Federal Ministry for Digital and Transport

INTERACTION BEHAVIOUR OF CYCLISTS AND E-SCOOTER RIDERS: INVESTIGATING SAFETY CRITICAL EVENTS BASED ON TRAJECTORY DATA

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Motivation

Everyday life impressions

riding

parking

together

interaction

DLR 2021, 2022

- Cyclists and e-scooter riders share the same infrastructure. This can lead encounters and conflicts.

Traffic Observation

14th September – 16th September 2021 (8 a.m. - 4 p.m.) in Berlin, Germany

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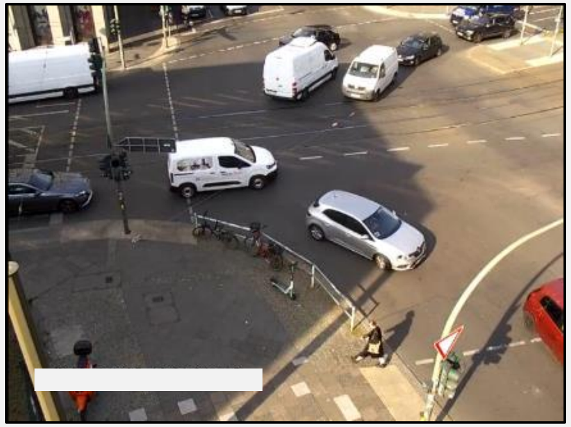
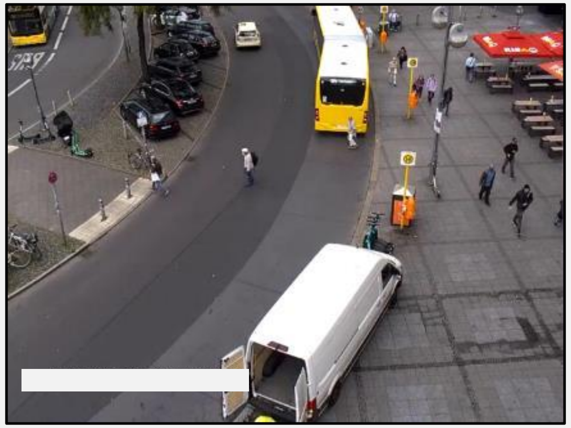
Adalbertstr. (edge)

Torstr./ Friedrichstr. (node)



Hardenbergplatz (square)



- There were no bicycle paths at measurement locations. Cyclists and e-scooter riders should use the roadway.

Data processing

Classification and data analysis

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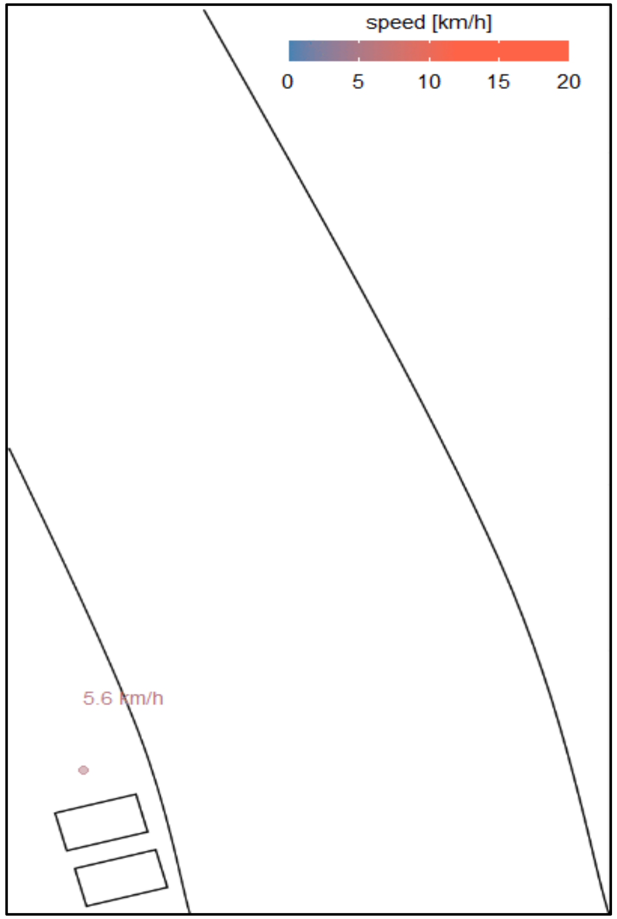
- Traffic camera calibration
- Traffic detection
  - Manual image search for e-scooters
  - Deep Learning based object detection
- ➢ E-scooter riders and parked e-scooter as a new class

Videos with bounding boxes
- Verification data analysis
- Video annotation

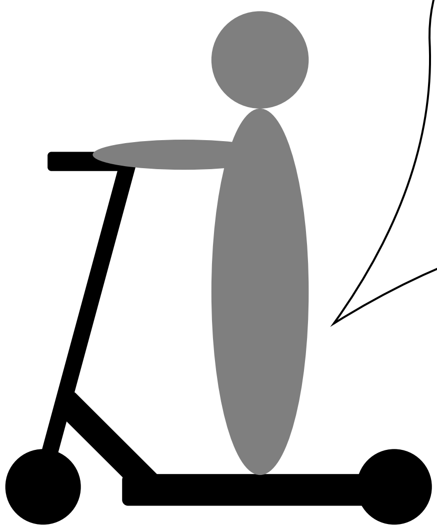
Trajectory analysis
- Normal / interaction behaviour
- Use of infrastructure

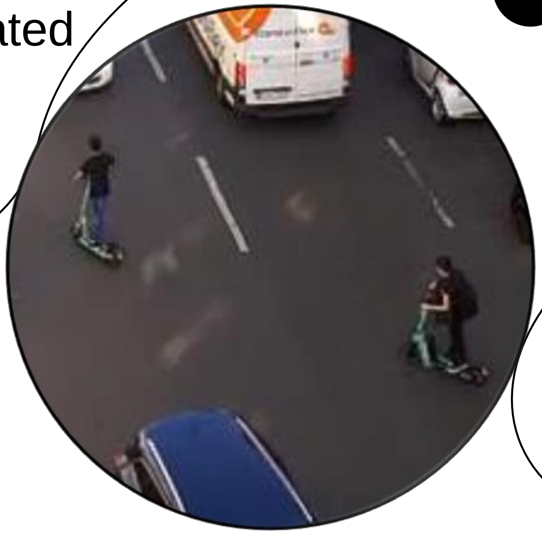


Results: video annotation
Who are e-scooter riders (in Berlin)?

5 times more **male** (n = 471) than female (n = 88)

86% were estimated **younger** than 35 years old (n = 446)





6% rode for a **delivery** service (n = 616)

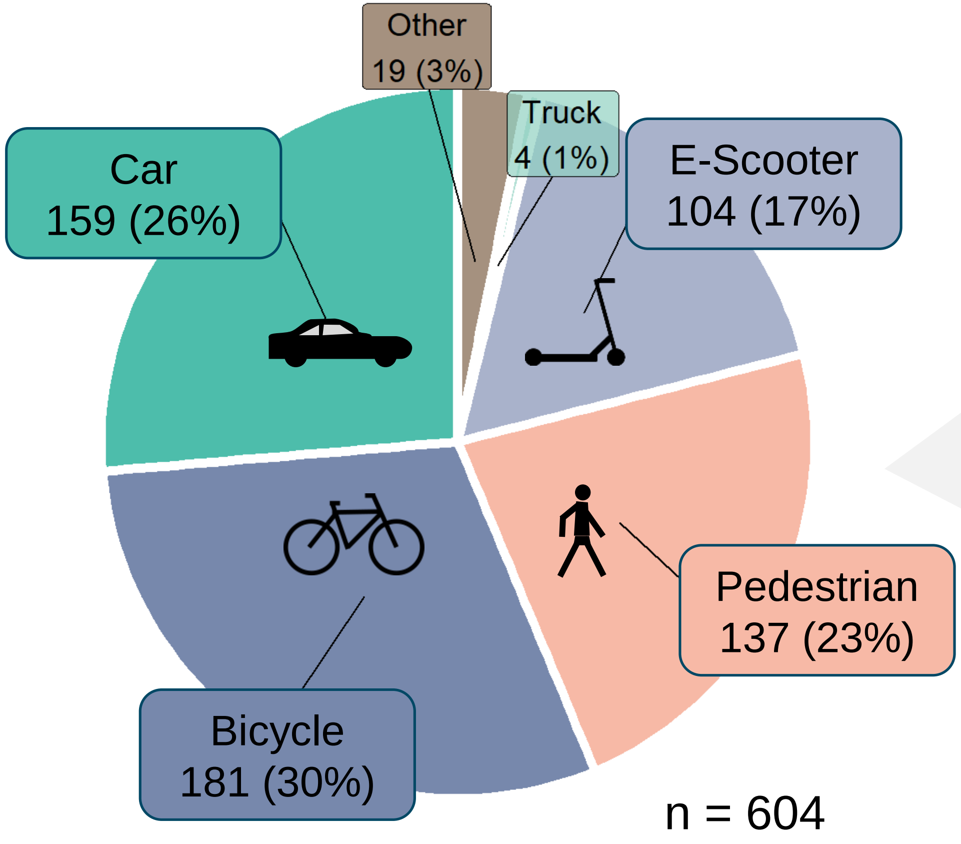
1% wore a **helmet** (n = 746)

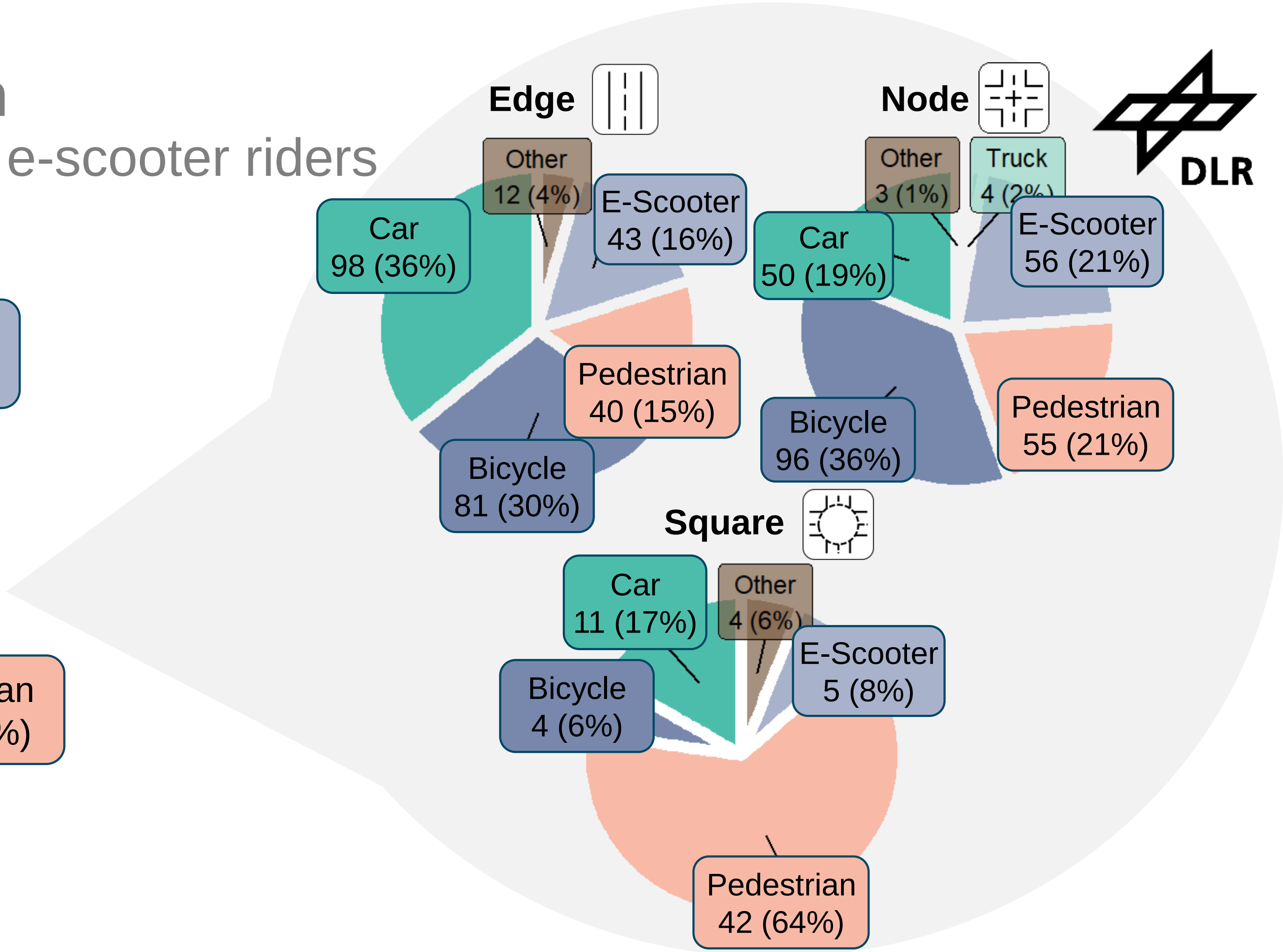
99% use a **rental** e-scooter (n = 587)

8% rode in **pairs** on an e-scooter (n = 746)

Results: video annotation

Frequent interaction partners of e-scooter riders

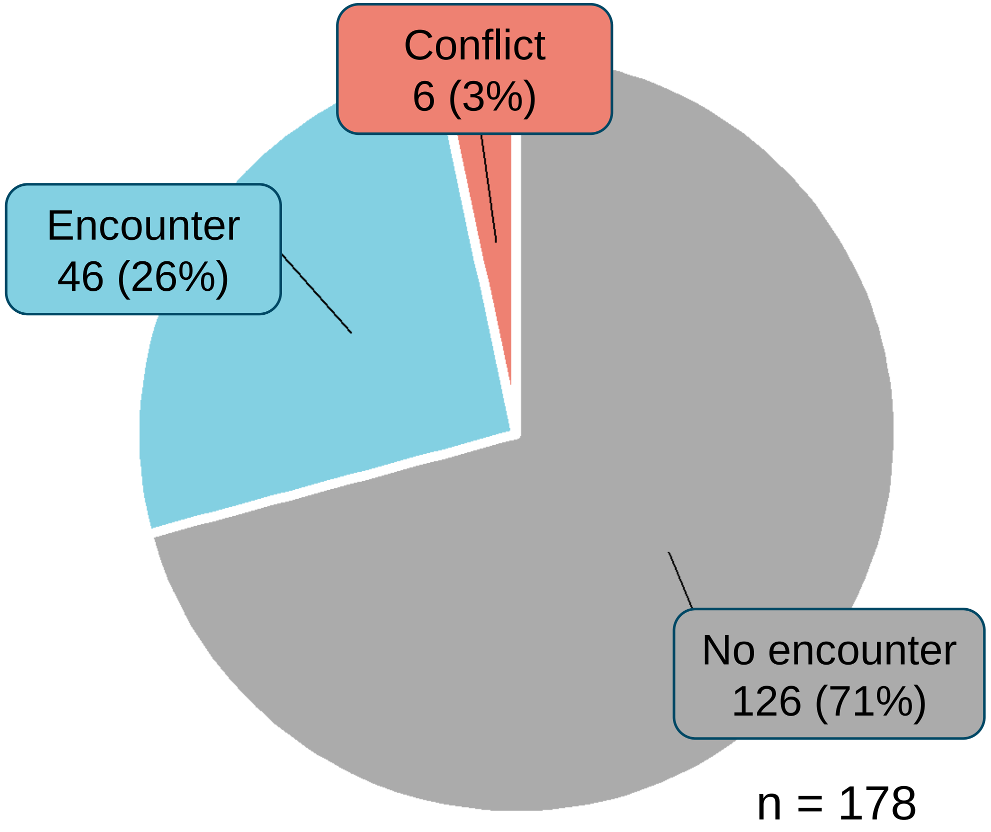


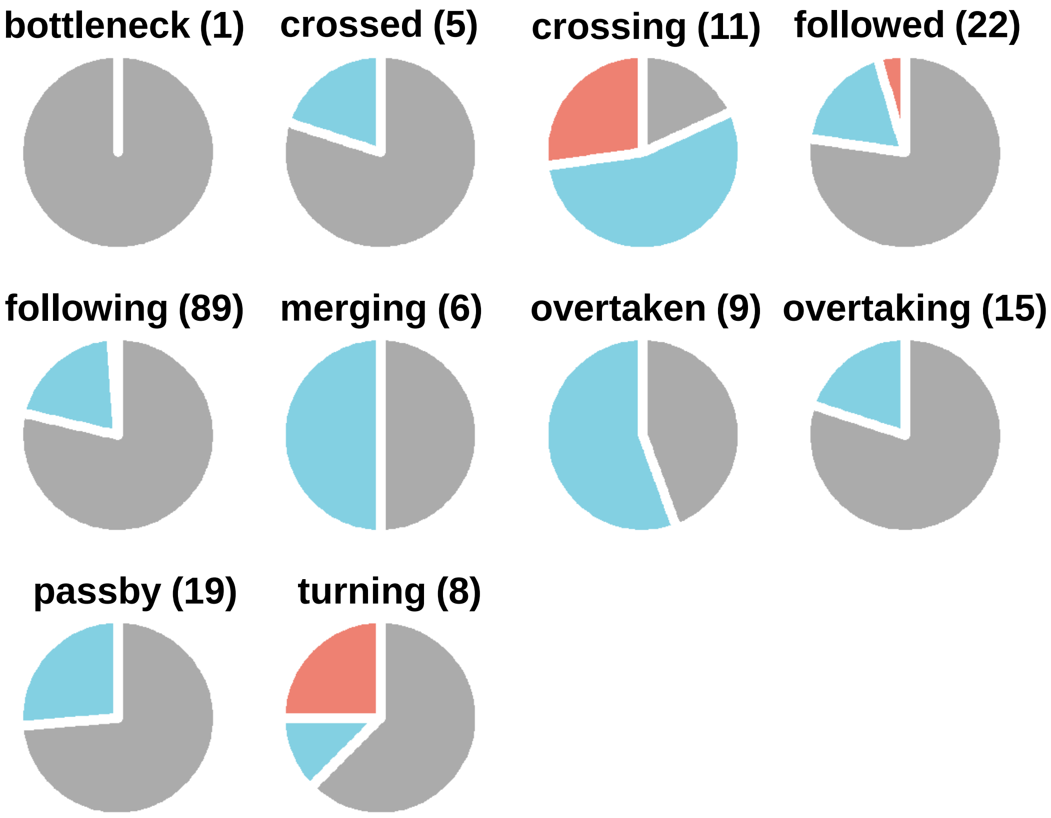


- About 2.400 e-scooter riders, 17.000 cyclists and 604 interactions of e-scooter riders with other road users were identified in the trajectory data and with video annotation.
- On average, cyclists are the most common conflict partners (30%) of e-scooter riders.

Results: video annotation

Different interaction scenarios of e-scooter riders with cyclists

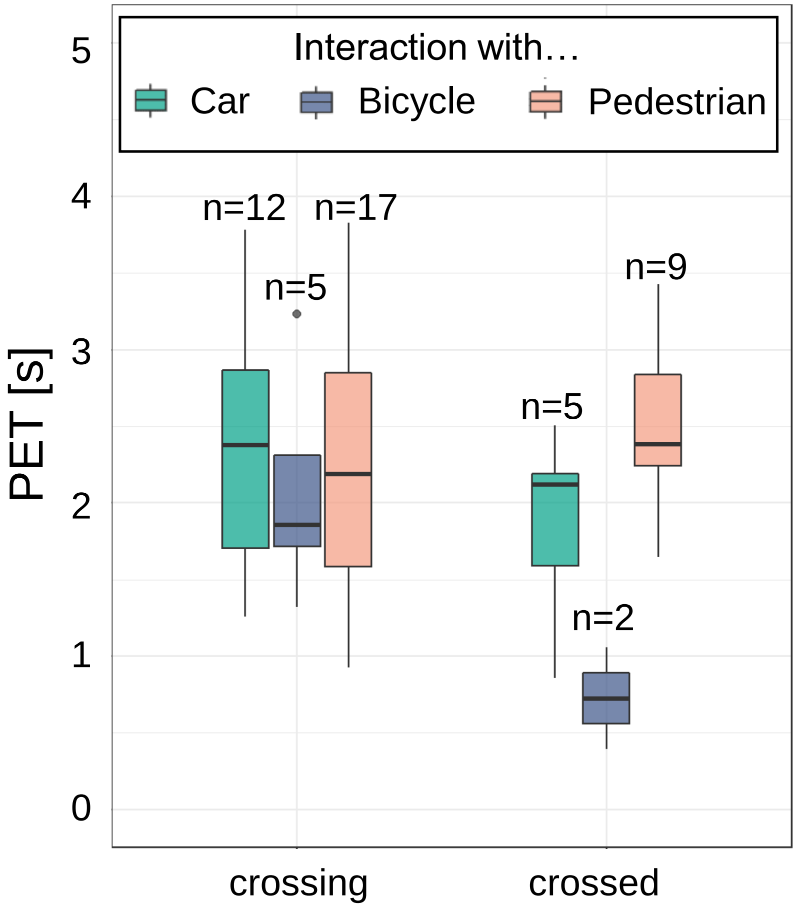




- In 26% of the cases, an encounter occurred where the speed was adjusted in time.
- In 3% of the cases, a conflict occurred. An accident was avoided by late swerving or braking.
- Encounters and conflicts occurred most frequently during crossing.

Results: trajectory analysis

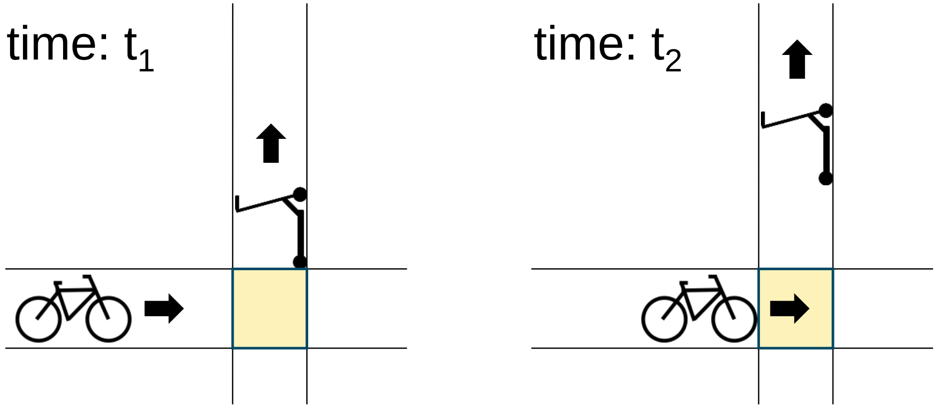
Crossing situation with e-scooter riders



e-scooter rider **crossing** cyclist

e-scooter rider **crossed** by cyclist

Post Encroachment Time (PET [s]) = $t_2 - t_1$



...rider leaving area of encroachment

…conflicting rider entering area of encroachment

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- PET (crossing) showed no difference between interaction partners.
- PET (crossed) was clearly lower when a cyclists crossed in front of an e-scooter rider.

Results: trajectory analysis

Example for critical crossing interaction of e-scooter rider and cyclist

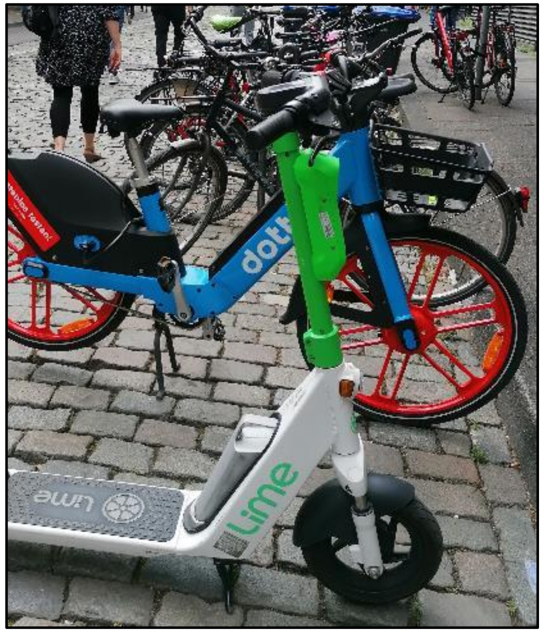
	initial speed	Max. deceleration
Cyclist	2.74 m/s	-5.51 m/s²
E-scooter	2.04 m/s	-3.88 m/s²

$pPET_{min}$ = 0.12 s PET* = 0.75 s

Conclusion and outlook

- On average, cyclists are the most common conflict partners (30%) of e-scooter riders.
- Encounters and conflicts occurred most frequently during crossing
- Results show a slight tendency towards riskier behaviour of e scooter riders

- Expansion of the cycling infrastructure for safe and shared use
- Further analyses of the traffic effects of e-scooter riders, bicycles and other new modes of transport that share this same infrastructure



difu 2022

Further MMoNK publications on this topic

- Leschik, C., Zhang, M., & Hardinghaust, M. (2022). *Analysis and comparison of the driving behaviour of e-scooter riders and cyclists using video and trajectory data in Berlin, Germany*, Contributions to the 10th International Cycling Safety Conference 2022 (ICSC2022), publisher: Prof. Dr. Tibor Petzoldt, Prof. Dr. Regine Gerike, Juliane Anke, Dr. Madlen Ringhand, Bettina Schröter, Technische Universität Dresden, 54-56
- Bauer, U., Hertel, M., Klein-Hitpaß, A., Reichow, V., Hardinghaus, M., Leschik, C., Cyganski, R. & Oostendorp, R. (2022). *E-Tretroller in Städten- Nutzung, Konflikte und kommunale Handlungsmöglichkeiten*. 978-3-88118-690-2
- Hardinghaus, M., Oostendorp, R., Zhang, M., & Leschik, C. (2022). *E-Scooters appear on bike infrastructure: users and usage, conflicts and coexistence with cycling*. https://elib.dlr.de/190718/2/ICSC%20Poster.pdf
- Oostendorp, R., & Reichow, V. (2022). *E-Tretroller im Stadtverkehr. Nutzung, Konflikte und Empfehlungen für Kommunen*. Planerin (2022) Nr. 5, S. 49-50, 1 B, 3 Q

Thank you for your attention

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Thanks to the project partners of Difu (“German Institute of Urban Affairs”).

Influence of parked PLEV on public transport
Further results from the trajectory analysis

No PLEV in the bus stop area

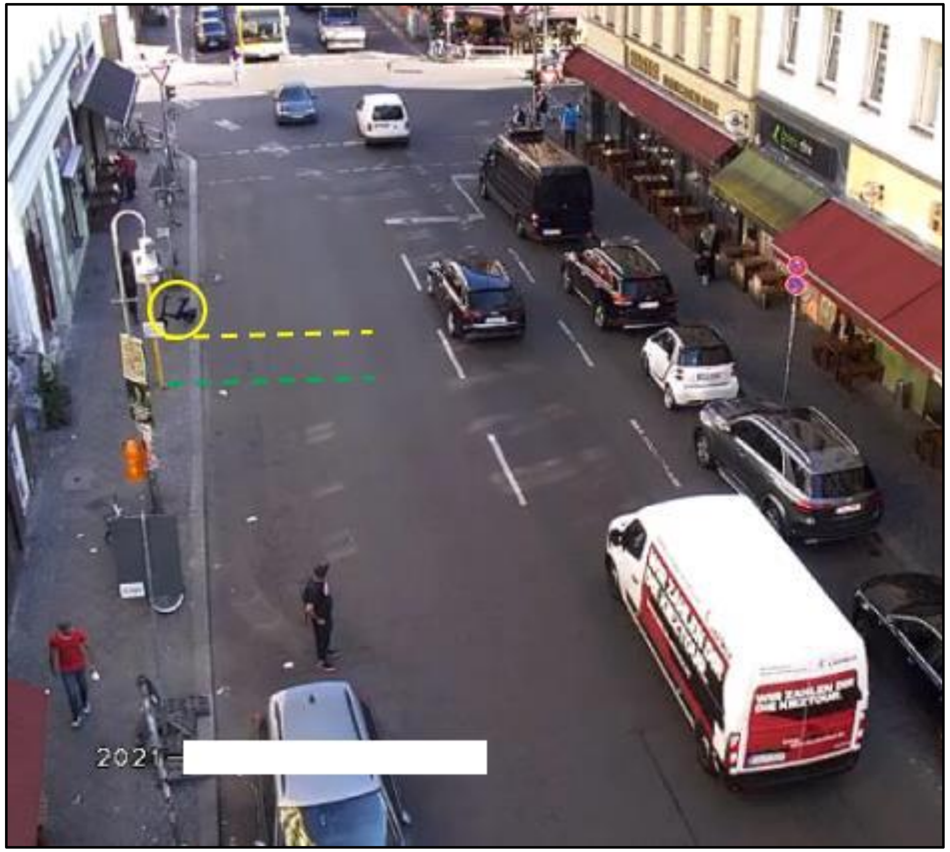
- 87.5% of the buses stop at the bus stop sign if there is no PLEV in the bus stop area (n = 8).

PLEV in the bus stop area

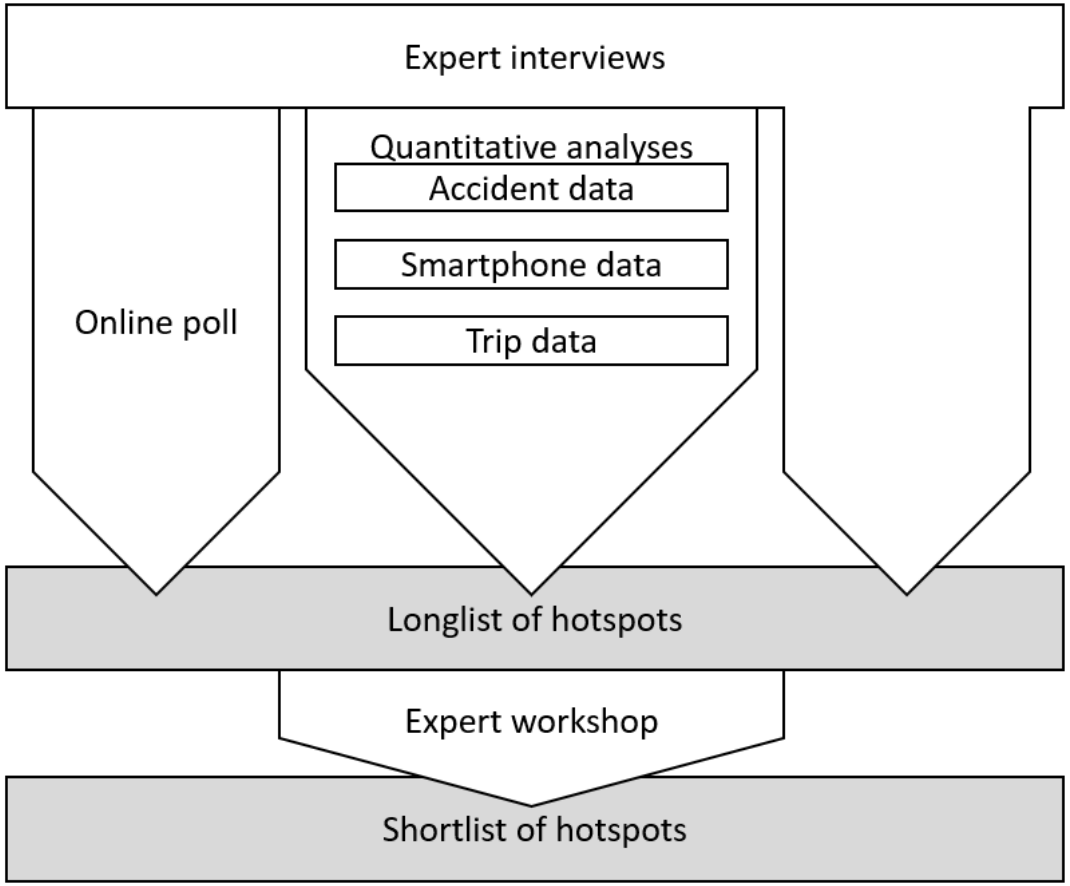
- 50% of the buses stop behind the PLEV (n = 8).

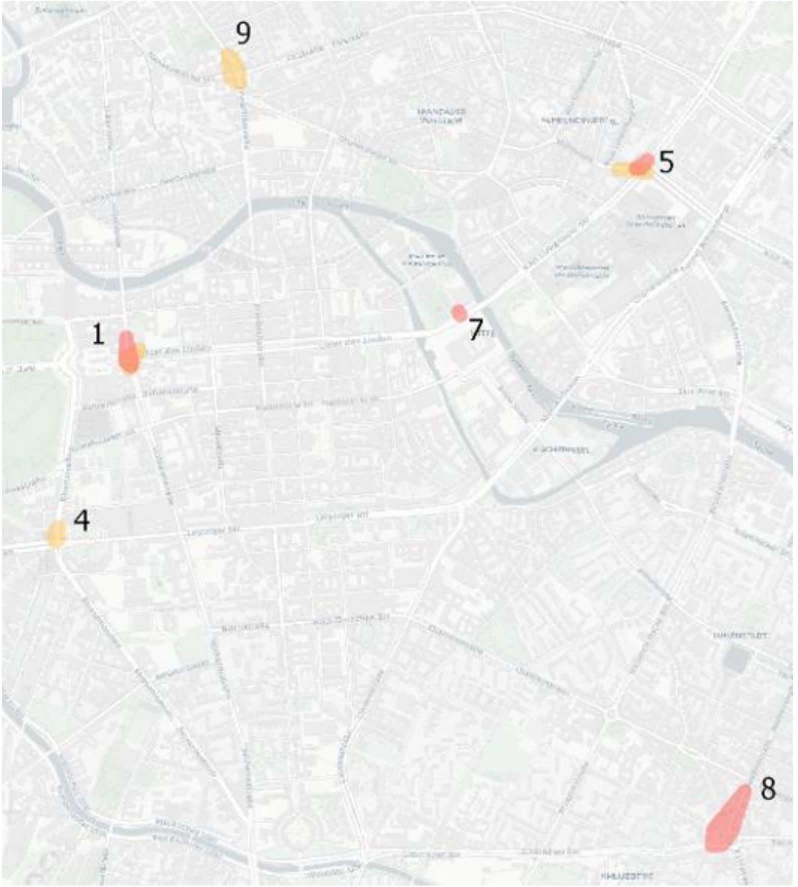
➢ The bus often stops in front of the PLEV so that passengers can board and disembark undisturbed.
➢ The bus obstructs the pedestrian crossing.
➢ BUT only a small sample

In almost 50% of all cases, the bus could not stop at the bus stop sign because a vehicle restricted the stopping area (these cases were not taken into account)



Multi-method approach to identify hazard hotspots





Hardinghaus, M.; Nieland, S.; Oostendorp, R.; Weschke, J. (in Review): Identifying E-Scooter Hazard Hot-Spots. In: Road Safety and Digitalization.