
5	0,41832	0	0,4	0,24786	0	0,2	0,14765	0	0,1
6	0,32135	0	0,3	0,23289	0	0,2	0,08738	0	0,1
7	0,34430	0	0,3	0,23256	0	0,2	0,09086	0	0,1
8	0,14320	0	0,1	0,08374	0	0,1	0,05359	0	0,1
9	0,27222	0	0,3	0,25643	0	0,3	0,04947	0	0,0
10	0,13265	0	0,1	0,05803	0	0,1	0,08460	0	0,1
11	0,27592	0	0,3	0,22629	0	0,2	0,05627	0	0,1
12	0,63259	0	0,6	0,54120	0	0,5	0,09518	0	0,1
13	0,36292	0	0,4	0,21258	0	0,2	0,13434	0	0,1
14	0,06749	0	0,1	0,03378	0	0,0	0,02751	0	0,0
15	0,53216	0	0,5	0,40164	0	0,4	0,11747	0	0,1
16	0,16468	1	-0,8	0,07796	0	0,1	0,06839	1	-0,9
17	0,57385	0	0,6	0,32827	0	0,3	0,23147	0	0,2
18	0,39206	0	0,4	0,29738	0	0,3	0,08670	0	0,1
19	0,41164	0	0,4	0,30566	0	0,3	0,08718	0	0,1
20	0,56620	0	0,6	0,44132	0	0,4	0,09359	0	0,1
21	0,91892	1	-0,1	0,52595	0	0,5	0,31281	1	-0,7
22	0,24773	0	0,2	0,16723	0	0,2	0,08043	0	0,1
23	0,43131	2	-1,6	0,25163	2	-1,7	0,19588	0	0,2
24	0,34959	0	0,3	0,25018	0	0,3	0,09726	0	0,1
25	0,34078	0	0,3	0,22035	0	0,2	0,10601	0	0,1
26	0,36108	0	0,4	0,22428	0	0,2	0,12237	0	0,1
27	0,08134	0	0,1	0,03962	0	0,0	0,03537	0	0,0
28	0,06359	0	0,1	0,02945	0	0,0	0,03803	0	0,0
29	0,51712	3	-2,5	0,38315	1	-0,6	0,09475	2	-1,9
30	0,66365	1	-0,3	0,35611	0	0,4	0,30048	1	-0,7
31	0,71324	1	-0,3	0,41060	1	-0,6	0,25088	0	0,3
32	0,25164	1	-0,7	0,10126	1	-0,9	0,13194	0	0,1
33	0,28164	0	0,3	0,25498	0	0,3	0,04290	0	0,0
34	0,29968	1	-0,7	0,28109	1	-0,7	0,04077	0	0,0
35	0,42769	0	0,4	0,25935	0	0,3	0,12140	0	0,1
36	0,37543	1	-0,6	0,26175	1	-0,7	0,08814	0	0,1
37	0,20005	0	0,2	0,06848	0	0,1	0,14005	0	0,1
38	0,88905	3	-2,1	0,45562	2	-1,5	0,46223	1	-0,5
39	0,09755	0	0,1	0,03863	0	0,0	0,06436	0	0,1
40	0,05667	0	0,1	0,02482	0	0,0	0,02432	0	0,0
41	0,09119	0	0,1	0,04190	0	0,0	0,04412	0	0,0
42	0,88700	0	0,9	0,58777	0	0,6	0,18991	0	0,2
43	0,28946	0	0,3	0,20358	0	0,2	0,08219	0	0,1
44	0,27945	0	0,3	0,22315	0	0,2	0,05649	0	0,1

[2] DO: Damage Only
[3] IF: Injury/Fatality

45	0,19164	1	-0,8	0,08022	0	0,1	0,07742	1	-0,9
46	1,58464	1	0,6	1,47785	1	0,5	0,12459	0	0,1
47	0,41325	0	0,4	0,30901	0	0,3	0,09278	0	0,1
48	0,64911	0	0,6	0,37511	0	0,4	0,20682	0	0,2
49	0,16087	0	0,2	0,05891	0	0,1	0,09890	0	0,1
50	0,11760	0	0,1	0,04451	0	0,0	0,07509	0	0,1
51	0,90751	1	-0,1	0,65117	1	-0,3	0,16290	0	0,2
52	0,41702	1	-0,6	0,37702	1	-0,6	0,04331	0	0,0
53	0,46192	1	-0,5	0,34137	1	-0,7	0,06385	0	0,1
54	0,38290	0	0,4	0,45712	0	0,5	0,01714	0	0,0
55	0,26645	1	-0,7	0,12620	0	0,1	0,12556	1	-0,9
56	0,15040	0	0,2	0,09102	0	0,1	0,04214	0	0,0
57	0,19576	1	-0,8	0,10335	0	0,1	0,08238	1	-0,9
58	1,02126	1	0,0	0,79433	0	0,8	0,18834	1	-0,8
59	0,17219	0	0,2	0,06708	0	0,1	0,11508	0	0,1
60	0,22669	0	0,2	0,18542	0	0,2	0,04421	0	0,0
61	0,30743	1	-0,7	0,30206	1	-0,7	0,02392	0	0,0
62	0,38432	0	0,4	0,28614	0	0,3	0,09217	0	0,1
63	0,06600	0	0,1	0,02900	0	0,0	0,02853	0	0,0
64	0,69947	0	0,7	0,52604	0	0,5	0,12804	0	0,1
65	0,30895	0	0,3	0,21284	0	0,2	0,06240	0	0,1
66	0,56529	0	0,6	0,43517	0	0,4	0,07432	0	0,1
67	0,25494	0	0,3	0,13385	0	0,1	0,07742	0	0,1
68	0,41519	0	0,4	0,24818	0	0,2	0,15596	0	0,2
69	0,21851	0	0,2	0,13762	0	0,1	0,07007	0	0,1
70	0,36836	0	0,4	0,25428	0	0,3	0,08163	0	0,1
71	0,12455	0	0,1	0,11864	0	0,1	0,01643	0	0,0
72	0,04986	0	0,0	0,04319	0	0,0	0,00729	0	0,0
73	0,04006	0	0,0	0,04176	0	0,0	0,00441	0	0,0
74	0,30377	0	0,3	0,14861	0	0,1	0,07088	0	0,1
75	0,14346	0	0,1	0,05905	0	0,1	0,05541	0	0,1
76	0,20776	1	-0,8	0,11033	1	-0,9	0,06285	0	0,1
77	0,66979	3	-2,3	0,71594	3	-2,3	0,04171	0	0,0
78	0,06389	0	0,1	0,02404	0	0,0	0,03403	0	0,0
79	0,35119	0	0,4	0,23742	0	0,2	0,10018	0	0,1
80	0,47662	0	0,5	0,32941	0	0,3	0,07184	0	0,1
81	0,40163	0	0,4	0,38444	0	0,4	0,04464	0	0,0
82	0,13941	0	0,1	0,04162	0	0,0	0,17149	0	0,2
83	1,19055	2	-0,8	0,95168	2	-1,0	0,16185	0	0,2
84	0,41190	3	-2,6	0,33584	3	-2,7	0,07990	0	0,1
85	0,20053	1	-0,8	0,07864	0	0,1	0,11166	1	-0,9
86	0,35693	0	0,4	0,21383	0	0,2	0,11714	0	0,1
87	0,04018	0	0,0	0,01061	0	0,0	0,07474	0	0,1
88	2,00408	0	2,0	1,00935	0	1,0	1,35127	0	1,4
89	1,47976	3	-1,5	0,92630	1	-0,1	0,65757	2	-1,3
90	0,80400	0	0,8	0,27933	0	0,3	0,85159	0	0,9
91	1,29117	1	0,3	1,01386	1	0,0	0,30392	0	0,3
92	0,28030	0	0,3	0,18426	0	0,2	0,08262	0	0,1
93	0,39471	1	-0,6	0,27921	1	-0,7	0,08565	0	0,1
94	0,27112	0	0,3	0,19815	0	0,2	0,04861	0	0,0
95	0,23803	0	0,2	0,07175	0	0,1	0,17983	0	0,2
96	0,33934	0	0,3	0,31945	0	0,3	0,03504	0	0,0
97	0,16847	0	0,2	0,10807	0	0,1	0,05172	0	0,1
98	1,00998	0	1,0	1,22640	0	1,2	0,03960	0	0,0
99	0,17703	1	-0,8	0,13823	1	-0,9	0,02502	0	0,0

100	0,42841	0	0,4	0,19000	0	0,2	0,22422	0	0,2
101	0,75173	0	0,8	0,29080	0	0,3	0,50269	0	0,5
102	0,55107	0	0,6	0,32105	0	0,3	0,15466	0	0,2
103	0,22791	1	-0,8	0,11694	1	-0,9	0,07573	0	0,1
104	0,37641	0	0,4	0,39911	0	0,4	0,03474	0	0,0
105	0,34323	0	0,3	0,36395	0	0,4	0,03132	0	0,0
106	0,26197	0	0,3	0,22188	0	0,2	0,03772	0	0,0
107	0,38907	0	0,4	0,41737	0	0,4	0,03587	0	0,0
108	0,12592	0	0,1	0,05588	0	0,1	0,05852	0	0,1
109	0,36928	0	0,4	0,32660	0	0,3	0,04945	0	0,0
110	0,44260	2	-1,6	0,34724	2	-1,7	0,09486	0	0,1
111	0,19758	0	0,2	0,15779	0	0,2	0,04318	0	0,0
112	0,53711	0	0,5	0,37124	0	0,4	0,14702	0	0,1
113	0,74134	0	0,7	0,86435	0	0,9	0,04028	0	0,0
114	0,58164	0	0,6	0,41918	0	0,4	0,14616	0	0,1
115	0,17792	1	-0,8	0,14193	1	-0,9	0,03780	0	0,0
116	0,37817	2	-1,6	0,29921	2	-1,7	0,05563	0	0,1
117	0,19410	0	0,2	0,14592	0	0,1	0,03280	0	0,0
118	0,85956	0	0,9	0,85921	0	0,9	0,07889	0	0,1
119	0,41662	0	0,4	0,30633	0	0,3	0,10297	0	0,1
120	0,21522	0	0,2	0,11392	0	0,1	0,11035	0	0,1
121	0,06390	1	-0,9	0,06701	1	-0,9	0,00651	0	0,0
122	0,23778	0	0,2	0,18891	0	0,2	0,05484	0	0,1
123	0,23840	0	0,2	0,10961	0	0,1	0,17500	0	0,2
124	0,44707	0	0,4	0,40338	0	0,4	0,07157	0	0,1
125	0,30044	0	0,3	0,15514	0	0,2	0,06556	0	0,1
126	1,56399	0	1,6	1,95849	0	2,0	0,07365	0	0,1
127	0,39745	0	0,4	0,24503	0	0,2	0,16333	0	0,2
128	0,07699	0	0,1	0,03999	0	0,0	0,02440	0	0,0
129	0,18669	0	0,2	0,12299	0	0,1	0,06286	0	0,1
130	0,61225	0	0,6	0,60871	0	0,6	0,05039	0	0,1
131	0,12636	0	0,1	0,03457	0	0,0	0,15849	0	0,2
132	0,62588	0	0,6	0,64549	0	0,6	0,04665	0	0,0
133	0,10091	0	0,1	0,02536	0	0,0	0,17936	0	0,2
134	1,09155	0	1,1	1,32906	0	1,3	0,04848	0	0,0
135	0,14128	0	0,1	0,05231	0	0,1	0,08364	0	0,1
136	0,29782	0	0,3	0,26361	0	0,3	0,03931	0	0,0
137	0,48016	0	0,5	0,37184	0	0,4	0,06760	0	0,1
138	0,27861	0	0,3	0,17948	0	0,2	0,06803	0	0,1
139	0,25527	0	0,3	0,22211	0	0,2	0,04163	0	0,0
140	0,96181	1	0,0	0,66299	1	-0,3	0,16810	0	0,2
141	0,40545	0	0,4	0,30667	0	0,3	0,09188	0	0,1
142	0,74152	1	-0,3	0,53130	1	-0,5	0,17409	0	0,2
143	0,18429	0	0,2	0,08883	0	0,1	0,07085	0	0,1
144	0,71432	0	0,7	0,52644	0	0,5	0,17148	0	0,2
145	0,55905	2	-1,4	0,42195	1	-0,6	0,13847	1	-0,9
146	0,34544	1	-0,7	0,23684	0	0,2	0,12917	1	-0,9
147	0,22500	0	0,2	0,12822	0	0,1	0,09400	0	0,1
148	0,28261	0	0,3	0,20764	0	0,2	0,06878	0	0,1
149	0,39222	0	0,4	0,26867	0	0,3	0,11006	0	0,1
150	0,09714	0	0,1	0,04852	0	0,0	0,03003	0	0,0
151	0,64770	0	0,6	0,44862	0	0,4	0,16618	0	0,2
152	0,39263	0	0,4	0,25982	0	0,3	0,12254	0	0,1
153	0,38897	0	0,4	0,26903	0	0,3	0,12422	0	0,1
154	0,62941	0	0,6	0,48378	0	0,5	0,10902	0	0,1

155	0,38521	0	0,4	0,25747	0	0,3	0,11742	0	0,1
156	0,05916	0	0,1	0,02196	0	0,0	0,05749	0	0,1
157	0,32250	0	0,3	0,18650	0	0,2	0,15545	0	0,2
158	0,40840	0	0,4	0,21450	0	0,2	0,25252	0	0,3
159	0,05144	0	0,1	0,02320	0	0,0	0,02324	0	0,0
160	0,47854	0	0,5	0,36997	0	0,4	0,08149	0	0,1
161	0,42110	0	0,4	0,24605	0	0,2	0,19693	0	0,2
162	0,10573	1	-0,9	0,03369	1	-1,0	0,11732	0	0,1
163	0,24283	0	0,2	0,17893	0	0,2	0,05458	0	0,1
164	0,83878	1	-0,2	0,72885	1	-0,3	0,13056	0	0,1
165	0,13907	0	0,1	0,05908	0	0,1	0,07215	0	0,1
166	0,11041	0	0,1	0,03908	0	0,0	0,10107	0	0,1
167	0,58912	4	-3,4	0,42347	3	-2,6	0,13820	1	-0,9
168	0,35319	0	0,4	0,22827	0	0,2	0,11942	0	0,1
169	0,26859	0	0,3	0,20987	0	0,2	0,05501	0	0,1
170	0,54430	1	-0,5	0,31523	0	0,3	0,18544	1	-0,8
171	0,35741	0	0,4	0,24789	0	0,2	0,10957	0	0,1
172	0,42337	0	0,4	0,30741	0	0,3	0,08314	0	0,1
173	0,58903	0	0,6	0,40449	0	0,4	0,15192	0	0,2
174	0,48009	0	0,5	0,36314	0	0,4	0,08405	0	0,1
175	0,22910	0	0,2	0,10376	0	0,1	0,11237	0	0,1
176	0,09408	1	-0,9	0,03849	1	-1,0	0,07087	0	0,1
177	0,28392	0	0,3	0,17385	0	0,2	0,09083	0	0,1
178	0,68939	0	0,7	0,39542	0	0,4	0,26134	0	0,3
179	0,24040	0	0,2	0,14378	0	0,1	0,09169	0	0,1
180	0,31579	0	0,3	0,20561	0	0,2	0,08375	0	0,1
181	0,56982	0	0,6	0,38958	0	0,4	0,16422	0	0,2
182	0,09244	0	0,1	0,05046	0	0,1	0,02670	0	0,0
183	0,46364	0	0,5	0,40609	0	0,4	0,07061	0	0,1
184	0,90335	0	0,9	0,63845	0	0,6	0,21768	0	0,2
185	0,85740	0	0,9	0,73959	0	0,7	0,11598	0	0,1
186	0,15633	0	0,2	0,05518	0	0,1	0,14622	0	0,1
187	0,40971	0	0,4	0,30726	0	0,3	0,09684	0	0,1
188	1,01216	0	1,0	0,62277	0	0,6	0,30671	0	0,3
189	0,49289	1	-0,5	0,34656	0	0,3	0,13645	1	-0,9
190	0,22858	0	0,2	0,08689	0	0,1	0,13730	0	0,1
191	0,65425	0	0,7	0,62944	0	0,6	0,06543	0	0,1
192	0,39836	0	0,4	0,29693	0	0,3	0,08667	0	0,1
193	0,07737	0	0,1	0,02823	0	0,0	0,07266	0	0,1
194	0,18959	0	0,2	0,10196	0	0,1	0,05752	0	0,1
195	0,65933	1	-0,3	0,50875	0	0,5	0,15329	1	-0,8
196	0,66942	0	0,7	0,35586	0	0,4	0,32104	0	0,3
197	0,24186	0	0,2	0,10179	0	0,1	0,13130	0	0,1
198	0,72930	1	-0,3	0,52428	1	-0,5	0,18522	0	0,2
199	0,28747	1	-0,7	0,21188	1	-0,8	0,08133	0	0,1
200	0,48983	0	0,5	0,32517	0	0,3	0,17420	0	0,2
201	0,41262	1	-0,6	0,28639	1	-0,7	0,11634	0	0,1
202	0,27041	0	0,3	0,26051	0	0,3	0,02662	0	0,0
203	0,68063	1	-0,3	0,38514	1	-0,6	0,26125	0	0,3
204	0,11147	0	0,1	0,05122	0	0,1	0,04815	0	0,0
205	0,22685	2	-1,8	0,17682	1	-0,8	0,04163	1	-1,0
206	0,18043	0	0,2	0,07291	0	0,1	0,12126	0	0,1
207	0,08671	0	0,1	0,03645	0	0,0	0,04504	0	0,0
208	0,35273	2	-1,6	0,23571	2	-1,8	0,10197	0	0,1
209	0,31317	0	0,3	0,22707	0	0,2	0,07672	0	0,1

210	0,63726	1	-0,4	0,40649	1	-0,6	0,20596	0	0,2
211	0,35768	0	0,4	0,24295	0	0,2	0,11202	0	0,1
212	0,22653	0	0,2	0,27886	0	0,3	0,01174	0	0,0
213	0,11392	0	0,1	0,04459	0	0,0	0,08384	0	0,1
214	0,05500	0	0,1	0,02504	0	0,0	0,02655	0	0,0
215	0,61786	2	-1,4	0,81543	2	-1,2	0,02104	0	0,0
216	0,33852	1	-0,7	0,31022	1	-0,7	0,03921	0	0,0
217	0,49032	0	0,5	0,37326	0	0,4	0,09528	0	0,1
218	0,25881	2	-1,7	0,21266	1	-0,8	0,03722	1	-1,0
219	0,48030	1	-0,5	0,41295	1	-0,6	0,08625	0	0,1
220	0,09709	0	0,1	0,07256	0	0,1	0,02925	0	0,0
221	0,58853	0	0,6	0,53716	0	0,5	0,05348	0	0,1
222	0,37798	0	0,4	0,43122	0	0,4	0,02350	0	0,0
223	1,02878	0	1,0	0,54866	0	0,5	0,55247	0	0,6
224	0,23010	0	0,2	0,15115	0	0,2	0,06290	0	0,1
225	0,09324	0	0,1	0,04814	0	0,0	0,02476	0	0,0
226	0,47005	0	0,5	0,42515	0	0,4	0,05323	0	0,1
227	0,47185	0	0,5	0,39781	0	0,4	0,06980	0	0,1
228	0,12627	0	0,1	0,04361	0	0,0	0,09351	0	0,1
229	0,29244	0	0,3	0,32248	0	0,3	0,02179	0	0,0
230	0,29063	0	0,3	0,19018	0	0,2	0,08019	0	0,1
231	0,87509	0	0,9	0,55384	0	0,6	0,23171	0	0,2
232	0,17521	0	0,2	0,10889	0	0,1	0,06152	0	0,1
233	0,30208	0	0,3	0,19076	0	0,2	0,11019	0	0,1
234	0,28539	0	0,3	0,16253	0	0,2	0,12402	0	0,1
235	0,26035	1	-0,7	0,14086	0	0,1	0,09710	1	-0,9
236	0,38708	1	-0,6	0,34346	1	-0,7	0,06771	0	0,1
237	0,46280	1	-0,5	0,39418	1	-0,6	0,06319	0	0,1
238	0,40446	0	0,4	0,22711	0	0,2	0,15069	0	0,2
239	0,24150	0	0,2	0,10975	0	0,1	0,09836	0	0,1
240	0,10080	0	0,1	0,03744	0	0,0	0,08252	0	0,1
241	0,03715	0	0,0	0,01179	0	0,0	0,03041	0	0,0
242	0,41294	0	0,4	0,35646	0	0,4	0,05222	0	0,1
243	0,82149	1	-0,2	0,61200	1	-0,4	0,16536	0	0,2
244	0,05537	0	0,1	0,04359	0	0,0	0,01166	0	0,0
245	0,09145	0	0,1	0,03484	0	0,0	0,07701	0	0,1
246	0,66957	1	-0,3	0,50873	1	-0,5	0,12229	0	0,1
247	0,08127	0	0,1	0,03666	0	0,0	0,03162	0	0,0
248	0,64106	0	0,6	0,47692	0	0,5	0,09901	0	0,1
249	0,56404	1	-0,4	0,33750	0	0,3	0,21660	1	-0,8
250	0,33206	1	-0,7	0,20776	1	-0,8	0,09048	0	0,1
251	0,42172	1	-0,6	0,25931	1	-0,7	0,10000	0	0,1
252	0,30538	0	0,3	0,17094	0	0,2	0,10396	0	0,1
253	0,55082	0	0,6	0,42957	0	0,4	0,09272	0	0,1
254	0,08596	1	-0,9	0,04060	0	0,0	0,02488	1	-1,0
255	0,28638	0	0,3	0,22269	0	0,2	0,03875	0	0,0
256	0,58052	2	-1,4	0,43465	2	-1,6	0,08633	0	0,1
257	0,79924	0	0,8	0,79914	0	0,8	0,06632	0	0,1
258	0,41411	0	0,4	0,30253	0	0,3	0,08859	0	0,1
259	0,10324	0	0,1	0,04538	0	0,0	0,04012	0	0,0
260	0,51773	0	0,5	0,26170	0	0,3	0,24557	0	0,2
261	0,17847	0	0,2	0,11663	0	0,1	0,04394	0	0,0
262	0,09720	0	0,1	0,03346	0	0,0	0,08237	0	0,1
263	0,35067	0	0,4	0,18174	0	0,2	0,13368	0	0,1
264	0,10312	0	0,1	0,03360	0	0,0	0,08211	0	0,1

265	0,17607	0	0,2	0,10761	0	0,1	0,07047	0	0,1
266	0,37363	0	0,4	0,31040	0	0,3	0,05533	0	0,1
267	0,38533	1	-0,6	0,20874	1	-0,8	0,13852	0	0,1
268	0,29880	1	-0,7	0,21571	1	-0,8	0,05837	0	0,1
269	0,33175	0	0,3	0,19800	0	0,2	0,13258	0	0,1
270	0,23647	0	0,2	0,13497	0	0,1	0,10691	0	0,1
271	0,71855	0	0,7	0,47405	0	0,5	0,19244	0	0,2
272	0,19268	0	0,2	0,18250	0	0,2	0,02034	0	0,0
273	0,23457	0	0,2	0,14969	0	0,1	0,05255	0	0,1
274	0,04861	0	0,0	0,02001	0	0,0	0,02458	0	0,0
275	0,05643	0	0,1	0,02985	0	0,0	0,01691	0	0,0
276	0,74749	1	-0,3	0,54924	1	-0,5	0,13092	0	0,1
277	0,30033	0	0,3	0,13654	0	0,1	0,25194	0	0,3
278	0,32401	0	0,3	0,17484	0	0,2	0,08767	0	0,1
279	0,42509	0	0,4	0,32137	0	0,3	0,12456	0	0,1
280	0,27843	0	0,3	0,18983	0	0,2	0,10620	0	0,1
281	0,47552	1	-0,5	0,26270	1	-0,7	0,20095	0	0,2
282	0,83488	2	-1,2	0,60707	1	-0,4	0,18077	1	-0,8
283	0,63255	0	0,6	0,41877	0	0,4	0,20084	0	0,2
284	0,42596	1	-0,6	0,27394	1	-0,7	0,16444	0	0,2
285	0,43889	0	0,4	0,21146	0	0,2	0,24181	0	0,2
286	0,12312	0	0,1	0,06405	0	0,1	0,03670	0	0,0
287	0,56273	0	0,6	0,35414	0	0,4	0,22256	0	0,2
288	0,39207	0	0,4	0,34201	0	0,3	0,05826	0	0,1
289	0,53528	0	0,5	0,48768	0	0,5	0,06471	0	0,1
290	1,27656	2	-0,7	1,14074	2	-0,9	0,16773	0	0,2
291	0,97571	1	0,0	0,81881	1	-0,2	0,21905	0	0,2
292	0,39346	0	0,4	0,23549	0	0,2	0,18083	0	0,2
293	0,19995	0	0,2	0,10112	0	0,1	0,15009	0	0,2
294	0,65652	0	0,7	0,33650	0	0,3	0,35215	0	0,4
295	0,44996	0	0,4	0,28082	0	0,3	0,17724	0	0,2
296	0,34026	1	-0,7	0,19638	1	-0,8	0,16128	0	0,2
297	0,10841	0	0,1	0,08118	0	0,1	0,02674	0	0,0
298	0,23889	0	0,2	0,14551	0	0,1	0,09561	0	0,1
299	0,16915	0	0,2	0,09523	0	0,1	0,08252	0	0,1
300	0,14306	0	0,1	0,08371	0	0,1	0,05392	0	0,1
301	0,37870	0	0,4	0,37766	0	0,4	0,03080	0	0,0
302	0,51611	2	-1,5	0,38591	1	-0,6	0,10415	1	-0,9
303	0,49217	2	-1,5	0,38332	2	-1,6	0,12195	0	0,1
304	0,41952	3	-2,6	0,23771	1	-0,8	0,17767	2	-1,8
305	0,56224	1	-0,4	0,29467	1	-0,7	0,28879	0	0,3
306	0,11396	0	0,1	0,05270	0	0,1	0,04435	0	0,0
307	0,63333	1	-0,4	0,47044	1	-0,5	0,13622	0	0,1
308	0,21113	0	0,2	0,13245	0	0,1	0,04167	0	0,0
309	0,21599	0	0,2	0,10951	0	0,1	0,05312	0	0,1
310	0,23186	0	0,2	0,12429	0	0,1	0,05154	0	0,1
311	0,86435	0	0,9	0,64487	0	0,6	0,24401	0	0,2
312	0,22977	0	0,2	0,14012	0	0,1	0,08727	0	0,1
313	0,41993	1	-0,6	0,21791	0	0,2	0,24155	1	-0,8
314	0,50466	0	0,5	0,28927	0	0,3	0,24638	0	0,2
315	0,10163	0	0,1	0,05012	0	0,1	0,03215	0	0,0
316	0,31862	1	-0,7	0,21812	1	-0,8	0,09235	0	0,1
317	0,30303	0	0,3	0,20540	0	0,2	0,07314	0	0,1
318	0,29505	0	0,3	0,20230	0	0,2	0,08639	0	0,1
319	0,38366	1	-0,6	0,26202	1	-0,7	0,08291	0	0,1

320	0,35510	0	0,4	0,19550	0	0,2	0,15831	0	0,2
321	0,50450	0	0,5	0,31856	0	0,3	0,16749	0	0,2
322	0,60274	0	0,6	0,44822	0	0,4	0,17640	0	0,2
323	0,68016	1	-0,3	0,51246	0	0,5	0,15670	1	-0,8
324	0,41876	0	0,4	0,31315	0	0,3	0,10388	0	0,1
325	0,31984	0	0,3	0,29233	0	0,3	0,03573	0	0,0
326	0,73847	2	-1,3	0,45060	0	0,5	0,31432	2	-1,7
327	0,38908	0	0,4	0,28922	0	0,3	0,08918	0	0,1
328	0,39164	0	0,4	0,30924	0	0,3	0,07106	0	0,1
329	0,45556	0	0,5	0,25598	0	0,3	0,22512	0	0,2
330	0,30118	0	0,3	0,25830	0	0,3	0,05601	0	0,1
331	0,04171	0	0,0	0,01856	0	0,0	0,02123	0	0,0
332	0,23546	0	0,2	0,17005	0	0,2	0,05470	0	0,1
333	0,46455	0	0,5	0,31137	0	0,3	0,13667	0	0,1
334	0,39586	0	0,4	0,22489	0	0,2	0,18494	0	0,2
335	0,57927	0	0,6	0,40738	0	0,4	0,09967	0	0,1
336	0,70375	0	0,7	0,49925	0	0,5	0,11814	0	0,1
337	0,35952	1	-0,6	0,21353	0	0,2	0,19681	1	-0,8
338	0,39254	0	0,4	0,22658	0	0,2	0,17893	0	0,2
339	0,25802	0	0,3	0,12868	0	0,1	0,13928	0	0,1
340	0,08484	0	0,1	0,03626	0	0,0	0,04519	0	0,0
341	0,40074	4	-3,6	0,21140	3	-2,8	0,18455	1	-0,8
342	0,86060	0	0,9	0,70832	0	0,7	0,14309	0	0,1
343	1,10989	4	-2,9	1,07005	3	-1,9	0,11817	1	-0,9
344	0,79314	1	-0,2	0,62514	0	0,6	0,10964	1	-0,9
345	0,90569	0	0,9	0,60444	0	0,6	0,23604	0	0,2
346	0,13211	0	0,1	0,07275	0	0,1	0,02592	0	0,0
347	0,69480	2	-1,3	0,33821	0	0,3	0,34552	2	-1,7
348	0,30257	1	-0,7	0,12579	0	0,1	0,26859	1	-0,7
349	0,32415	0	0,3	0,16715	0	0,2	0,16797	0	0,2
350	0,17598	0	0,2	0,13106	0	0,1	0,03969	0	0,0
351	0,12743	0	0,1	0,05047	0	0,1	0,08469	0	0,1
352	0,39628	0	0,4	0,27517	0	0,3	0,07767	0	0,1
353	0,37272	1	-0,6	0,28959	0	0,3	0,06330	1	-0,9
354	0,65191	0	0,7	0,55369	0	0,6	0,09272	0	0,1
355	0,86041	3	-2,1	0,86446	3	-2,1	0,08378	0	0,1
356	0,74420	0	0,7	0,58764	0	0,6	0,12378	0	0,1
357	0,64809	1	-0,4	0,49667	1	-0,5	0,11710	0	0,1
358	0,41912	0	0,4	0,25362	0	0,3	0,13325	0	0,1
359	0,33953	0	0,3	0,14649	0	0,1	0,12057	0	0,1
360	0,32584	0	0,3	0,19998	0	0,2	0,09746	0	0,1
361	0,17628	0	0,2	0,07023	0	0,1	0,17220	0	0,2
362	0,34686	0	0,3	0,25481	0	0,3	0,06592	0	0,1
363	0,18999	0	0,2	0,11675	0	0,1	0,07197	0	0,1
364	0,32687	0	0,3	0,30315	0	0,3	0,04536	0	0,0
365	0,93974	1	-0,1	0,93122	1	-0,1	0,07628	0	0,1
366	0,30979	1	-0,7	0,23393	1	-0,8	0,07106	0	0,1
367	0,33866	1	-0,7	0,15534	0	0,2	0,21335	1	-0,8
368	0,29981	1	-0,7	0,18180	0	0,2	0,08678	1	-0,9
369	0,19394	0	0,2	0,15431	0	0,2	0,04346	0	0,0
370	0,09008	1	-0,9	0,03908	0	0,0	0,04139	1	-1,0
371	0,36487	0	0,4	0,23209	0	0,2	0,12849	0	0,1
372	0,19408	1	-0,8	0,11361	1	-0,9	0,07458	0	0,1
373	0,11093	0	0,1	0,04759	0	0,0	0,06943	0	0,1
374	0,10561	0	0,1	0,04459	0	0,0	0,06787	0	0,1

375	0,42530	0	0,4	0,28159	0	0,3	0,11053	0	0,1
376	0,57627	0	0,6	0,35253	0	0,4	0,19841	0	0,2
377	0,60184	0	0,6	0,34194	0	0,3	0,25604	0	0,3
378	0,17520	0	0,2	0,06708	0	0,1	0,09892	0	0,1
379	0,29300	0	0,3	0,18373	0	0,2	0,09247	0	0,1
380	0,31899	0	0,3	0,19513	0	0,2	0,11073	0	0,1
381	0,10123	0	0,1	0,07130	0	0,1	0,02792	0	0,0
382	0,11175	1	-0,9	0,08549	1	-0,9	0,02488	0	0,0
383	0,05948	0	0,1	0,02747	0	0,0	0,02873	0	0,0
384	0,28038	0	0,3	0,29578	0	0,3	0,02876	0	0,0
385	0,26492	0	0,3	0,27269	0	0,3	0,03503	0	0,0
386	0,09799	0	0,1	0,05751	0	0,1	0,02566	0	0,0
387	0,07142	0	0,1	0,02415	0	0,0	0,05416	0	0,1
388	0,50606	0	0,5	0,29620	0	0,3	0,17424	0	0,2
389	0,49223	0	0,5	0,35588	0	0,4	0,08939	0	0,1
390	0,88408	0	0,9	0,66148	0	0,7	0,12525	0	0,1
391	0,27458	1	-0,7	0,15845	0	0,2	0,09058	1	-0,9
392	0,05714	0	0,1	0,03342	0	0,0	0,02168	0	0,0
393	0,23080	0	0,2	0,23056	0	0,2	0,02338	0	0,0
394	0,30921	3	-2,7	0,23043	2	-1,8	0,08206	1	-0,9
395	1,04251	1	0,0	0,75120	1	-0,2	0,18426	0	0,2
396	0,41313	0	0,4	0,28644	0	0,3	0,06998	0	0,1
397	0,39270	0	0,4	0,39623	0	0,4	0,03817	0	0,0
398	0,72375	1	-0,3	0,57491	1	-0,4	0,12312	0	0,1
399	0,28429	0	0,3	0,28366	0	0,3	0,02932	0	0,0
400	0,45520	0	0,5	0,49197	0	0,5	0,04946	0	0,0
401	0,53692	0	0,5	0,53916	0	0,5	0,06186	0	0,1
402	0,28688	1	-0,7	0,19170	1	-0,8	0,08734	0	0,1
403	1,14005	4	-2,9	0,97691	3	-2,0	0,17384	1	-0,8
404	0,77153	1	-0,2	0,49703	1	-0,5	0,18747	0	0,2
405	0,05224	0	0,1	0,01786	0	0,0	0,05462	0	0,1
406	0,38727	0	0,4	0,28471	0	0,3	0,10573	0	0,1
407	0,31987	0	0,3	0,21994	0	0,2	0,08267	0	0,1
408	0,45599	3	-2,5	0,36581	2	-1,6	0,08522	1	-0,9
409	0,30999	0	0,3	0,22271	0	0,2	0,07999	0	0,1
410	0,25577	0	0,3	0,12605	0	0,1	0,15872	0	0,2
411	0,10828	0	0,1	0,04361	0	0,0	0,07010	0	0,1
412	0,31278	0	0,3	0,21935	0	0,2	0,10584	0	0,1
413	0,26606	0	0,3	0,24651	0	0,2	0,04016	0	0,0
414	0,65655	0	0,7	0,53581	0	0,5	0,11432	0	0,1
415	0,47584	0	0,5	0,33200	0	0,3	0,12996	0	0,1
416	0,53876	0	0,5	0,33897	0	0,3	0,13683	0	0,1
417	0,42756	0	0,4	0,45655	0	0,5	0,04440	0	0,0
418	0,34424	0	0,3	0,41934	0	0,4	0,03167	0	0,0
419	0,21970	1	-0,8	0,30549	1	-0,7	0,00884	0	0,0
420	0,11781	0	0,1	0,07632	0	0,1	0,03899	0	0,0
421	0,44109	1	-0,6	0,29356	0	0,3	0,11209	1	-0,9
422	0,38922	0	0,4	0,34419	0	0,3	0,03611	0	0,0
423	0,14972	0	0,1	0,12707	0	0,1	0,02448	0	0,0
424	0,34340	0	0,3	0,36181	0	0,4	0,03852	0	0,0
425	0,11523	0	0,1	0,06718	0	0,1	0,02850	0	0,0
426	0,17192	0	0,2	0,13106	0	0,1	0,02569	0	0,0
427	0,26315	0	0,3	0,16780	0	0,2	0,05924	0	0,1
428	0,27547	0	0,3	0,16784	0	0,2	0,09130	0	0,1
429	0,03886	0	0,0	0,01972	0	0,0	0,01635	0	0,0

430	0,17658	0	0,2	0,10077	0	0,1	0,06557	0	0,1
431	0,07973	0	0,1	0,06049	0	0,1	0,01887	0	0,0
432	0,53917	0	0,5	0,33088	0	0,3	0,15631	0	0,2
433	0,19922	0	0,2	0,07170	0	0,1	0,15034	0	0,2
434	0,26162	0	0,3	0,16319	0	0,2	0,08274	0	0,1
435	0,40758	0	0,4	0,22634	0	0,2	0,15510	0	0,2
436	0,33787	0	0,3	0,23444	0	0,2	0,09004	0	0,1
437	0,61931	1	-0,4	0,45358	1	-0,5	0,11985	0	0,1
438	0,41717	0	0,4	0,26409	0	0,3	0,14375	0	0,1
439	0,33799	0	0,3	0,15361	0	0,2	0,22245	0	0,2
440	0,19940	0	0,2	0,12136	0	0,1	0,07327	0	0,1
441	0,38324	1	-0,6	0,33474	1	-0,7	0,05944	0	0,1
442	0,50255	1	-0,5	0,51272	1	-0,5	0,04685	0	0,0
443	0,70818	0	0,7	0,70528	0	0,7	0,05759	0	0,1
444	0,43252	0	0,4	0,27088	0	0,3	0,18751	0	0,2
445	0,50032	0	0,5	0,33264	0	0,3	0,18007	0	0,2
446	0,46358	0	0,5	0,23627	0	0,2	0,23180	0	0,2
447	1,22138	0	1,2	0,85751	0	0,9	0,22196	0	0,2
448	1,47029	1	0,5	0,85014	1	-0,1	0,45673	0	0,5
449	0,22833	1	-0,8	0,14711	1	-0,9	0,06734	0	0,1
450	0,11512	0	0,1	0,06629	0	0,1	0,02430	0	0,0
451	0,32914	0	0,3	0,21353	0	0,2	0,11346	0	0,1
452	0,24029	0	0,2	0,24350	0	0,2	0,01990	0	0,0
453	0,44697	0	0,4	0,28336	0	0,3	0,12991	0	0,1
454	0,38801	0	0,4	0,36609	0	0,4	0,03806	0	0,0
455	0,26656	0	0,3	0,19857	0	0,2	0,08336	0	0,1
456	0,10493	0	0,1	0,07960	0	0,1	0,02690	0	0,0
457	0,10734	0	0,1	0,04375	0	0,0	0,06113	0	0,1
458	0,27069	0	0,3	0,17192	0	0,2	0,09892	0	0,1
459	0,26089	0	0,3	0,18623	0	0,2	0,05806	0	0,1
460	0,40393	1	-0,6	0,27022	1	-0,7	0,08579	0	0,1
461	0,91163	1	-0,1	0,62541	1	-0,4	0,17769	0	0,2
462	0,14418	0	0,1	0,10974	0	0,1	0,02916	0	0,0
463	0,28314	0	0,3	0,17516	0	0,2	0,10641	0	0,1
464	0,09096	0	0,1	0,04498	0	0,0	0,03234	0	0,0
465	0,52986	0	0,5	0,27387	0	0,3	0,21214	0	0,2
466	0,73285	0	0,7	0,49688	0	0,5	0,13312	0	0,1
467	0,52109	0	0,5	0,26706	0	0,3	0,28386	0	0,3
468	0,94474	2	-1,1	0,63508	1	-0,4	0,27371	1	-0,7
469	0,33092	0	0,3	0,15932	0	0,2	0,18531	0	0,2
470	0,09103	0	0,1	0,05054	0	0,1	0,03150	0	0,0
471	0,79063	2	-1,2	0,36653	1	-0,6	0,63102	1	-0,4
472	0,35131	0	0,4	0,28538	0	0,3	0,06561	0	0,1
473	0,28295	0	0,3	0,23053	0	0,2	0,05253	0	0,1
474	0,24541	0	0,2	0,17276	0	0,2	0,05877	0	0,1
475	0,58990	0	0,6	0,38539	0	0,4	0,16300	0	0,2
476	0,06169	0	0,1	0,02879	0	0,0	0,03243	0	0,0
477	0,28739	0	0,3	0,19178	0	0,2	0,09176	0	0,1
478	0,26971	0	0,3	0,17080	0	0,2	0,10126	0	0,1
479	0,52236	1	-0,5	0,50694	1	-0,5	0,06055	0	0,1
480	0,35041	0	0,4	0,22275	0	0,2	0,14617	0	0,1
481	0,54693	2	-1,5	0,31123	1	-0,7	0,27782	1	-0,7
482	0,31144	1	-0,7	0,21263	1	-0,8	0,08457	0	0,1
483	0,38765	0	0,4	0,19526	0	0,2	0,18042	0	0,2
484	0,35668	0	0,4	0,26453	0	0,3	0,07393	0	0,1

485	0,47145	0	0,5	0,19700	0	0,2	0,33378	0	0,3
486	0,49528	0	0,5	0,25891	0	0,3	0,23583	0	0,2
487	0,34682	0	0,3	0,20787	0	0,2	0,12747	0	0,1
488	0,48875	0	0,5	0,33987	0	0,3	0,10146	0	0,1
489	0,22296	0	0,2	0,14280	0	0,1	0,05433	0	0,1
490	0,61811	0	0,6	0,35442	0	0,4	0,24721	0	0,2
491	0,36906	1	-0,6	0,24522	1	-0,8	0,11109	0	0,1
492	0,87566	0	0,9	0,74949	0	0,7	0,12568	0	0,1
493	0,28977	1	-0,7	0,16189	0	0,2	0,15065	1	-0,8
494	0,04424	0	0,0	0,01849	0	0,0	0,02827	0	0,0
495	0,40153	0	0,4	0,29232	0	0,3	0,10158	0	0,1
496	0,12077	0	0,1	0,07574	0	0,1	0,03810	0	0,0
497	0,19929	1	-0,8	0,15814	1	-0,8	0,04714	0	0,0
498	0,67161	1	-0,3	0,77294	1	-0,2	0,05272	0	0,1
499	1,35858	3	-1,6	0,94795	3	-2,1	0,27098	0	0,3
500	0,44373	0	0,4	0,33058	0	0,3	0,09640	0	0,1
501	0,55947	0	0,6	0,37251	0	0,4	0,17844	0	0,2
502	0,41827	1	-0,6	0,26414	1	-0,7	0,14504	0	0,1
503	0,26806	0	0,3	0,16962	0	0,2	0,09650	0	0,1
504	0,38930	0	0,4	0,29458	0	0,3	0,08037	0	0,1
505	0,36774	0	0,4	0,23139	0	0,2	0,13104	0	0,1
506	0,34569	0	0,3	0,12925	0	0,1	0,28220	0	0,3
507	0,30298	0	0,3	0,22952	0	0,2	0,05590	0	0,1
508	0,58600	0	0,6	0,36257	0	0,4	0,22411	0	0,2
509	0,67644	0	0,7	0,53698	0	0,5	0,11651	0	0,1
510	1,06238	0	1,1	0,72748	0	0,7	0,24321	0	0,2
511	0,49244	0	0,5	0,39944	0	0,4	0,10643	0	0,1
512	0,73311	0	0,7	0,45408	0	0,5	0,24338	0	0,2
513	0,48005	2	-1,5	0,30607	1	-0,7	0,14473	1	-0,9
514	0,10227	0	0,1	0,03792	0	0,0	0,07942	0	0,1
515	0,43978	0	0,4	0,30992	0	0,3	0,12777	0	0,1
516	0,24396	0	0,2	0,17485	0	0,2	0,07114	0	0,1
517	0,46223	0	0,5	0,28927	0	0,3	0,17885	0	0,2
518	0,20488	0	0,2	0,16604	0	0,2	0,03223	0	0,0
519	0,64063	2	-1,4	0,40226	1	-0,6	0,25839	1	-0,7
520	0,15939	0	0,2	0,05443	0	0,1	0,15215	0	0,2
521	0,30289	0	0,3	0,19320	0	0,2	0,10272	0	0,1
522	0,33713	0	0,3	0,22225	0	0,2	0,10503	0	0,1
523	0,33850	0	0,3	0,19626	0	0,2	0,12878	0	0,1
524	0,36536	1	-0,6	0,20903	1	-0,8	0,15002	0	0,2
525	0,37261	1	-0,6	0,19183	1	-0,8	0,18799	0	0,2
526	0,26070	1	-0,7	0,18097	1	-0,8	0,06619	0	0,1
527	0,26967	0	0,3	0,16910	0	0,2	0,09750	0	0,1
528	0,28806	0	0,3	0,17088	0	0,2	0,11782	0	0,1
529	0,29477	0	0,3	0,18066	0	0,2	0,11493	0	0,1
530	0,22442	1	-0,8	0,15930	1	-0,8	0,05367	0	0,1
531	0,20401	0	0,2	0,10545	0	0,1	0,11569	0	0,1
532	0,25716	1	-0,7	0,16373	0	0,2	0,08290	1	-0,9
533	0,21151	1	-0,8	0,12823	0	0,1	0,06821	1	-0,9
534	0,29119	0	0,3	0,23858	0	0,2	0,05676	0	0,1
535	0,81949	0	0,8	0,57308	0	0,6	0,20590	0	0,2
536	0,21199	0	0,2	0,14719	0	0,1	0,04892	0	0,0
537	0,28099	0	0,3	0,19635	0	0,2	0,07031	0	0,1
538	0,22941	0	0,2	0,11941	0	0,1	0,11770	0	0,1
539	0,43459	3	-2,6	0,30088	2	-1,7	0,12368	1	-0,9

540	0,16759	0	0,2	0,04845	0	0,0	0,26493	0	0,3
541	0,28750	0	0,3	0,18151	0	0,2	0,09467	0	0,1
542	0,89005	3	-2,1	0,57175	1	-0,4	0,14267	0	0,1
543	0,28818	0	0,3	0,16045	0	0,2	0,14444	0	0,1
544	1,19886	2	-0,8	0,96150	2	-1,0	0,12718	0	0,1
545	0,44059	0	0,4	0,24771	0	0,2	0,21331	0	0,2
546	0,60823	0	0,6	0,52255	0	0,5	0,10579	0	0,1
547	0,82098	0	0,8	0,47973	0	0,5	0,24995	0	0,2
548	0,88788	3	-2,1	0,53154	3	-2,5	0,31606	0	0,3
549	0,45048	3	-2,5	0,25708	2	-1,7	0,18799	1	-0,8
550	0,54056	0	0,5	0,31830	0	0,3	0,26803	0	0,3
551	0,49776	1	-0,5	0,34639	1	-0,7	0,14128	0	0,1
552	0,45232	1	-0,5	0,20419	0	0,2	0,30571	1	-0,7
553	0,30348	2	-1,7	0,26974	1	-0,7	0,05020	1	-0,9
554	0,50397	1	-0,5	0,34439	0	0,3	0,12630	1	-0,9
555	0,36522	0	0,4	0,18990	0	0,2	0,12888	0	0,1
556	0,09457	0	0,1	0,09336	0	0,1	0,00891	0	0,0
557	0,07750	0	0,1	0,05262	0	0,1	0,01264	0	0,0
558	0,19100	0	0,2	0,16569	0	0,2	0,02537	0	0,0
559	0,43635	1	-0,6	0,26641	1	-0,7	0,12919	0	0,1
560	0,21430	0	0,2	0,14915	0	0,1	0,05717	0	0,1
561	0,42569	0	0,4	0,26667	0	0,3	0,11524	0	0,1
562	0,11356	0	0,1	0,04997	0	0,0	0,06430	0	0,1
563	0,31464	0	0,3	0,14159	0	0,1	0,19278	0	0,2
564	0,17157	0	0,2	0,08228	0	0,1	0,07494	0	0,1
565	0,10530	0	0,1	0,09429	0	0,1	0,01368	0	0,0
566	0,05333	0	0,1	0,03048	0	0,0	0,01278	0	0,0
567	0,05395	0	0,1	0,02832	0	0,0	0,01338	0	0,0
568	0,17914	0	0,2	0,16590	0	0,2	0,01935	0	0,0
569	0,09243	0	0,1	0,05864	0	0,1	0,01314	0	0,0
570	0,02603	0	0,0	0,01439	0	0,0	0,00682	0	0,0
571	0,07288	0	0,1	0,03180	0	0,0	0,04291	0	0,0
572	2,23834	4	-1,8	1,31496	1	0,3	0,90572	3	-2,1
573	0,10590	0	0,1	0,05474	0	0,1	0,04398	0	0,0
574	0,01483	0	0,0	0,00822	0	0,0	0,00282	0	0,0
575	0,06822	0	0,1	0,06463	0	0,1	0,01029	0	0,0
576	0,02138	0	0,0	0,01622	0	0,0	0,00252	0	0,0
577	0,04528	1	-1,0	0,02381	1	-1,0	0,01213	0	0,0
578	1,37989	1	0,4	0,92050	1	-0,1	0,32122	0	0,3
579	0,04211	1	-1,0	0,02084	1	-1,0	0,01435	0	0,0
580	0,02841	0	0,0	0,01406	0	0,0	0,00900	0	0,0
581	0,01307	0	0,0	0,00641	0	0,0	0,00496	0	0,0
582	0,03356	0	0,0	0,01450	0	0,0	0,01148	0	0,0
583	0,07945	0	0,1	0,06770	0	0,1	0,01442	0	0,0
584	0,04378	0	0,0	0,03975	0	0,0	0,00727	0	0,0
585	0,02711	0	0,0	0,01121	0	0,0	0,01581	0	0,0
586	0,08376	0	0,1	0,06727	0	0,1	0,01858	0	0,0
587	0,03005	0	0,0	0,01420	0	0,0	0,01094	0	0,0
588	0,02226	0	0,0	0,01938	0	0,0	0,00484	0	0,0
589	0,01532	0	0,0	0,00620	0	0,0	0,00875	0	0,0
590	0,06945	0	0,1	0,05642	0	0,1	0,01103	0	0,0
591	0,09860	0	0,1	0,08565	0	0,1	0,01729	0	0,0
592	0,11206	0	0,1	0,05808	0	0,1	0,02893	0	0,0
593	0,41400	0	0,4	0,33518	0	0,3	0,05835	0	0,1
594	0,30188	0	0,3	0,24096	0	0,2	0,04617	0	0,0

595	0,04744	0	0,0	0,02356	0	0,0	0,01650	0	0,0
596	0,12586	0	0,1	0,10945	0	0,1	0,01912	0	0,0
597	0,03179	0	0,0	0,01664	0	0,0	0,00878	0	0,0
598	0,39273	0	0,4	0,38813	0	0,4	0,03154	0	0,0
599	0,20363	1	-0,8	0,06086	0	0,1	0,25713	1	-0,7
600	0,27548	1	-0,7	0,09429	0	0,1	0,25669	1	-0,7
601	0,65201	0	0,7	0,46508	0	0,5	0,17246	0	0,2
602	0,52573	0	0,5	0,35506	0	0,4	0,17382	0	0,2
603	0,12021	0	0,1	0,05065	0	0,1	0,07807	0	0,1
604	0,42983	0	0,4	0,26889	0	0,3	0,16493	0	0,2
605	0,14401	0	0,1	0,07731	0	0,1	0,05520	0	0,1
606	0,08613	1	-0,9	0,04125	1	-1,0	0,03276	0	0,0
607	0,35234	1	-0,6	0,28969	1	-0,7	0,06209	0	0,1
608	0,12219	1	-0,9	0,08461	1	-0,9	0,02784	0	0,0
609	0,25046	1	-0,7	0,14615	0	0,1	0,09631	1	-0,9
610	0,66184	1	-0,3	0,45572	1	-0,5	0,15277	0	0,2
611	0,48280	0	0,5	0,48424	0	0,5	0,03625	0	0,0
612	1,34719	3	-1,7	1,08942	2	-0,9	0,34249	1	-0,7
613	0,12219	0	0,1	0,04233	0	0,0	0,12370	0	0,1
614	0,24255	1	-0,8	0,17465	1	-0,8	0,05794	0	0,1
615	0,02688	0	0,0	0,01751	0	0,0	0,00476	0	0,0
616	1,56563	1	0,6	1,43618	1	0,4	0,19247	0	0,2
617	1,66715	3	-1,3	1,23552	3	-1,8	0,38994	0	0,4
618	0,12950	0	0,1	0,04947	0	0,0	0,11109	0	0,1
619	0,25867	0	0,3	0,19905	0	0,2	0,04463	0	0,0
620	0,17119	0	0,2	0,11128	0	0,1	0,05060	0	0,1
621	0,15278	0	0,2	0,15186	0	0,2	0,01613	0	0,0
622	0,52681	1	-0,5	0,40870	1	-0,6	0,09391	0	0,1
623	0,01732	0	0,0	0,01075	0	0,0	0,00712	0	0,0
624	1,21098	2	-0,8	0,97455	2	-1,0	0,18380	0	0,2
625	0,35941	0	0,4	0,25720	0	0,3	0,08349	0	0,1
626	0,27648	0	0,3	0,16199	0	0,2	0,08649	0	0,1
627	0,44291	4	-3,6	0,35345	4	-3,6	0,06703	0	0,1
628	0,08489	0	0,1	0,02955	0	0,0	0,06323	0	0,1
629	0,45649	2	-1,5	0,31641	1	-0,7	0,09298	1	-0,9
630	0,11280	0	0,1	0,09878	0	0,1	0,02271	0	0,0
631	0,03709	0	0,0	0,02404	0	0,0	0,00746	0	0,0
632	0,73368	3	-2,3	0,43135	2	-1,6	0,26488	1	-0,7
633	0,26044	0	0,3	0,19471	0	0,2	0,07507	0	0,1
634	0,05627	0	0,1	0,03181	0	0,0	0,02125	0	0,0
635	0,06123	0	0,1	0,06370	0	0,1	0,00652	0	0,0
636	0,11483	0	0,1	0,10799	0	0,1	0,01469	0	0,0
637	0,04160	0	0,0	0,03380	0	0,0	0,00912	0	0,0
638	0,08083	1	-0,9	0,06476	0	0,1	0,01196	1	-1,0
639	0,08717	0	0,1	0,08571	0	0,1	0,00904	0	0,0
640	0,73609	3	-2,3	0,60366	2	-1,4	0,17835	1	-0,8
641	0,01090	0	0,0	0,00428	0	0,0	0,00746	0	0,0
642	0,02126	0	0,0	0,01431	0	0,0	0,00683	0	0,0
643	0,01209	0	0,0	0,00565	0	0,0	0,00715	0	0,0
644	0,05654	0	0,1	0,03576	0	0,0	0,01943	0	0,0
645	0,01525	0	0,0	0,00596	0	0,0	0,01229	0	0,0
646	0,00728	0	0,0	0,00350	0	0,0	0,00419	0	0,0
647	0,17527	0	0,2	0,12939	0	0,1	0,03429	0	0,0
648	0,07148	0	0,1	0,05093	0	0,1	0,02302	0	0,0
649	0,47525	3	-2,5	0,26523	2	-1,7	0,13342	1	-0,9

650	1,62042	1	0,6	1,01620	1	0,0	0,63151	0	0,6
651	0,50557	0	0,5	0,33862	0	0,3	0,14501	0	0,1
652	0,60358	0	0,6	0,36299	0	0,4	0,16413	0	0,2
653	0,08900	0	0,1	0,03200	0	0,0	0,06785	0	0,1
654	0,05035	0	0,1	0,01587	0	0,0	0,04916	0	0,0
655	0,03247	1	-1,0	0,00798	0	0,0	0,04171	1	-1,0
656	0,00814	0	0,0	0,00371	0	0,0	0,00454	0	0,0
657	0,40692	0	0,4	0,22305	0	0,2	0,14641	0	0,1
658	0,19959	0	0,2	0,08940	0	0,1	0,08807	0	0,1
659	0,07445	0	0,1	0,03119	0	0,0	0,05039	0	0,1
660	0,12509	0	0,1	0,04556	0	0,0	0,11930	0	0,1
661	0,78618	0	0,8	0,35401	0	0,4	0,43620	0	0,4
662	0,17421	0	0,2	0,09649	0	0,1	0,07180	0	0,1
663	0,91439	1	-0,1	0,70405	1	-0,3	0,21718	0	0,2
664	0,25772	0	0,3	0,12255	0	0,1	0,10658	0	0,1
665	0,71873	0	0,7	0,29795	0	0,3	0,56041	0	0,6
666	0,30794	0	0,3	0,18742	0	0,2	0,11779	0	0,1

X.2. Residual Analysis – Top-10 underpredicted level crossings

For a small number of level crossings, the accident values are underpredicted. An analysis is made for the top-10 level crossings with the largest underpredicting. In Table 27, the top-10 underpredicted crossings can be seen. On the following pages, these crossings will be discussed.

Table 27: Top-10 Underpredicted level crossings

No.	Name	Network	City	Predicted Means – Observed Accidents
341	**DH9-11-DenHaag-Anna_Bijnslaan**	The Hague	The Hague	-3,6
627	**SUNIJ54-Nieuwegein-Koekoekslaan-4**	Utrecht	Nieuwegein	-3,6
167	**DH15-13-DenHaag-Fellowshiplaan**	The Hague	The Hague	-3,4
343	**DH9-13-DenHaag-Televisiestraat**	The Hague	The Hague	-2,9
403	**RTD21-49-Schiedam-Rotterdamsedijk-3**	Rotterdam	Schiedam	-2,9
394	**RTD21-38-Schiedam-Parkweg**	Rotterdam	Schiedam	-2,7
84	**ASD25-9-Amsterdam-Van_Nijenrodeweg-1**	Amsterdam	Amsterdam	-2,6
304	**DH3-8-DenHaag-Weimarstraat**	The Hague	The Hague	-2,6
539	**RTD25-7-Rotterdam-Melanchtonweg-2**	Rotterdam	Rotterdam	-2,6
549	**RTD4-12-Rotterdam-Korfmakerstraat**	Rotterdam	Rotterdam	-2,5

Table 28: Residual Analysis – 341 Den Haag Anna Bijnslaan.

No.	Location	Total Accidents	Predicted Means	Predicted-Observed
341	Den Haag Anna Bijnslaan	4	0,4007	-3,6

Location Photo

Remarks

There is a conflict situation between road traffic and urban rail traffic on this LCS. Urban rail traffic gets permission to drive at the exact moment as road traffic (see the second picture). The tram driver needs to observe the traffic situation and intervene if necessary. This conflict situation is present to improve the intersection's capacity; however, it creates dangerous situations because different flows are located simultaneously at the intersection.

Furthermore, the safety measures at this intersection are limited. Warning lights are only present for pedestrians; road traffic is not warned for urban rail vehicles. Also, the intersection with the tram tracks is not marked. Also noteworthy is the presence of trees along the tram track, which can further restrict visibility. In addition, the spatial design lacks waiting space for traffic. When traffic has to wait for oncoming traffic, the traffic is located on the tram tracks.

Table 29: Residual Analysis – 627 Nieuwegein Koekoekslaan.

No.	Location	Total Accidents	Predicted Means	Predicted-Observed
627	Nieuwegein Koekoekslaan	4	0,4429	-3,6

Location Photo

Remarks

On this LCS, a low number of safety measures are implemented, while visibility is relatively limited. When a tram passes, the traffic light turns red. The rest of the time, the traffic light is green. The traffic light is almost always green since a tram only passes four times an hour (eight in total). Also, a sharp curve is located on the south side of the LCS, limiting the view of the tram track and traffic light.

Table 30: Residual Analysis – 167 The Hague Fellowshiplaan.

No.	Location	Total Accidents	Predicted Means	Predicted-Observed
167	Den Haag Fellowshiplaan	4	0,5891	-3,4

Location Photo

Remarks

This LCS is located very close to a tram stop, and as an effect, a second tram can become invisible when a tram is stopping at the tram stop. Furthermore, the intersection situation on the north side is complex, with three intersections located very close to each other. Also, the spatial design lacks waiting space for traffic. When traffic has to wait for oncoming traffic, the traffic is located on the tram tracks.

Table 31: Residual Analysis – 343 The Hague Televisiestraat.

No.	Location	Total Accidents	Predicted Means	Predicted-Observed
343	Den Haag Televisiestraat	4	1,1099	-2,9

Location Photo

Remarks

The tram track is located in a curve on this LCS, and the average speed is relatively high since there are long stretches of separated tram track on both sides. However, there is no warning installation at this intersection and no markings on the surface. Also, the trees lower the visibility on the level crossing. In addition, the spatial design lacks waiting space for traffic. Therefore, when traffic has to wait for oncoming traffic, the traffic is located on the tram tracks.

Table 32: Residual Analysis – 403 Schiedam Rotterdamsedijk.

No.	Location	Total Accidents	Predicted Means	Predicted-Observed
403	Schiedam Rotterdamsedijk	4	1,1401	-2,9

Location Photo

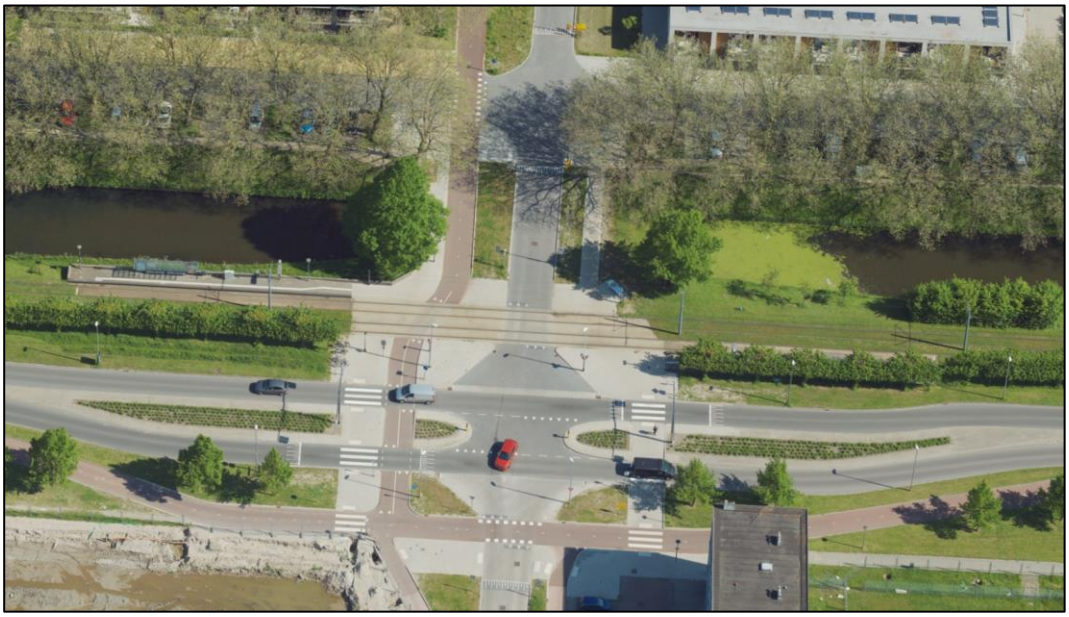
Remarks

This LCS is located at a busy intersection between Rotterdam and Schiedam. The LCS is a roundabout where the tram tracks pass straight through. A warning light is present just before the tracks, but no warning system is present on the adjacent roads to the roundabout. Therefore, the view on the warning lights is relatively limited. Also, there is no manoeuvring space available when a tram passes, which could cause the entire intersection to be blocked.

Table 33: Residual Analysis – 394 Schiedam Parkweg.

No.	Location	Total Accidents	Predicted Means	Predicted-Observed
394	Schiedam Parkweg	3	0,3092	-2,7

Location Photo



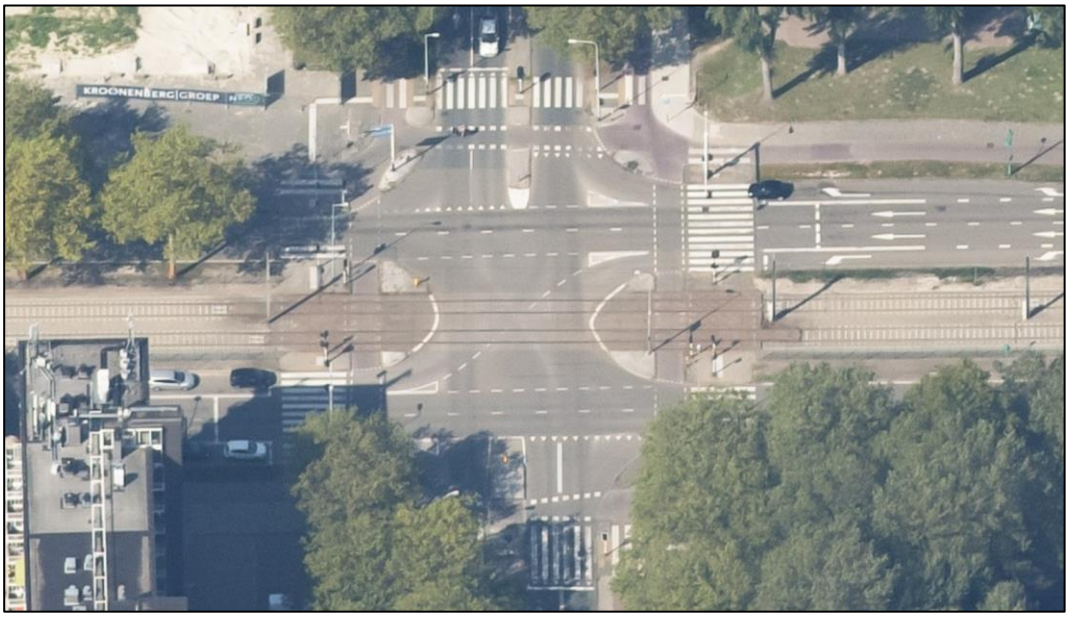
Remarks

A tram stop is located adjacent to the LCS, which could cause a second tram becomes invisible when another tram stops at the stop. In addition, the spatial design lacks waiting space for traffic. When traffic has to wait for oncoming traffic at the intersection, the traffic is located on the tram tracks. Also, the trees and bushes along the tram tracks could block the view on trams.

Table 34: Residual Analysis – 84 Amsterdam Van Nijenrodeweg.

No.	Location	Total Accidents	Predicted Means	Predicted-Observed
84	Amsterdam Van Nijenrodeweg	3	0,4120	-2,6

Location Photo



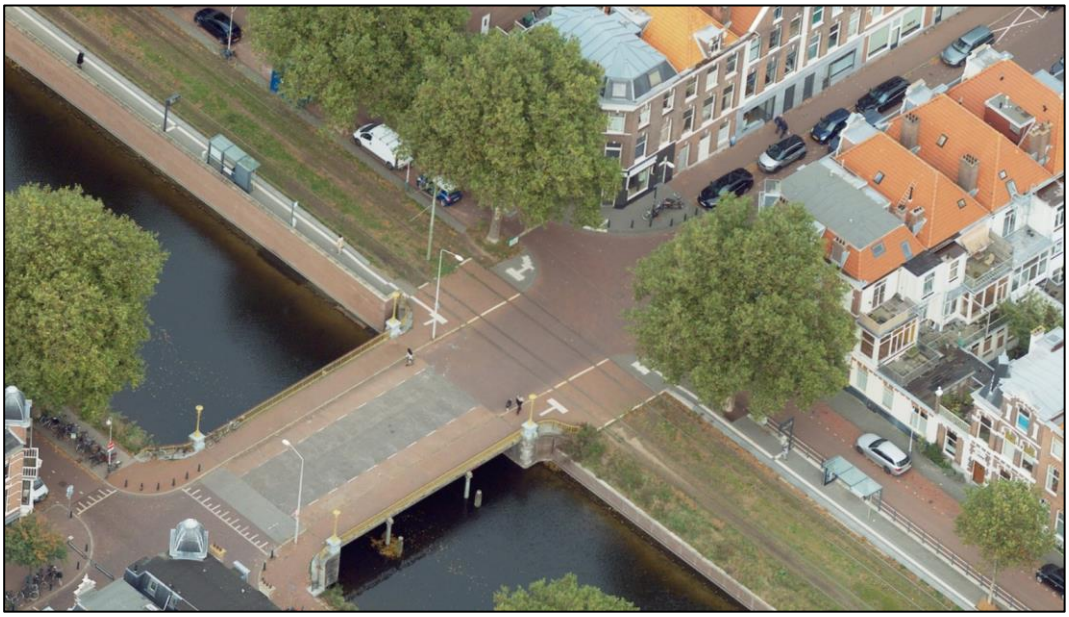
Remarks

This LCS is located at a large intersection in the western part of Amsterdam. The intersection is equipped with a traffic light, but no additional warning lights are present for the tram tracks. Furthermore, there is a conflict situation at the intersection for traffic from the east and west. Road traffic that turns left must give way to straight-through traffic, leading to a blockage of the LCS. Furthermore, the spatial design lacks waiting space for traffic, which causes traffic to stop on the tram tracks.

Table 35: Residual Analysis – 304 The Hague Weimarstraat.

No.	Location	Total Accidents	Predicted Means	Predicted-Observed
304	Den Haag Weimarstraat	3	0,4195	-2,6

Location Photo



Remarks

The safety measures on this LCS are minimal. No warning lights, markings or signs are applied. Also, a stop is located adjacent to the intersection, which could cause a second tram becomes invisible when a tram stops at the stop. In addition, the spatial design lacks waiting space for traffic. When traffic has to wait for oncoming traffic, the traffic is located on the tram tracks. Furthermore, the trees along the tram track could block the view.

Table 36: Residual Analysis – 539 Rotterdam Melanchtonweg.

No.	Location	Total Accidents	Predicted Means	Predicted-Observed
539	Rotterdam Melanchtonweg	3	0,4346	-2,6

Location Photo

Remarks

On this LCS, two warning systems are present. One warning system is for fire trucks since a fire department is close to the LCS. The other warning system is for trams. Two different warning systems could contradict each other since people may expect a fire truck, but it is meant for a tram. Also, at the LCS, the bike path stops abruptly. There is no regulated situation here, so this can be confusing for traffic. In addition, the waiting space for traffic at the intersection is limited, which could cause a blockade of tram tracks by traffic.

Table 37: Residual Analysis – 549 Rotterdam Korfmakerstraat.

No.	Location	Total Accidents	Predicted Means	Predicted-Observed
549	Rotterdam Korfmakersstraat	3	0,4505	-2,5

Location Photo

Remarks

On this LCS, no warning system is located. Furthermore, trees along the tram track block the view on the tram track. In addition, the spatial design lacks waiting space for traffic. When traffic has to wait for oncoming traffic, the traffic is located on the tram tracks. Another confusing situation is the pedestrian crossing. The pedestrian crossing is located on the road but not on the tram tracks, which means car traffic must give way to pedestrians, but trams do not have to, which can create confusing situations for pedestrians as they may expect to have the right of way.

Four additional factors were determined in the top-10 that were not included in the model but may explain why more accidents occurred than the model predicted, as shown in Table 38. These variables are based on a digital field study and the researcher's insight and can be implemented in future research.

Table 38: Additional factors.

Analysis	Description
Adjacent Stop	A tram stop is located adjacent to the level crossing at three of the ten most underpredicted level crossings. As a result, a second tram becomes invisible to traffic because it is behind the other tram. Also, the effect of a stop may be that pedestrians are still rushing to catch the tram, making them less attentive to a second tram.
Trees along the tracks and adjacent roads	At six of the ten most underpredicted level crossings, trees along the tram tracks and adjacent roads were present. From a certain angle, as seen from road traffic, the trees could result in the tram becoming invisible, causing drivers to overlook a tram when turning left onto a level crossing. The model includes a variable for sight restrictions at a level crossing; however, a row of trees along the track was not specified. If traffic runs parallel to the tracks and turns onto a level crossing, the row of trees can make the trams invisible.
Conflict situation at the intersection	At two of the ten most underpredicted level crossings, a conflict situation is present at the intersection. A conflict situation involves the simultaneous conflict of two different traffic flows. For example, this may involve trams driving into the intersection simultaneously as road traffic or road traffic turning off has to wait for oncoming traffic before it can turn.
Spatial design tram crossing	At nine of the ten most underpredicted level crossings, no or limited queuing space for traffic is available between the level crossing and the intersection, which means that traffic must wait on or in front of the tracks. A risk here is that traffic will be on the tram tracks, creating a potentially dangerous situation.

From the literature review and theoretical framework, it followed that built environment and facilities can affect the number and severity of crashes. Within the analysis, no significant relationships were found for the proximity of facilities, except for restaurants. Also, no significant results were found for other variables related to the built environment. Although the variables related to the built environment and facilities in the model are not significant, they can have an effect that is not captured by the used variables in the model. Therefore, additional factors have been explored above which could increase the model's accuracy. Further research is needed to see if the proposed factors are significant.

Appendix XI – Predicted Accidents – Scenario Analysis Utrecht

XI.1. Predicted Damage Only Accidents – 8 years

Table 39: Predicted Accidents (Damage Only) – 8 years.

Rank	No.	Name	City	Observed DO Accidents	Expected Accidents (EBM)	σ Estimate (EBM)
1.	**618**	Richterslaan	Nieuwegein	3	2,14	± 1,06
2.	**613**	Symfonielaan-1	Nieuwegein	2	1,73	± 0,98
3.	**625**	Henri_Dunantlaan	Nieuwegein	2	1,5	± 0,86
4.	**628**	Koekoekslaan-4	Nieuwegein	4	1,24	± 0,55
5.	**617**	Sweelincklaan	Nieuwegein	1	1,14	± 0,79
6.	**641**	Weg_der_Verenigde_Naties	Utrecht	2	1,13	± 0,65
7.	**633**	Overste_den_Oudenlaan	Utrecht	2	0,92	± 0,53
8.	**651**	Beneluxlaan-1	Utrecht	1	0,88	± 0,61
9.	**623**	Zuidstedeweg-1	Nieuwegein	1	0,8	± 0,56
10.	**611**	Europalaan-6	Utrecht	1	0,74	± 0,51
11.	**650**	24_Oktoberplein	Utrecht	2	0,58	± 0,33
12.	**630**	Roerdomplaan	Nieuwegein	1	0,55	± 0,38
13.	**615**	Croeselaan-2	Utrecht	1	0,51	± 0,36
14.	**608**	Hollantlaan-1	Utrecht	1	0,47	± 0,33
15.	**612**	Griffioenlaan	Utrecht	0	0,41	± 0,40
16.	**603**	Europaplein-1	Utrecht	0	0,3	± 0,29
17.	**605**	Australielaan	Utrecht	0	0,29	± 0,28
18.	**602**	Vasco_da_Gamalaan	Utrecht	0	0,27	± 0,26
19.	**626**	Graadt_van_Roggenweg-2	Utrecht	0	0,27	± 0,26
20.	**652**	Admiraal_Helfrichlaan	Utrecht	0	0,25	± 0,24
21.	**609**	Europalaan-4	Utrecht	1	0,22	± 0,15
22.	**620**	Schouwstede	Nieuwegein	0	0,2	± 0,20
23.	**610**	Europalaan-5	Utrecht	0	0,18	± 0,18
24.	**622**	Weverstede	Nieuwegein	0	0,18	± 0,18
25.	**634**	Europalaan-1	IJsselstein	0	0,17	± 0,16
26.	**621**	Graadt_van_Roggenweg-1	Utrecht	0	0,16	± 0,15
27.	**627**	Koekoekslaan-1	Nieuwegein	0	0,16	± 0,15
28.	**648**	Baronieweg	IJsselstein	0	0,14	± 0,13
29.	**606**	Croeselaan-1	Utrecht	0	0,13	± 0,12
30.	**637**	De_Clinckhoef-2	IJsselstein	0	0,12	± 0,12
31.	**631**	Harpij	Nieuwegein	0	0,11	± 0,11
32.	**601**	Beneluxlaan-3	Utrecht	0	0,09	± 0,09
33.	**639**	Zomerdijk	IJsselstein	0	0,09	± 0,09
34.	**607**	Europalaan-3	Utrecht	1	0,08	± 0,06
35.	**619**	Hagestede	Nieuwegein	0	0,08	± 0,08
36.	**640**	Kerspellaan	IJsselstein	0	0,08	± 0,08
37.	**600**	Beneluxlaan-2	Utrecht	0	0,07	± 0,07
38.	**636**	De_Baan	IJsselstein	0	0,06	± 0,05
39.	**649**	Tuinensingel	IJsselstein	0	0,06	± 0,06
40.	**604**	Europaplein-2	Utrecht	0	0,05	± 0,05
41.	**645**	Duizendblad	IJsselstein	0	0,05	± 0,05
42.	**614**	Regaalsingel	Nieuwegein	0	0,04	± 0,04
43.	**632**	Sperwerlaan	Nieuwegein	0	0,04	± 0,04
44.	**638**	Planetenbaan	IJsselstein	0	0,04	± 0,04
45.	**629**	Randijk	Nieuwegein	0	0,03	± 0,03
46.	**635**	Poortdijk	IJsselstein	0	0,03	± 0,03
47.	**616**	Marimbalaan	Nieuwegein	0	0,02	± 0,02
48	**624**	Oudegein	Nieuwegein	0	0,02	± 0,02
49.	**643**	Teenschillerlaan	IJsselstein	0	0,02	± 0,02
50.	**644**	De_Biezen	IJsselstein	0	0,01	± 0,01
51.	**646**	Groene_Dijk	IJsselstein	0	0,01	± 0,01
52.	**642**	Achtersloot	IJsselstein	0	0	± 0,00
53.	**647**	Basiliekpad	IJsselstein	0	0	± 0,00
					18,88	

XI.2. Predicted Injury/Fatality accidents – 8 years

Table 40: Predicted accidents (injury/fatality) – 8 years.

Rank	No.	Name	City	Observed IF Accidents	Expected Accidents (EBM)	σ Estimate (EBM)
1.	**613**	Symfonielaan-1	Nieuwegein	1	0,67	± 0,48
2.	**600**	Beneluxlaan-2	Utrecht	1	0,40	± 0,29
3.	**633**	Overste_den_Oudenlaan	Utrecht	1	0,40	± 0,29
4.	**601**	Beneluxlaan-3	Utrecht	1	0,38	± 0,28
5.	**650**	24_Oktoberplein	Utrecht	1	0,38	± 0,28
6.	**651**	Beneluxlaan-1	Utrecht	0	0,37	± 0,38
7.	**618**	Richterslaan	Nieuwegein	0	0,29	± 0,30
8.	**641**	Weg_der_Verenigde_Naties	Utrecht	1	0,26	± 0,18
9.	**610**	Europalaan-5	Utrecht	1	0,21	± 0,15
10.	**605**	Australielaan	Utrecht	0	0,19	± 0,19
11.	**603**	Europaplein-1	Utrecht	0	0,18	± 0,19
12.	**611**	Europalaan-6	Utrecht	0	0,18	± 0,19
13.	**626**	Graadt_van_Roggenweg-2	Utrecht	0	0,17	± 0,18
14.	**625**	Henri_Dunantlaan	Nieuwegein	0	0,16	± 0,17
15.	**617**	Sweelincklaan	Nieuwegein	0	0,15	± 0,16
16.	**623**	Zuidstedeweg-1	Nieuwegein	0	0,15	± 0,16
17.	**630**	Roerdomplaan	Nieuwegein	1	0,15	± 0,11
18.	**602**	Vasco_da_Gamalaan	Utrecht	0	0,14	± 0,15
19.	**652**	Admiraal_Helfrichlaan	Utrecht	0	0,14	± 0,15
20.	**606**	Croeselaan-1	Utrecht	0	0,12	± 0,12
21.	**619**	Hagestede	Nieuwegein	0	0,11	± 0,12
22.	**628**	Koekoekslaan-4	Nieuwegein	0	0,11	± 0,12
23.	**627**	Koekoekslaan-1	Nieuwegein	0	0,1	± 0,10
24.	**614**	Regaalsingel	Nieuwegein	0	0,08	± 0,08
25.	**629**	Randijk	Nieuwegein	0	0,08	± 0,08
26.	**604**	Europaplein-2	Utrecht	0	0,07	± 0,08
27.	**612**	Griffioenlaan	Utrecht	0	0,07	± 0,07
28.	**615**	Croeselaan-2	Utrecht	0	0,07	± 0,08
29.	**634**	Europalaan-1	IJsselstein	0	0,07	± 0,07
30.	**608**	Hollantlaan-1	Utrecht	0	0,06	± 0,07
31.	**620**	Schouwstede	Nieuwegein	0	0,06	± 0,06
32.	**621**	Graadt_van_Roggenweg-1	Utrecht	0	0,06	± 0,06
33.	**622**	Weverstede	Nieuwegein	0	0,06	± 0,07
34.	**607**	Europalaan-3	Utrecht	0	0,04	± 0,04
35.	**609**	Europalaan-4	Utrecht	0	0,04	± 0,05
36.	**631**	Harpij	Nieuwegein	0	0,02	± 0,03
37.	**632**	Sperwerlaan	Nieuwegein	0	0,02	± 0,02
38.	**635**	Poortdijk	IJsselstein	0	0,02	± 0,02
39.	**639**	Zomerdijk	IJsselstein	1	0,02	± 0,02
40.	**648**	Baronieweg	IJsselstein	0	0,02	± 0,02
41.	**616**	Marimbalaan	Nieuwegein	0	0,01	± 0,01
42.	**624**	Oudegein	Nieuwegein	0	0,01	± 0,01
43.	**636**	De_Baan	IJsselstein	0	0,01	± 0,01
44.	**637**	De_Clinckhoef-2	IJsselstein	0	0,01	± 0,01
45.	**638**	Planetenbaan	IJsselstein	0	0,01	± 0,01
46.	**640**	Kerspellaan	IJsselstein	0	0,01	± 0,01
47.	**644**	De_Biezen	IJsselstein	0	0,01	± 0,01
48	**645**	Duizendblad	IJsselstein	0	0,01	± 0,01
49.	**646**	Groene_Dijk	IJsselstein	0	0,01	± 0,01
50.	**647**	Basiliekpad	IJsselstein	0	0,01	± 0,01
51.	**649**	Tuinensingel	IJsselstein	0	0,01	± 0,01
52.	**642**	Achtersloot	IJsselstein	0	0	± 0,00
53.	**643**	Teenschillerlaan	IJsselstein	0	0	± 0,00
					6,42	

Appendix XII – Cost-Benefit Analysis

XII.1. Costs of Accidents

For the costs of accidents, safety key figures from SWOV[4] are used. These costs include the social costs of traffic accidents, including medical costs, handling costs, material costs, cost of lost production, intangible costs, and travel time losses due to traffic jams. Within these costs, vehicle damage is included; however, this is only for passenger cars, vans and trucks, and motorcycles (SWOV, 2020). This implies that the damage costs to trams are not included in the key figures. An overview of the safety key figures can be seen in Table 41, which are converted to the 2022 price level using CBS[5] inflation numbers.

Table 41: Safety Key Figures (SWOV, 2009) (CBS, 2022).

	Price level 2009	**Inflation (2009-2022)**	**Price level 2022**
Fatality	€ 2.612.000	25,3%	€ 3.273.582
Injury	€ 281.000	25,3%	€ 352.173
Damage Only	€ 3.500	25,3%	€ 4.386

In the first half of 2021, three accidents with derailments occurred in which five trams were damaged, with total damage of five million euros (Province of Utrecht, 2021). Based on the incident log, in the first half of 2021, fourteen collisions have been registered in the Utrecht area (Province of Utrecht, 2021). For other accidents, no damage numbers related to trams were found. Therefore, for the average damage of a tram, the total damage of three derailment accidents is divided by the total accidents, resulting in average damage to a tram of € 357.143,- per accident. In the years before 2021, an older type of tram was used, with a lower risk of derailment compared to the new tram types (de Moor, 2021) (Dekra Rail, 2021). For this reason, it was decided not to include costs of derailments before 2021 because currently, only the new vehicles are being used, which have a higher risk of derailment.

In the accident data, 64 injuries were registered, and ten fatalities. The SPF is a combined injury/fatality function, so it is assumed that 6.4 injuries are recorded for one fatality. In Equation 1, the costs for an injury/fatality accident is determined.

$$Costs\ IF\ Accident = \frac{1{,}0 * Costs\ of\ Fatality\ Accident + 6{,}4 * Costs\ of\ Injury\ Accident}{7{,}4} + Costs\ Damage\ Tram \quad (1)$$

$$Costs\ IF\ Accident = \frac{1{,}0 * € 3.273.582 + 6{,}4 * € 352.173}{7{,}4} + € 357.143 = € 1.104.101,-$$

The costs for a damage only accident is determined in Equation 2.

$$Costs\ DO\ Accidents = Costs\ of\ Damage\ Only\ accident + Costs\ Damage\ Tram \quad (2)$$

$$Costs\ DO\ Accidents = € 4.386 + € 357.143 = € 361.529,-$$

[4] SWOV: Dutch Scientific Road Safety Research Foundation
[5] CBS: Dutch Central Agency for Statistics

XII.2. Costs of Countermeasures

XII.2.1. Scenario 1: Barriers

For the application of boom barriers, two types of barrier installations are applicable. The first type is an AHOB[6] type, the same type applied in conventional railroad lines in the Netherlands. The AHOB is a fail-safe installation, which means that it should always function without failures, resulting in high costs. Another option is a VOS[7] type, which are barriers that operate together with the traffic light system, and this installation is not fail-safe (CROW, 2007). However, this variant has lower costs compared to the AHOB type.

No exact cost price can be provided for the cost of applying barriers, as this varies by intersection and environment. Therefore, it is chosen to calculate an average value. In 2014, the AHOB level crossings were renewed, involving replacement costs of € 12.041.000,-, for nineteen level crossings (BRU, 2014). Converted to the price level of 2022, this is € 722.658,- per AHOB level crossing (CBS, 2022). Some experts were questioned, giving a target amount between € 750.000 and € 1.000.000 for an AHOB crossing (Dinissen et al., 2022). Therefore, the average costs for an AHOB installation are estimated to be € 875.000. Furthermore, the lifetime of an AHOB installation is twelve years, resulting in a total price of € 72.917,- per year (BRU, 2014). For a VOS type, a rough estimation is provided between € 50.000 and € 100.000 when VOS barriers are installed (Dinissen et al., 2022). For this research, a value of € 100.000 is applied.

The total investment costs for applying AHOB boom barriers and VOS boom barriers are determined in Table 42.

Table 42: Calculation Investments Costs Scenario 1.

	Scenario 0 – Do-Nothing	**Scenario 1A – Apply barriers Top-10 IF Locations** **10 barriers**		**Scenario 1B – Apply barriers All locations** **34 barriers**	
Barrier Type	**-**	**AHOB**	**VOS**	**AHOB**	**VOS**
Lifetime	**-**	12 years	12 years	12 years	12 years
Costs per measure	-	€ 875.000	€ 100.000	€ 875.000	€ 100.000
Total investment	-	€ 8.750.000	€ 1.000.000	€ 29.750.000	€ 3.400.000

XII.2.2. Scenario 2: Decrease tram speed

When the speed of a tram is decreased on a level crossing, the travel time increases. Therefore, Value of Time values from Rijkswaterstaat[8] are applied to value the additional travel time (Rijkswaterstaat, 2022). For this purpose, public transport figures for the Value of Time have been used. These figures consist of two reference scenarios for expected growth in welfare: WLO high and WLO low. For this study, an average was taken between the two scenarios. The Value of Time figures consists of three different motives: commuting, business and other. Moreover, an average for the three motives is given, which is used in this study. An overview of the Value of Time figures is provided in Table 43. In Appendix XIV.3, the values are interpolated for the intervening years.

Table 43: Values of Time, per person, including VAT, per hour (Rijkswaterstaat, 2022).

	Type of Passenger	**2020**	**2030**	**2040**	**2050**
WLO Low	Average (commuting/business and other)	€ 9,57	€ 10,22	€ 10,97	€ 11,80
WLO High	Average (commuting/business and other)	€ 9,76	€ 10,69	€ 11,99	€ 11,99
WLO Average	**Average (commuting/business and other)**	**€ 9,67**	**€ 10,46**	**€ 11,48**	**€ 11,90**

[6] AHOB: Automatic Half Barrier *(Dutch: Automatische Halve Overweg Bomen)*.
[7] VOS: Safety Support Barriers *(Dutch: Veiligheidsondersteunende Slagbomen)*.
[8] Rijkswaterstaat: Dutch Directorate-General for Public Works and Water Management.

Numbers from the Province of Utrecht show that passenger numbers over the period 2016 through 2019 on the tram line are about 5.6 million passengers (pax) per year (Province of Utrecht, 2020). The numbers for 2020 and 2021 are lower; due to the Covid-19 crisis and the renovation of the tram line. Therefore, it is assumed that the average number of passengers is the same as from 2016 to 2019. Combined with the average number of travellers per year, the average number of passengers per trip is calculated, which can be found in Appendix XIV.1. Some line segments could have more passengers than the average and other segments could have less passengers. Since passenger numbers for each segment are unknown, it was not possible to conduct a detailed calculation. Data is only available for the total number of passengers on the line, so it is impossible to determine the number of passengers for each line segment.

Decreasing the tram's speed causes additional travel time. For this purpose, the speed from the statistical model was used, and the delay time is considered when a speed of 20 km/h is applied on the level crossing, making use of the average acceleration and deceleration values of trams, which are found to be 1,30 m/s^2 (Ministry of Transport and Waterways, 2004). At locations that already had a speed lower than 20 km/h, the speed was not adjusted in the model. The delay time for both scenarios is determined below based on the calculations that can be found in Appendix XIV.2.

Scenario 2A
When the speed on the top-10 IF accident locations is deceased to 20 km/h, a total delay time of 57,0 seconds is found. The additional costs are determined by multiplying the delay time by the Value of Time from Table 43. Therefore, the delay time results in additional costs of € 0,1531 per passenger, € 9,646 per trip and € 857.407 per year when the Value of Time costs for 2020 are applied.

The Value of Time costs for scenario 2A are determined in Appendix XIV.3 for 2020 – 2050. Starting with the reference year 2023, the total costs for scenario 2A for the observed period of twelve years between 2023 and 2034 are € 11.023.749.

Scenario 2B
When the speed is decreased on all crossings without a barrier, an average delay time of 106,8 seconds is found. For 2020, based on Table 43, this results in additional costs of € 0,287 per passenger, € 18,073 per trip and € 1.606.509 per year.

The Value of Time costs for scenario 2B are determined in Appendix XIV.3 for 2020 – 2050. Starting with the reference year 2023, the total costs for scenario 2B for the observed period of twelve years between 2023 and 2034 are € 20.655.025.

XII.3. Calculation Costs of Accidents

Table 44: Costs of Accidents – Scenario 1.

	Scenario 0 – Do-Nothing		**Scenario 1A – Apply barriers Top-10 IF Locations**		**Scenario 1B – Apply barriers All locations**	
Severity	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*
Expected Accidents 8 years	**18,88**	**6,42**	**11,71**	**3,09**	**2,92**	**0,68**
Expected Accidents 1 year	2,36	0,80	1,46	0,39	0,37	0,09
Costs / Accident[9]	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101
Costs of Accidents / Year	€ 853.208	€ 886.041	€ 529.188	€ 426.459	€ 131.958	€ 93.849

Table 45: Costs of Accidents – Scenario 2.

	Scenario 0 – Do-Nothing		**Scenario 2A – Decrease Speed Top-10 IF Locations**		**Scenario 2B – Decrease Speed All locations**	
Severity	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*
Expected Accidents 8 years	**18,88**	**6,42**	**13,85**	**4,58**	**11,14**	**3,74**
Expected Accidents 1 year	2,36	0,80	1,73	0,57	1,39	0,47
Costs / Accident[9]	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101
Costs of Accidents / Year	€ 853.208	€ 883.281	€ 625.897	€ 632.098	€ 503.429	€ 516.167

[9] See Appendix XII.1.

Appendix XIII – Sensitivity Analysis – Cost-Benefit Analysis

Four sensitivity analyses are executed to explore the explanatory power of the cost-benefit analysis. An overview of the analyses can be found in Table 46.

Table 46: Sensitivity Analysis – Scenario Analysis.

Analysis	Appendix	Description
Lowest estimate	XIII.1	As explained in section 4.3, EBM predicts the number of accidents for every crossing and provides an estimate of this value. This estimate gives a range for the number of accidents to be expected. For the lowest estimate, the estimate is subtracted from the number of expected accidents, so this analysis considers the least predicted number of accidents.
Highest estimate	XIII.2	This sensitivity analysis is equal to the lowest estimate analysis; however, the estimate of EBM is added to the number of expected accidents. This analysis considers the greatest predicted number of accidents.
-50% damage rate Tram	XIII.3	A sensitivity analysis has been drawn up since the average dame rate per tram is not precisely known. In Appendix XII.1, the damage per accident for a tram is set at € 357.143, regardless of the accident's severity. In this analysis, this damage amount is reduced by 50% to examine the effect of this reduction. Therefore, the damage amount is set at € 182.957 per accident for a single tram in an accident.
Value of Time	XIII.4	Value of Time has been considered to quantify the delay time in terms of costs. The average value from Rijkswaterstaat was selected. The initial analysis shows that decreasing the tram's speed results in the highest overall costs. This analysis assesses the effect of the lowest Value of Time instead of the average Value of Time in the initial analysis. Also, an analysis was conducted in which the travel time loss was halved because some line segments could have more passengers than other line segments, so the average travel time for all passengers could be lower since not all passengers travel the entire line. The costs for the additional travel time are determined in Appendix XIV.3.

XIII.1. Lowest Estimate Predicted Accidents

Table 47: Costs of Accidents – Lowest Estimate – Scenario 1.

	Scenario 0 – Do-Nothing		**Scenario 1A – Apply barriers Top-10 IF Locations**		**Scenario 1B – Apply barriers All locations**	
Severity	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*
Expected Accidents 8 years	**6,08**	**0,75**	**3,17**	**0,04**	**0,06**	**0,04**
Expected Accidents 1 year	0,76	0,09	0,40	0,01	0,01	0,01
Costs / Accident[10]	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101
Costs of Accidents / Year	€ 274.762	€ 103.509	€ 143.256	€ 5.521	€ 2.711	€ 5.521

Table 48: Costs of Accidents – Lowest Estimate – Scenario 2.

	Scenario 0 – Do-Nothing		**Scenario 2A – Decrease Speed Top-10 IF Locations**		**Scenario 2B – Decrease Speed All locations**	
Severity	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*
Expected Accidents 8 years	**6,08**	**0,75**	**3,96**	**0,39**	**3,35**	**0,40**
Expected Accidents 1 year	0,76	0,09	0,50	0,05	0,42	0,05
Costs / Accident[10]	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101
Costs of Accidents / Year	€ 274.762	€ 99.369	€ 178.957	€ 53.825	€ 151.390	€ 55.205

Table 49: Scenario 1 with AHOB barriers – Lowest Estimate.

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 1A** **Apply AHOB barriers** **Top-10 IF locations**	**Scenario 1B** **Apply AHOB barriers** **All locations**
Costs IF Accidents / Year	€ 103.509	€ 5.521	€ 5.521
Costs DO Accidents / Year	€ 274.762	€ 143.256	€ 2.711
Costs of Countermeasures	-	€ 8.750.000	€ 29.750.000
Total Costs	**€ 4.539.258**	**€ 10.535.316**	**€ 29.848.784**
Present Value	-	*€ -5.996.058*	*€ -25.309.526*
Net Present Value	-	€ -6.306.081	€ -25.809.408

Table 50: Scenario 1 with VOS barriers – Lowest Estimate.

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 1A** **Apply VOS barriers** **Top-10 IF locations**	**Scenario 1B** **Apply VOS barriers** **All locations**
Costs IF Accidents / Year	€ 103.509	€ 5.521	€ 5.521
Costs DO Accidents / Year	€ 274.762	€ 143.256	€ 2.711
Costs of Countermeasures	-	€ 1.000.000	€ 3.400.000
Total Costs	**€ 4.539.258**	**€ 2.785.316**	**€ 3.498.784**
Present Value	-	*€ 1.753.942*	*€ 1.040.474*
Net Present Value	-	€ 1.443.919	€ 540.592

[10] See Appendix XII.1.

Table 51: Scenario 2 – Lowest Estimate.

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 2A** **Decreasing speed** **Top-10 IF locations**	**Scenario 2B** **Decreasing speed** **All locations**
Costs IF Accidents / Year	€ 103.509	€ 53.825	€ 55.205
Costs DO Accidents / Year	€ 274.762	€ 178.957	€ 151.390
Costs of Countermeasures	-	€ 11.023.749[11]	€ 20.655.025[11]
Total Costs	**€ 4.539.258**	**€ 13.817.131**	**€ 23.134.169**
Present Value	-	*€ -9.277.873*	*€ -18.594.911*
Net Present Value	**-**	€ -8.211.901	€ -16.461.278

[11] See Appendix XIV.3.

XIII.2. Highest Estimate Predicted Accidents

Table 52: Costs of Accidents – Highest Estimate – Scenario 1.

	Scenario 0 – Do-Nothing		**Scenario 1A – Apply barriers Top-10 IF Locations**		**Scenario 1B – Apply barriers All locations**	
Severity	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*
Expected Accidents 8 years	**31,68**	**12,16**	**20,25**	**6,19**	**5,18**	**1,32**
Expected Accidents 1 year	3,96	1,52	2,53	0,77	0,65	0,17
Costs / Accident[12]	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101
Costs of Accidents / Year	€ 1.431.655	€ 1.678.234	€ 915.120	€ 854.298	€ 234.090	€ 182.177

Table 53: Costs of Accidents – Highest Estimate – Scenario 2.

	Scenario 0 – Do-Nothing		**Scenario 2A – Decrease Speed Top-10 IF Locations**		**Scenario 2B – Decrease Speed All locations**	
Severity	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*
Expected Accidents 8 years	**31,68**	**12,16**	**23,74**	**8,83**	**18,93**	**7,13**
Expected Accidents 1 year	3,96	1,52	2,97	1,10	2,37	0,89
Costs / Accident[12]	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101	€ 361.529	€ 1.104.101
Costs of Accidents / Year	€ 1.431.655	€ 1.678.234	€ 1.072.837	€ 1.218.651	€ 855.468	€ 984.030

Table 54: Scenario 1 with AHOB barriers – Highest Estimate.

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 1A** **Apply AHOB barriers** **Top-10 IF locations**	**Scenario 1B** **Apply AHOB barriers** **All locations**
Costs IF Accidents / Year	€ 1.678.234	€ 854.298	€ 182.177
Costs DO Accidents / Year	€ 1.431.655	€ 915.120	€ 234.090
Costs of Countermeasures	-	€ 8.750.000	€ 29.750.000
Total Costs	**€ 37.318.660**	**€ 29.983.021**	**€ 34.745.200**
Present Value	-	*€ 7.335.639*	*€ 2.573.460*
Net Present Value	-	€ 5.524.814	€ -1.065.323

Table 55: Scenario 1 with VOS barriers – Highest Estimate.

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 1A** **Apply VOS barriers** **Top-10 IF locations**	**Scenario 1B** **Apply VOS barriers** **All locations**
Costs IF Accidents / Year	€ 1.678.234	€ 854.298	€ 182.177
Costs DO Accidents / Year	€ 1.431.655	€ 915.120	€ 234.090
Costs of Countermeasures	-	€ 1.000.000	€ 3.400.000
Total Costs	**€ 37.318.660**	**€ 22.233.021**	**€ 8.395.200**
Present Value	-	*€ 15.085.639*	*€ 28.923.460*
Net Present Value	-	€ 13.274.814	€ 25.284.677

[12] See Appendix XII.1.

Table 56: Scenario 2 – Highest Estimate.

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 2A** **Decreasing speed** **Top-10 IF locations**	**Scenario 2B** **Decreasing speed** **All locations**
Costs IF Accidents / Year	€ 1.678.234	€ 53.825	€ 55.205
Costs DO Accidents / Year	€ 1.431.655	€ 178.957	€ 151.390
Costs of Countermeasures	-	€ 11.023.749[13]	€ 20.655.025[13]
Total Costs	**€ 37.318.660**	**€ 38.521.615**	**€ 42.729.001**
Present Value	-	*€ -1.202.955*	*€ -5.410.341*
Net Present Value	**-**	€ -1.046.009	€ -4.760.949

[13] See Appendix XIV.3.

XIII.3. -50% damage rate tram

Within this scenario, the damage to trams is decreased by 50%, which results in average damage of € 178.572 for a tram during an accident instead of € 357.143 in the initial cost-benefit analysis. With a decreased damage rate of a tram, a damage-only accident costs € 182.957, and for an injury/fatality accident, the costs are € 925.529.

Table 57: Costs of Accidents – -50% damage rate tram – Scenario 1.

	Scenario 0 – Do-Nothing		**Scenario 1A – Apply barriers Top-10 IF Locations**		**Scenario 1B – Apply barriers All locations**	
Severity	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*
Expected Accidents 8 years	**18,88**	**6,42**	**11,71**	**3,09**	**2,92**	**0,68**
Expected Accidents 1 year	2,36	0,80	1,46	0,39	0,37	0,09
Costs / Accident	€ 182.957	€ 925.529	€ 182.957	€ 925.529	€ 182.957	€ 925.529
Costs of Accidents / Year	€ 431.779	€ 742.737	€ 267.803	€ 357.486	€ 66.779	€ 78.670

Table 58: Costs of Accidents – -50% damage rate tram – Scenario 2.

	Scenario 0 – Do-Nothing		**Scenario 2A – Decrease Speed Top-10 IF Locations**		**Scenario 2B – Decrease Speed All locations**	
Severity	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*	*Damage Only*	*Injury/Fatality*
Expected Accidents 8 years	**18,88**	**6,42**	**13,85**	**4,58**	**11,14**	**3,74**
Expected Accidents 1 year	2,36	0,80	1,73	0,57	1,39	0,47
Costs / Accident	€ 182.957	€ 925.529	€ 182.957	€ 925.529	€ 182.957	€ 925.529
Costs of Accidents / Year	€ 431.779	€ 742.737	€ 316.744	€ 529.865	€ 254.768	€ 432.685

Table 59: Scenario 1 with AHOB barriers – -50% damage rate tram.

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 1A** **Apply AHOB barriers** **Top-10 IF locations**	**Scenario 1B** **Apply AHOB barriers** **All locations**
Costs IF Accidents / Year	€ 742.737	€ 357.486	€ 78.670
Costs DO Accidents / Year	€ 431.779	€ 267.803	€ 66.779
Costs of Countermeasures	-	€ 8.750.000	€ 29.750.000
Total Costs	**€ 14.094.187**	**€ 16.253.467**	**€ 31.495.391**
Present Value	-	*€ -2.159.280*	*€ -17.401.204*
Net Present Value	-	€ -2.901.224	€ -18.791.359

Table 60: Scenario 1 with VOS barriers – -50% damage rate tram.

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 1A** **Apply VOS barriers** **Top-10 IF locations**	**Scenario 1B** **Apply VOS barriers** **All locations**
Costs IF Accidents / Year	€ 742.737	€ 357.486	€ 78.670
Costs DO Accidents / Year	€ 431.779	€ 267.803	€ 66.779
Costs of Countermeasures	-	€ 1.000.000	€ 3.400.000
Total Costs	**€ 14.094.187**	**€ 8.503.467**	**€ 5.145.391**
Present Value	-	*€ 5.590.720*	*€ 8.948.796*
Net Present Value	-	€ 4.848.776	€ 7.558.641

Table 61: Scenario 2 – -50% damage rate tram.

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 2A** **Decreasing speed** **Top-10 IF locations**	**Scenario 2B** **Decreasing speed** **All locations**
Costs IF Accidents / Year	€ 742.737	€ 529.865	€ 432.685
Costs DO Accidents / Year	€ 431.779	€ 316.744	€ 254.768
Costs of Countermeasures	-	€ 11.023.749[14]	€ 20.655.025[14]
Total Costs	**€ 14.094.187**	**€ 21.183.065**	**€ 28.904.454**
Present Value	-	*€ -7.088.878*	*€ -14.810.267*
Net Present Value	**-**	€ -6.269.331	€ -13.102.688

[14] See Appendix XIV.3.

XIII.4. Value of Time

For scenario 1, the results are equal to the initial analysis since the Value of Time is not considered for scenario 1.

Lowest Value of Time

Table 62: Scenario 2 – Lowest Value of Time

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 2A** **Decreasing speed** **Top-10 IF locations**	**Scenario 2B** **Decreasing speed** **All locations**
No. / Costs IF Accidents / Year	0,80 / € 886.041	0,57 / € 632.098	0,47 / € 516.167
No. / Costs DO Accidents / Year	2,36 / € 853.208	1,73 / € 625.897	1,39 / € 503.429
Costs of Countermeasures	-	€ 10.779.207[15]	€ 20.196.829[15]
Total Costs	**€ 20.837.871**	**€ 25.875.146**	**€ 32.431.986**
Present Value	-	*€ -5.004.152*	*€ -11.560.992*
Net Present Value	**-**	€ -4.423.791	€ -10.227.628

With the lowest Value of Time, the NPV values are negative for both scenarios. The costs are slightly lower than the initial analysis because the lowest Value of Time costs are applied instead of the average costs.

50% reduction of additional travel time

Table 63: Scenario 2 – Reduction of additional travel time

Base year 2023 *Period: 2023-2034 (12 years)* *Discount Rate: 2,25%*	**Scenario 0** **Do-nothing**	**Scenario 2A** **Decreasing speed** **Top-10 IF locations**	**Scenario 2B** **Decreasing speed** **All locations**
No. / Costs IF Accidents / Year	0,80 / € 886.041	0,57 / € 632.098	0,47 / € 516.167
No. / Costs DO Accidents / Year	2,36 / € 853.208	1,73 / € 625.897	1,39 / € 503.429
Costs of Countermeasures	-	€ 5.511.875[16]	€ 10.327.513[16]
Total Costs	**€ 20.837.871**	**€ 20.607.814**	**€ 22.562.669**
Present Value	-	*€ 230.057*	*€ -1.724.798*
Net Present Value	**-**	€ 244.315	€ -1.691.675

With a 50% reduction of additional travel time, Scenario 2A results in a positive NPV. The positive NPV implies lower costs than in the do-nothing scenario. However, for Scenario 2B, the costs are still higher than in the do-nothing scenario.

[15] See Appendix XIV.3.
[16] See Appendix XIV.3.

Appendix XIV – Additional Calculations Scenario Analysis

XIV.1. Calculation of average passengers per trip

Table 64: Trams/day on SUNIJ line (U-OV, 2021)

		Utrecht -> Nieuwegein/IJsselstein	Nieuwegein/IJsselstein -> Utrecht
Monday – Friday, total trips		135	131
Saturday, total trips		122	116
Sunday, total trips		72	71
Average trips	Day	124	120
Total trips	Day	244	
Total trips	Year	89.060	
Total passengers	Year	5.600.000	
Average no. of passengers/trip	Trip	63	

XIV.2. Calculation of additional travel time scenario 2

Table 65: Calculation additional travel time by decreasing tram speed on a crossing.

Adjusted Speed - Delay time calculator

Acceleration Tram	1,3 m/s²	Initial Speed	40 km/h	11,1111 m/s	
Deceleration Tram	1,3 m/s²	Adjusted Speed	20 km/h	5,5556 m/s	
		Difference in Speed	20 km/h	5,5556 m/s	

In front of LCS		Level Crossing		Behind the LCS		Total	
Distance	35,6 m	Distance	50,0 m	Distance	35,6 m	20 km/h	17,5 s
Time	4,3 s	Time	9,0 s	Time	4,3 s		
Initial Speed - Time	3,2 s	Initial Speed - Time	4,5 s	Initial Speed - Distance	3,2 s	40 km/h	10,9 s

Distance (s): $\frac{V_{Start}^2 - V_{End}^2}{2 * a}$ *Difference* **6,6 s**

Time (t): $\frac{2 * s}{V_{Start} + V_{End}}$

The standard length of a level crossing is assumed to be fifty meters.

XIV.3. Interpolation and calculation Value of Time

Table 66: Input Values of Time calculations

Additional Travel Time Scenario 2A	57,0 seconds
Additional Travel Time Scenario 2B	106,8 seconds
Total Passengers/Year	5.600.000 pax

Table 67: Value of Time, per person, incl. VAT, per hour, WLO Average (Rijkswaterstaat, 2022)

Year	Values of Time, pax/hour	Values of Time, pax/hour	Costs Scenario 2A	Costs Scenario 2A	Costs Scenario 2B	Costs Scenario 2B
	Average WLO	*Lowest WLO*	*Average WLO*	*Lowest WLO*	*Average WLO*	*Lowest WLO*
2020	**€ 9,67**	**€ 9,57**	€ 857.407	€ 848.540	€ 1.606.509	€ 1.589.896
2021	€ 9,75	€ 9,64	€ 864.411	€ 854.303	€ 1.619.634	€ 1.600.695
2022	€ 9,83	€ 9,70	€ 871.416	€ 860.067	€ 1.632.758	€ 1.611.493
2023	€ 9,91	€ 9,77	€ 878.421	€ 865.830	€ 1.645.883	€ 1.622.292
2024	€ 9,99	€ 9,83	€ 885.425	€ 871.593	€ 1.659.007	€ 1.633.091
2025	€ 10,07	€ 9,90	€ 892.430	€ 877.357	€ 1.672.132	€ 1.643.889
2026	€ 10,14	€ 9,96	€ 899.435	€ 883.120	€ 1.685.257	€ 1.654.688
2027	€ 10,22	€ 10,03	€ 906.439	€ 888.883	€ 1.698.381	€ 1.665.487
2028	€ 10,30	€ 10,09	€ 913.444	€ 894.647	€ 1.711.506	€ 1.676.285
2029	€ 10,38	€ 10,16	€ 920.449	€ 900.410	€ 1.724.630	€ 1.687.084
2030	**€ 10,46**	**€ 10,22**	€ 927.453	€ 906.173	€ 1.737.755	€ 1.697.883
2031	€ 10,56	€ 10,30	€ 936.497	€ 912.823	€ 1.754.700	€ 1.710.343
2032	€ 10,66	€ 10,37	€ 945.541	€ 919.473	€ 1.771.646	€ 1.722.803
2033	€ 10,77	€ 10,45	€ 954.585	€ 926.123	€ 1.788.591	€ 1.735.263
2034	€ 10,87	€ 10,52	€ 963.629	€ 932.773	€ 1.805.537	€ 1.747.723
2035	€ 10,97	€ 10,60	€ 972.673	€ 939.423	€ 1.822.483	€ 1.760.183
2036	€ 11,07	€ 10,67	€ 981.717	€ 946.073	€ 1.839.428	€ 1.772.643
2037	€ 11,17	€ 10,75	€ 990.761	€ 952.723	€ 1.856.374	€ 1.785.103
2038	€ 11,28	€ 10,82	€ 999.805	€ 959.373	€ 1.873.319	€ 1.797.563
2039	€ 11,38	€ 10,90	€ 1.008.849	€ 966.023	€ 1.890.265	€ 1.810.023
2040	**€ 11,48**	**€ 10,97**	€ 1.017.893	€ 972.673	€ 1.907.211	€ 1.822.483
2041	€ 11,52	€ 11,05	€ 1.021.617	€ 980.033	€ 1.914.188	€ 1.836.272
2042	€ 11,56	€ 11,14	€ 1.025.341	€ 987.392	€ 1.921.166	€ 1.850.061
2043	€ 11,61	€ 11,22	€ 1.029.065	€ 994.751	€ 1.928.143	€ 1.863.850
2044	€ 11,65	€ 11,30	€ 1.032.789	€ 1.002.111	€ 1.935.121	€ 1.877.639
2045	€ 11,69	€ 11,39	€ 1.036.513	€ 1.009.470	€ 1.942.099	€ 1.891.428
2046	€ 11,73	€ 11,47	€ 1.040.237	€ 1.016.829	€ 1.949.076	€ 1.905.217
2047	€ 11,77	€ 11,55	€ 1.043.961	€ 1.024.189	€ 1.956.054	€ 1.919.006
2048	€ 11,82	€ 11,63	€ 1.047.685	€ 1.031.548	€ 1.963.031	€ 1.932.795
2049	€ 11,86	€ 11,72	€ 1.051.409	€ 1.038.907	€ 1.970.009	€ 1.946.584
2050	**€ 11,90**	**€ 11,80**	€ 1.055.133	€ 1.046.267	€ 1.976.987	€ 1.960.373

Table 68: Sum Value of Time.

	Costs Scenario 2A	Costs Scenario 2A	Costs Scenario 2B	Costs Scenario 2B
	Average WLO	*Lowest WLO*	*Average WLO*	*Lowest WLO*
Sum 2023-2034	€ 11.023.749	€ 10.779.205	€ 20.655.025	€ 20.196.829

Table 69: Input Values of Time – 50% of additional travel time.

Additional Travel Time Scenario 2A	28,5 seconds
Additional Travel Time Scenario 2B	53,4 seconds
Total Passengers/Year	5.600.000 pax

Table 70: Sum Value of Time – 50% of additional travel time.

	Costs Scenario 2A	Costs Scenario 2B
	Average WLO	*Average WLO*
Sum 2023-2034	€ 5.511.875	€ 10.327.513

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