A crash hotspot identification and safety ranking methodology

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Together with:

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International Comparative Analyses of Road Traffic Safety Statistics and Safety Modeling

- **Research Team**
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  - Third country partners: University of Central Florida (US), Purdue University (US), Loughborough University (UK), German Aerospace Center (DE)
  - Collaboration with Olympia Odos Motorway

- **Project duration**
  36 months & extension (Oct. 2019- Apr. 2023)

Presentation Focus

WP on Crash Hotspot Analysis

Overview

Objective: Development of a methodology for crash hotspot analysis and **network-wide** ranking for **urban and rural motorways and rural roads**.

Characteristics: Flexible and easy to use due to the need to be suitable for large-scale (i.e., network-wide) implementations

- Presentation of the methodology (data needs, formulas, etc.)
- Sensitivity analysis to assess the impact of the various parameters/ assumptions of the methodology
- Results and discussion

Input data

Crash data

- At least 3 years of crash data
- Crashes with injuries (mild, severe, fatal)

Traffic data

- Traffic volume data (Annual Average Daily Traffic)

Road geometry data

- These data are not used for the analysis per se
- Presence of horizontal curves, number of lanes, presence and type of junctions → Segmentation

Methodology (1/4)

1. Network segmentation

- Max. section lengths have been defined per road type.
- The sections are homogeneous (hor. curve & no. lanes)
- Three approaches exist to deal with junctions:
  - 1st approach: midpoint of the junction as the section limit
  - 2nd and 3rd approaches: boundary of the area of influence of the junction as limit of the section

Methodology (2/4)

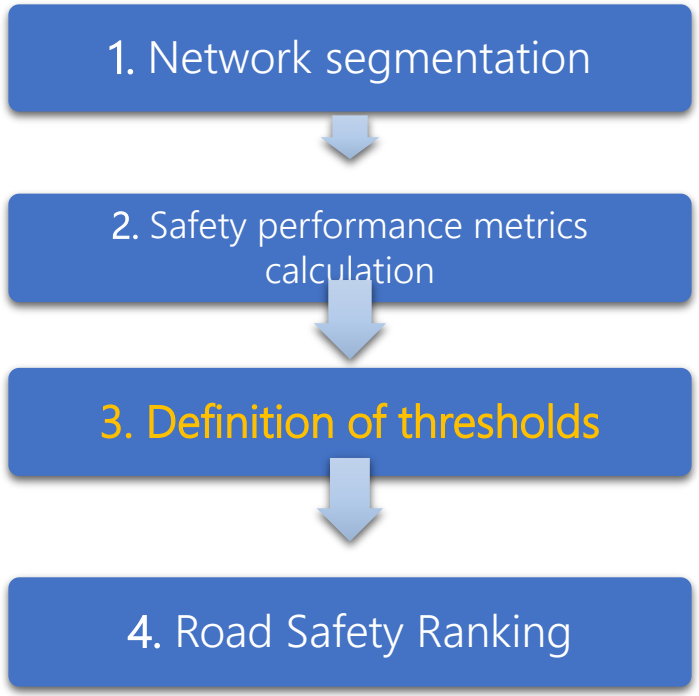
2. Safety performance metric calculation

- crash data should be available for at least 3 years to implement the methodology.
- The number of crashes with fatalities and injuries across all modes are considered.
  - *Future: common definition AIS → crashes with serious injuries (MAIS 3+) and fatalities*
- For each section, the lower and upper number of expected crashes is estimated based on the Poisson method using the number of occurred crashes.
- Crash Rate (if traffic data are available) and Crash Density are estimated per section using the lower and upper number of expected crashes.

Methodology (3/4)

3. Definition of critical thresholds

- The safety performance of a section is compared against the safety performance of the Reference Population to which the section belongs to.
- The Reference Population is the set of roads across a country/region with same characteristics, e.g., all urban motorways.
- Crash Rate (if traffic data are available) and Crash Density are estimated for each Reference Population group.



Methodology (4/4)

4. Road Safety Ranking

- Based on the Crash Rate (or Density) value for the reference population (CRRF) and the lower & upper thresholds for the section's Crash Rate (CR-lower, CR-upper, respectively), a section is classified as:

Class 3: High Risk section

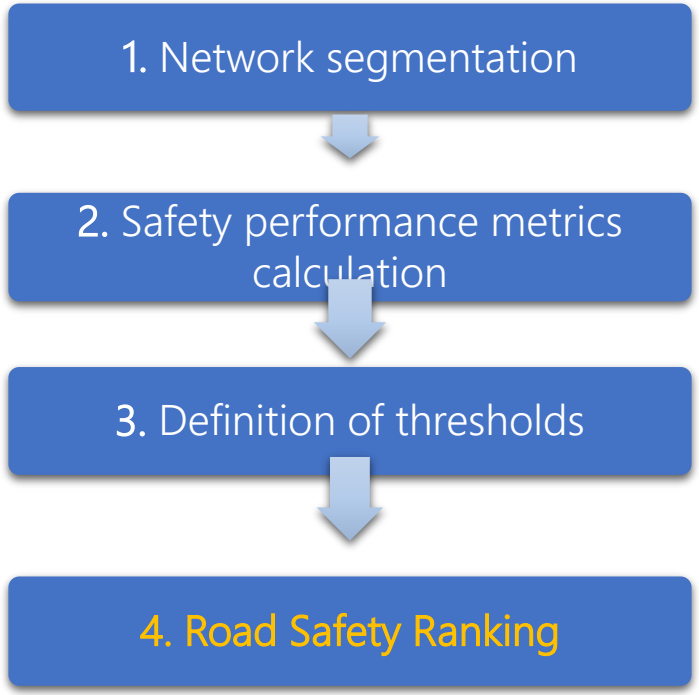
when CRRF < CR-lower < CR-upper

Class 2: Unsure section

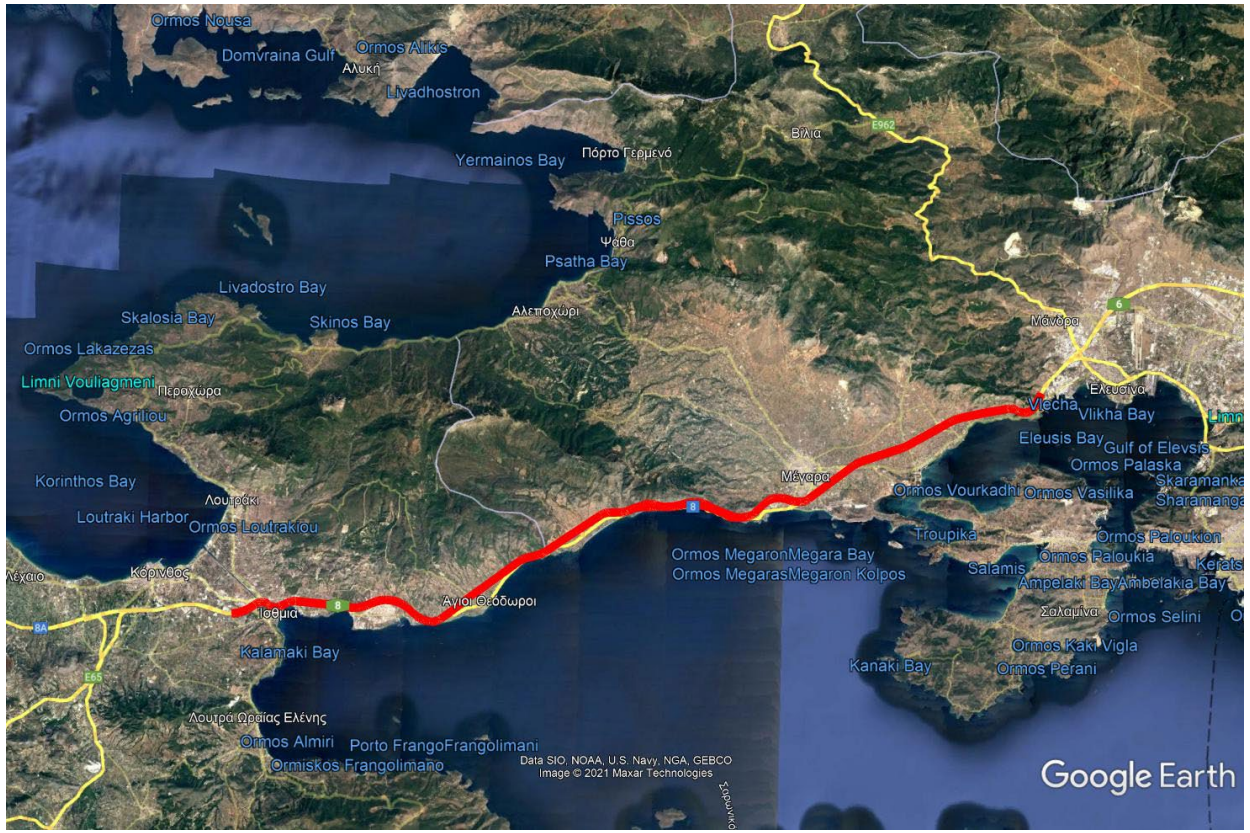
when CR-lower ≤ CRRF ≤ CR-upper

Class 1: Low Risk section

when CRRF > CR-upper > CR-lower



Application



Study site characteristics

- Part of the Olympia Odos motorway (~50km)
- Data for analysis has been provided by the road operator & has been retrieved from Google Earth

Data

- 56 injury crashes
- AADT range: 9.000-11.000 veh/day

Results – Case 1

- Analysis per direction of traffic
- Data for the reference population → Entire Olympia Odos motorway

- Segmentation: The road is divided in sections that are homogenous and start/end at junctions
- Crashes: Injury crashes

						Years	5					Ranking		
						Crash CI		Crash Desnity		Crash Rate		By Acc. Density	By Acc. Rate	Final
Code	Start point	End point	Length (km)	Crashes	AADT	Lower	Upper	**Lower**	**Upper**	**Lower**	**Upper**	Status	Status	Status
1	26950	29950	3	2	11,342	1	8	0.07	0.53	1.61	12.87	Unsure	Unsure	Unsure
2	29950	33550	3.6	1	11,342	1	6	0.06	0.33	1.34	8.05	Unsure	Unsure	Unsure
3	33550	38950	5.4	2	11,078	1	8	0.04	0.3	0.92	7.32	Unsure	Unsure	Unsure
4	38950	41350	2.4	1	10,228	1	6	0.08	0.5	2.23	13.38	Unsure	Unsure	Unsure
5	41350	44750	3.4	5	10,303	2	12	0.12	0.71	3.13	18.76	High Risk	High Risk	High Risk
6	44750	52550	4	0	10,303	0	4	0	0.2	0	5.31	Low Risk	Low Risk	Low Risk
7	52550	55550	3	1	9,816	1	6	0.07	0.4	1.86	11.16	Unsure	Unsure	Unsure
8	55550	59750	4.2	3	9,465	1	9	0.05	0.43	1.38	12.4	Unsure	Unsure	Unsure
9	59750	64950	5.2	1	9,379	1	6	0.04	0.23	1.12	6.74	Unsure	Unsure	Unsure
10	64950	69350	4.4	1	9,033	1	6	0.05	0.27	1.38	8.27	Unsure	Unsure	Unsure
11	69350	73550	3.4	4	9,033	2	11	0.12	0.65	3.57	19.61	High Risk	High Risk	High Risk
12	73550	76150	2.6	0	8,470	0	4	0	0.31	0	9.95	Low Risk	Low Risk	Low Risk
13	76150	77550	1.4	2	8,106	1	8	0.14	1.14	4.83	38.6	High Risk	High Risk	High Risk

						Years	5					Ranking		
						Crash CI		Crash Density		Crash Rate		By Acc. Density	By Acc. Rate	Final
Code	Start point	End point	Length (km)	Crashes	AADT	Lower	Upper	**Lower**	**Upper**	**Lower**	**Upper**	Status	Status	Status
1	77550	76150	1.4	1	8,106	1	6	0.14	0.86	4.83	28.95	High Risk	High Risk	High Risk
2	76150	73550	2.6	0	8,470	0	4	0	0.31	0	9.95	Low Risk	Low Risk	Low Risk
3	73550	66750	5.8	3	9,033	1	9	0.03	0.31	1.05	9.41	Unsure	Unsure	Unsure
4	66750	64950	1.8	0	9,033	0	4	0	0.44	0	13.47	Low Risk	Low Risk	Low Risk
5	64950	59950	5	1	9,379	1	6	0.04	0.24	1.17	7.01	Unsure	Unsure	Unsure
6	59950	57550	2.4	1	9,465	1	6	0.08	0.5	2.41	14.46	Unsure	Unsure	Unsure
7	57550	54550	3	0	9,465	0	4	0	0.27	0	7.71	Low Risk	Low Risk	Low Risk
8	54550	52150	2.4	1	9,816	1	6	0.08	0.5	2.32	13.95	Unsure	Unsure	Unsure
9	52150	48150	4	4	10,303	2	11	0.1	0.55	2.66	14.62	Unsure	Unsure	Unsure
10	47750	41950	5.4	7	10,303	3	15	0.11	0.56	2.95	14.76	Unsure	Unsure	Unsure
11	41950	38150	3.8	7	10,353	3	15	0.16	0.79	4.18	20.88	High Risk	High Risk	High Risk
12	38150	33150	5	1	11,078	1	6	0.04	0.24	0.99	5.93	Unsure	Unsure	Unsure
13	33150	26950	6.2	3	11,342	1	9	0.03	0.29	0.78	7.01	Unsure	Unsure	Unsure

Results – Case 2

- Analysis per direction of traffic
- Data for the reference population → Entire Olympia Odos motorway

- <u>Segmentation:</u> The road is divided in sections that are homogenous and start/end at junctions
- <u>Crashes:</u> Injury **and PDO** crashes

						Years	5					Ranking		
						Crash CI		Crash Density		Crash Rate		By Acc. Density	By Acc. Rate	Final
Code	Start point	End point	Length (km)	Crashes	AADT	Lower	Upper	**Lower**	**Upper**	**Lower**	**Upper**	Status	Status	Status
1	26950	29950	3	32	11,342	22	46	1.47	3.07	35.4	74.03	Unsure	Unsure	Unsure
2	29950	33550	3.6	38	11,342	27	53	1.5	2.94	36.21	71.08	Unsure	Unsure	Unsure
3	33550	38950	5.4	63	11,078	49	81	1.81	3	44.85	74.14	Unsure	Unsure	Unsure
4	38950	41350	2.4	25	10,228	17	37	1.42	3.08	37.92	82.54	Unsure	Unsure	Unsure
5	41350	44750	3.4	26	10,303	17	39	1	2.29	26.57	60.96	Low Risk	Low Risk	Low Risk
6	44750	52550	4	45	10,303	33	61	1.65	3.05	43.85	81.05	Unsure	Unsure	Unsure
7	52550	55550	3	26	9,816	17	39	1.13	2.6	31.61	72.52	Unsure	Unsure	Unsure
8	55550	59750	4.2	43	9,465	32	58	1.52	2.76	44.08	79.89	Unsure	Unsure	Unsure
9	59750	64950	5.2	50	9,379	38	66	1.46	2.54	42.67	74.1	Unsure	Unsure	Unsure
10	64950	69350	4.4	43	9,033	32	58	1.45	2.64	44.09	79.91	Unsure	Unsure	Unsure
11	69350	73550	3.4	77	9,033	61	97	3.59	5.71	108.76	172.94	High Risk	High Risk	High Risk
12	73550	76150	2.6	14	8,470	8	24	0.62	1.85	19.89	59.68	Low Risk	Low Risk	Low Risk
13	76150	77550	1.4	7	8,106	3	15	0.43	2.14	14.48	72.38	Low Risk	Unsure	Unsure

					Crash CI		Crash Density		Crash Rate		By Acc. Density	By Acc. Rate	Final
Start point	End point	Length (km)	Crashes	AADT	Lower	Upper	**Lower**	**Upper**	**Lower**	**Upper**	Status	Status	Status
77550	76150	1.4	18	8,106	11	29	1.57	4.14	53.08	139.93	Unsure	Unsure	Unsure
76150	73550	2.6	23	8,470	15	35	1.15	2.69	37.3	87.03	Unsure	Unsure	Unsure
73550	66750	5.8	91	9,033	74	112	2.55	3.86	77.34	117.06	High Risk	High Risk	High Risk
66750	64950	1.8	17	9,033	10	28	1.11	3.11	33.68	94.3	Unsure	Unsure	Unsure
64950	59950	5	43	9,379	32	58	1.28	2.32	37.37	67.73	Low Risk	Unsure	Unsure
59950	57550	2.4	22	9,465	14	34	1.17	2.83	33.75	81.96	Unsure	Unsure	Unsure
57550	54550	3	23	9,465	15	35	1	2.33	28.93	67.49	Low Risk	Unsure	Unsure
54550	52150	2.4	31	9,816	22	45	1.83	3.75	51.13	104.59	Unsure	Unsure	Unsure
52150	48150	4	47	10,303	35	63	1.75	3.15	46.5	83.71	Unsure	Unsure	Unsure
47750	41950	5.4	85	10,303	68	106	2.52	3.93	66.93	104.32	High Risk	High Risk	High Risk
41950	38150	3.8	62	10,353	48	80	2.53	4.21	66.81	111.35	High Risk	High Risk	High Risk
38150	33150	5	97	11,078	79	119	3.16	4.76	78.1	117.64	High Risk	High Risk	High Risk
33150	26950	6.2	74	11,342	59	93	1.9	3	45.94	72.42	Unsure	Unsure	Unsure

Results – Case 3

- Analysis per direction of traffic
- Data for the reference population → Entire Olympia Odos motorway

- Segmentation: The road is divided in sections that are homogenous and start/end at junctions
- Crashes: Injury crashes
- Different parameters for the Poisson method
  - *Different upper and lower numbers for the expected crashes per section*

alpha = 0,10

						Crash CI		Crash Density		Crash Rate		By Acc. Density	By Acc. Rate	Final
Code	Start point	End point	Length (km)	Crashes	AADT	Lower	Upper	Lower	Upper	Lower	Upper	Status	Status	Status
1	26950	29950	3	2	11,342	1	7	0.07	0.47	1.61	11.26	Unsure	Unsure	Unsure
2	29950	33550	3.6	1	11,342	1	5	0.06	0.28	1.34	6.71	Unsure	Unsure	Unsure
3	33550	38950	5.4	2	11,078	1	7	0.04	0.26	0.92	6.41	Unsure	Unsure	Unsure
4	38950	41350	2.4	1	10,228	1	5	0.08	0.42	2.23	11.15	Unsure	Unsure	Unsure
5	41350	44750	3.4	5	10,303	2	11	0.12	0.65	3.13	17.19	High Risk	High Risk	High Risk
6	44750	52550	4	0	10,303	0	3	0	0.15	0	3.99	Low Risk	Low Risk	Low Risk
7	52550	55550	3	1	9,816	1	5	0.07	0.33	1.86	9.3	Unsure	Unsure	Unsure
8	55550	59750	4.2	3	9,465	1	8	0.05	0.38	1.38	11.02	Unsure	Unsure	Unsure
9	59750	64950	5.2	1	9,379	1	5	0.04	0.19	1.12	5.61	Unsure	Unsure	Unsure
10	64950	69350	4.4	1	9,033	1	5	0.05	0.23	1.38	6.89	Unsure	Unsure	Unsure
11	69350	73550	3.4	4	9,033	2	10	0.12	0.59	3.57	17.83	High Risk	High Risk	High Risk
12	73550	76150	2.6	0	8,470	0	3	0	0.23	0	7.46	Low Risk	Low Risk	Low Risk
			1.4	2	8,106	1	7	0.14	1	4.83	33.78	High Risk	High Risk	High Risk
			1.4	1	8,106	1	5	0.14	0.71	4.83	24.13	High Risk	High Risk	High Risk
2	76150	73550	2.6	0	8,470	0	3	0	0.23	0	7.46	Low Risk	Low Risk	Low Risk
3	73550	66750	5.8	3	9,033	1	8	0.03	0.28	1.05	8.36	Unsure	Unsure	Unsure
4	66750	64950	1.8	0	9,033	0	3	0	0.33	0	10.1	Low Risk	Low Risk	Low Risk
5	64950	59950	5	1	9,379	1	5	0.04	0.2	1.17	5.84	Unsure	Unsure	Unsure
6	59950	57550	2.4	1	9,465	1	5	0.08	0.42	2.41	12.05	Unsure	Unsure	Unsure
7	57550	54550	3	0	9,465	0	3	0	0.2	0	5.79	Low Risk	Low Risk	Low Risk
8	54550	52150	2.4	1	9,816	1	5	0.08	0.42	2.32	11.62	Unsure	Unsure	Unsure
9	52150	48150	4	4	10,303	2	10	0.1	0.5	2.66	13.29	Unsure	Unsure	Unsure
10	47750	41950	5.4	7	10,303	4	14	0.15	0.52	3.94	13.78	High Risk	High Risk	High Risk
11	41950	38150	3.8	7	10,353	4	14	0.21	0.74	5.57	19.49	High Risk	High Risk	High Risk
12	38150	33150	5	1	11,078	1	5	0.04	0.2	0.99	4.94	Unsure	Unsure	Unsure
13	33150	26950	6.2	3	11,342	1	8	0.03	0.26	0.78	6.23	Unsure	Unsure	Unsure

alpha = 0,01

						Crash CI		Crash Density		Crash Rate		By Acc. Density	By Acc. Rate	Final
Code	Start point	End point	Length (km)	Crashes	AADT	Lower	Upper	Lower	Upper	Lower	Upper	Status	Status	Status
1	26950	29950	3	2	11,342	1	10	0.07	0.67	1.61	16.09	Unsure	Unsure	Unsure
2	29950	33550	3.6	1	11,342	1	8	0.06	0.44	1.34	10.73	Unsure	Unsure	Unsure
3	33550	38950	5.4	2	11,078	1	10	0.04	0.37	0.92	9.15	Unsure	Unsure	Unsure
4	38950	41350	2.4	1	10,228	1	8	0.08	0.67	2.23	17.85	Unsure	Unsure	Unsure
5	41350	44750	3.4	5	10,303	2	15	0.12	0.88	3.13	23.45	High Risk	High Risk	High Risk
6	44750	52550	4	0	10,303	0	6	0	0.3	0	7.97	Low Risk	Low Risk	Low Risk
7	52550	55550	3	1	9,816	1	8	0.07	0.53	1.86	14.88	Unsure	Unsure	Unsure
8	55550	59750	4.2	3	9,465	1	11	0.05	0.52	1.38	15.15	Unsure	Unsure	Unsure
9	59750	64950	5.2	1	9,379	1	8	0.04	0.31	1.12	8.98	Unsure	Unsure	Unsure
10	64950	69350	4.4	1	9,033	1	8	0.05	0.36	1.38	11.02	Unsure	Unsure	Unsure
11	69350	73550	3.4	4	9,033	1	13	0.06	0.76	1.78	23.18	Unsure	Unsure	Unsure
12	73550	76150	2.6	0	8,470	0	6	0	0.46	0	14.92	Low Risk	Low Risk	Low Risk
			1.4	2	8,106	1	10	0.14	1.43	4.83	48.25	High Risk	High Risk	High Risk
			1.4	1	8,106	1	8	0.14	1.14	4.83	38.6	High Risk	High Risk	High Risk
2	76150	73550	2.6	0	8,470	0	6	0	0.46	0	14.92	Low Risk	Low Risk	Low Risk
3	73550	66750	5.8	3	9,033	1	11	0.03	0.38	1.05	11.5	Unsure	Unsure	Unsure
4	66750	64950	1.8	0	9,033	0	6	0	0.67	0	20.21	Low Risk	Low Risk	Low Risk
5	64950	59950	5	1	9,379	1	8	0.04	0.32	1.17	9.34	Unsure	Unsure	Unsure
6	59950	57550	2.4	1	9,465	1	8	0.08	0.67	2.41	19.28	Unsure	Unsure	Unsure
7	57550	54550	3	0	9,465	0	6	0	0.4	0	11.57	Low Risk	Low Risk	Low Risk
8	54550	52150	2.4	1	9,816	1	8	0.08	0.67	2.32	18.59	Unsure	Unsure	Unsure
9	52150	48150	4	4	10,303	1	13	0.05	0.65	1.33	17.27	Unsure	Unsure	Unsure
10	47750	41950	5.4	7	10,303	3	18	0.11	0.67	2.95	17.72	Unsure	Unsure	Unsure
11	41950	38150	3.8	7	10,353	3	18	0.16	0.95	4.18	25.05	High Risk	High Risk	High Risk
12	38150	33150	5	1	11,078	1	8	0.04	0.32	0.99	7.91	Unsure	Unsure	Unsure
13	33150	26950	6.2	3	11,342	1	11	0.03	0.35	0.78	8.57	Unsure	Unsure	Unsure

Results – Case 4

- Analysis per direction of traffic
- Data for the reference population → Entire Olympia Odos motorway

- Segmentation: The road is divided in sections that are homogenous only in terms of traffic volume
  - *Simplified segmentation that results in larger and so, fewer sections.*
- Crashes: Injury crashes

						Years	5					Ranking		
						Crash CI		Crash Density		Crash Rate		By Acc. Density	By Acc. Rate	Final
Code	Start	End	Length (km)	Crashes	AADT	Lower	Upper	Lower	Upper	Lower	Upper	Status	Status	Status
1	26950	33550	6.6	3	11,342	1	9	0.03	0.27	0.73	6.58	Unsure	Unsure	Unsure
2	33550	38950	5.4	2	11,078	1	8	0.04	0.3	0.92	7.32	Unsure	Unsure	Unsure
3	38950	41350	2.4	1	10,228	1	6	0.08	0.5	2.23	13.38	Unsure	Unsure	Unsure
4	41350	52550	7.4	5	10,303	2	12	0.05	0.32	1.44	8.62	Unsure	Unsure	Unsure
5	52550	55550	3	1	9,816	1	6	0.07	0.4	1.86	11.16	Unsure	Unsure	Unsure
6	55550	64150	8.6	4	9,465	2	11	0.05	0.26	1.35	7.4	Unsure	Unsure	Unsure
7	64150	75350	10.4	5	9,033	2	12	0.04	0.23	1.17	6.99	Unsure	Unsure	Unsure
8	75350	77550	2.2	2	7,914	1	8	0.09	0.73	3.15	25.16	Unsure	High Risk	High Risk

						Years	5					Ranking		
						Crash CI		Crash Density		Crash Rate		By Acc. Density	By Acc. Rate	Final
Code	Start	End	Length (km)	Crashes	AADT	Lower	Upper	Lower	Upper	Lower	Upper	Status	Status	Status
1	77550	75150	2.4	1	7,914	1	6	0.08	0.50	2.88	17.3	Unsure	Unsure	Unsure
2	75150	64150	10	3	9,033	1	9	0.02	0.18	0.61	5.46	Unsure	Unsure	Unsure
3	64150	55550	8.6	2	9,465	1	8	0.02	0.19	0.67	5.38	Unsure	Unsure	Unsure
4	55550	52150	3.4	1	9,816	1	6	0.06	0.35	1.64	9.84	Unsure	Unsure	Unsure
5	52150	41150	10.2	11	10,303	6	20	0.12	0.39	3.13	10.42	High Risk	Unsure	Unsure
6	41150	38150	3	7	10,228	3	15	0.2	1	5.35	26.77	High Risk	High Risk	High Risk
7	38150	33150	5	1	11,078	1	6	0.04	0.24	0.99	5.93	Unsure	Unsure	Unsure
8	33150	26950	6.2	3	11,342	1	9	0.03	0.29	0.78	7.01	Unsure	Unsure	Unsure

Conclusion

- Flexible and easy to use methodology to the need to be suitable for large-scale (i.e., network-wide) implementations.
- The type of crashes significantly affects the final results. However, in cases where PDO crashes are so high in number, road safety assessment frameworks might also need to focus on reducing PDO crashes too.
- Extensions of the methodology may examine its use in urban settings.

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