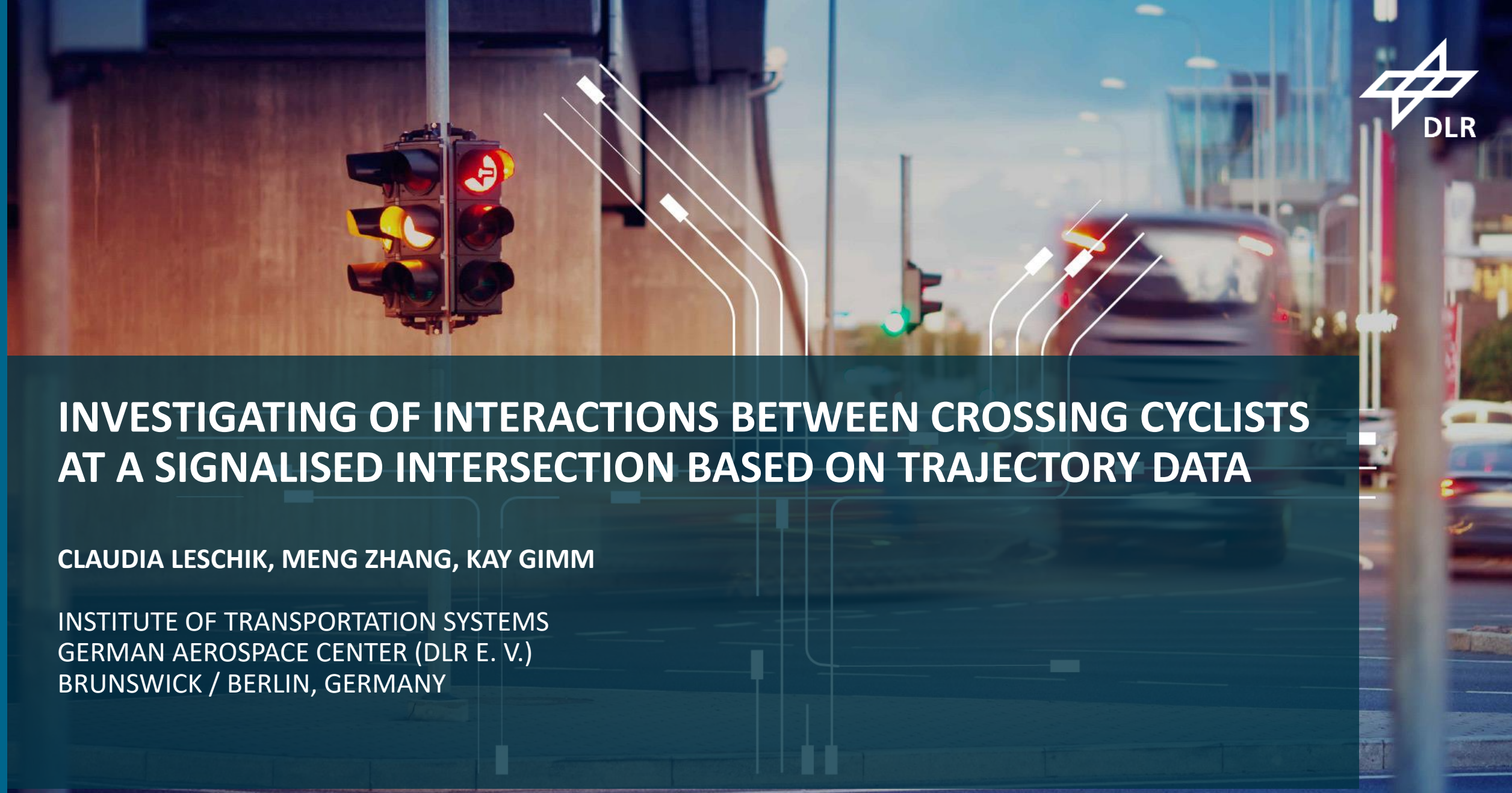

INVESTIGATING OF INTERACTIONS BETWEEN CROSSING CYCLISTS AT A SIGNALISED INTERSECTION BASED ON TRAJECTORY DATA

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DLR (Unreal Engine 5)

News about accidents between cyclists crossing each other

Accident involving several cyclists: woman injured

Die Frau musste ausweichen und kam zu Fall.

https://regionalheute.de/, 23.11.23

Priority mistake by Anna (41) costs 82-year-old cyclist his life, judge imposes sentence in Apeldoorn

https://www.destentor.nl/, 24.06.24

The victim of a fatal accident in Apeldoorn is shielded by police and bystanders.

Cyclist falls on stone after crash - dies in hospital

https://www.fnp.de/, 22.07.2024

Senior citizen (87) dies after bicycle accident in bochum

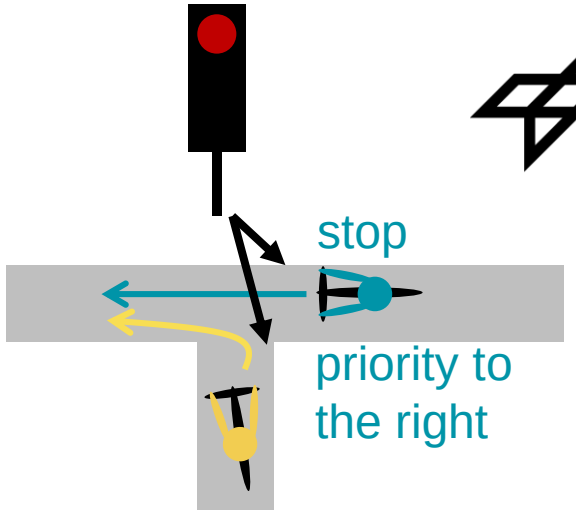
https://www.waz.de/, 24.04.24

Bayern

82 year old man dies after bicycle accident

https://www.n-tv.de/, 02.10.23

Motivation
Research Question and Aim



- Situation in Germany legally clarified depending on the traffic light position
- Over the years 2016-2023, the most common types of bicycle-bicycle accidents are
  - crossing (32.16-38.01%)
  - oncoming (30.7-36.4%)
  - riding side by side or overtaking (21.31-17.56%) and
  - riding in a convoy (10.17-12.04%) accidents. [1]

- What is the actual behaviour of cyclists in real-world situations?
- To what extent are cyclists compliant with this regulation?

[1] Statistische Ämter des Bundes und der Länder. Unfallatlas Deutschland [accident atlas Germany]. 15.08.2024. https://unfallatlas.statistikportal.de/

- The aim of this study is to examine how cyclists interact in a crossing scenario and to determine whether breaking the rules results in critical interactions.

METHOD

Traffic Behaviour Data Collection

Application Platform for Intelligent Mobility (AIM) Research Intersection

- intersection in Brunswick, Germany
- sensor system build up 2014
  - 14 stereo cameras with 20 fps
  - infrared flash
- scope of detection
  - GNSS-based timestamp
  - Location
  - Speed
  - Acceleration
  - User type (e.g. pedestrian, bicycle or car)
  - Size of each detected user
- traffic light-controlled intersection (bicycle- and footpath)

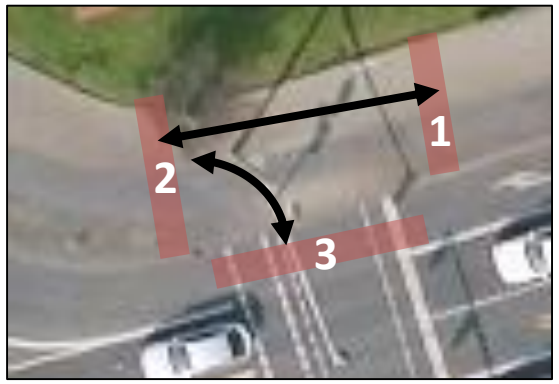
- Data Output: Augmented scene videos and trajectory data

Method

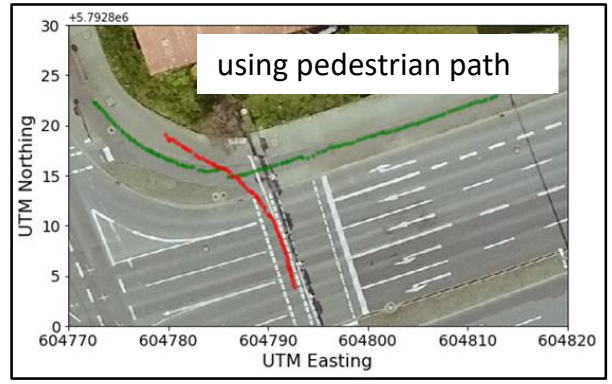
Dataset and Data processing

- 166 hours recorded in February and October 2022, and April 2023
- identified pairs of trajectories intersect the area of interest within a time frame of 3s using polygons
- centres of the objects were used for calculation

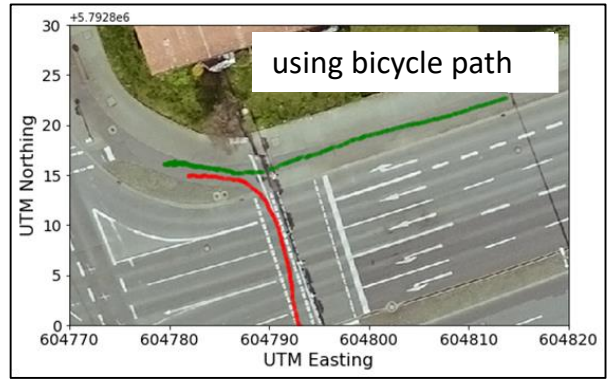
use classified objects



find interaction pairs



calculate speed, distance and PET
distinction between crossing and merging



- Data Output: Interaction pairs (trajectories and videos)

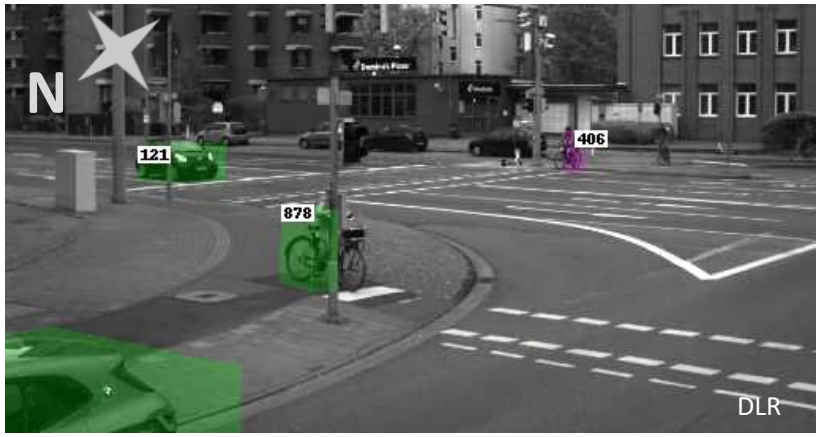
RESULTS

Results
Speed and Distance

- About 66 % (n = 31) of cyclists (n = 47) cut the corner by using the pedestrian path because they were travelling further to the north.

- The cyclist coming from the east is either slower or travelling at the same speed as the cyclist coming from the south.
- If the cyclist from the south crosses the footpath and takes the right of way of the cyclist from the east, the cyclist from the south is cycling 1.75 times faster.

- It was found that the priority to the right rule was respected in only 50 % of the cases (n = 82).

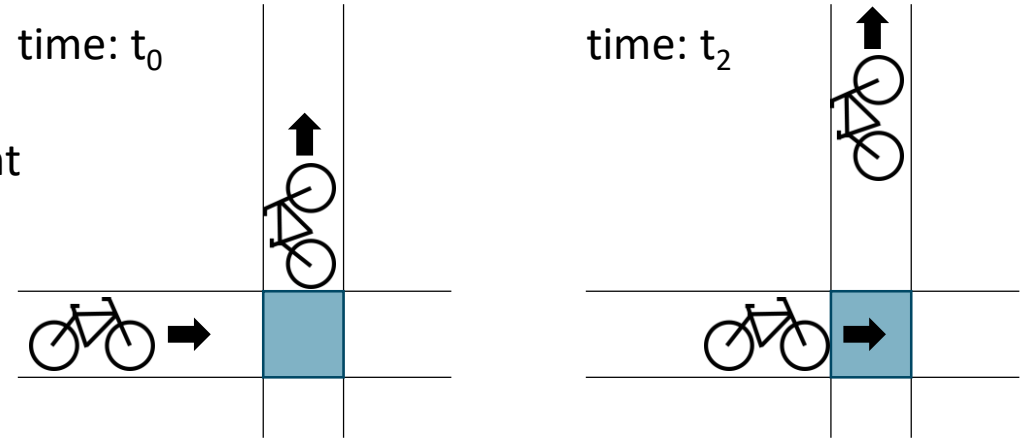


Results

Post Encroachment Time (PET)

Post Encroachment Time (PET [s]) = $t_0 - t_1$

...rider leaving
area of encroachment



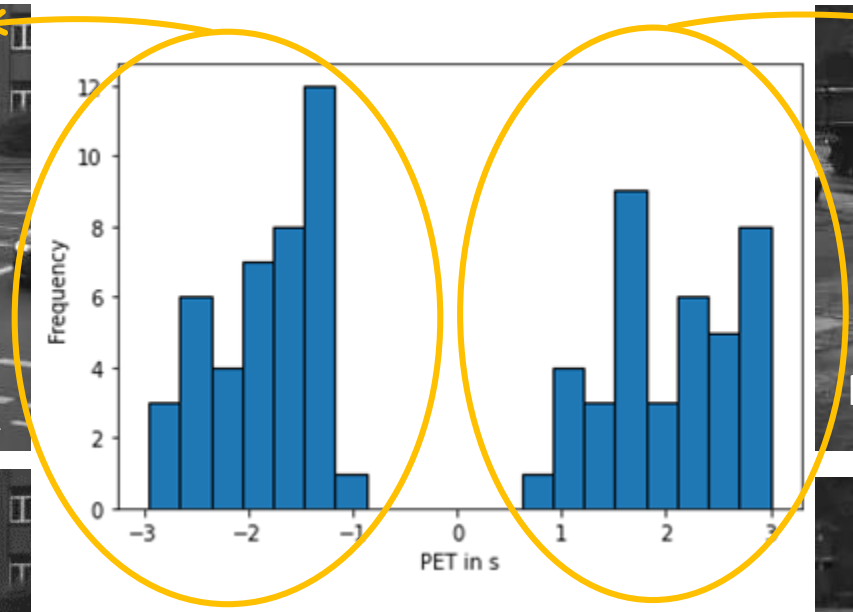
…conflicting rider
entering
area of encroachment

Negative PET
- cyclist who has the right of way goes first

Positive PET
- cyclist who has the right of way goes second

Results
Post Encroachment Time (PET)

cyclist who has the right of way goes first



cyclist who has the right of way goes second

- The lowest values for PET were observed when the cyclist from the south merged onto the bicycle path.

OUTLOOK AND CONCLUSION

Conclusion
and Outlook

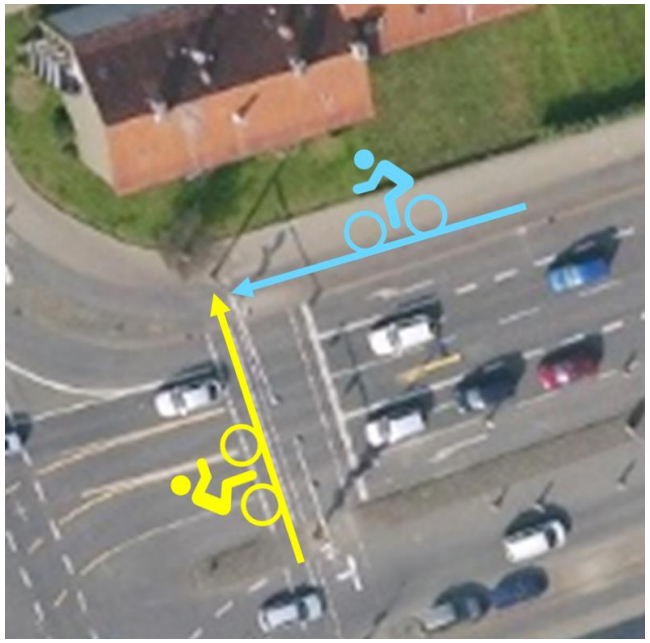
- Priority to the right rule was respected in only 50 % of the cases partly leasing to critical events.
- Cyclist from the south crossed the pedestrian path and took the right of way of the cyclist from the east: velocity was 75% faster than the cyclist from the east.
- The lowest values for PET: cyclist from the south merged onto the bicycle path.

- Further analysis will be conducted to ascertain the reasons for non-compliance with the established regulations.
- A comparative study will be undertaken to identify the differences and similarities between crossing interactions in the bicycle lanes and those occurring in the absence of such lanes.

Outlook

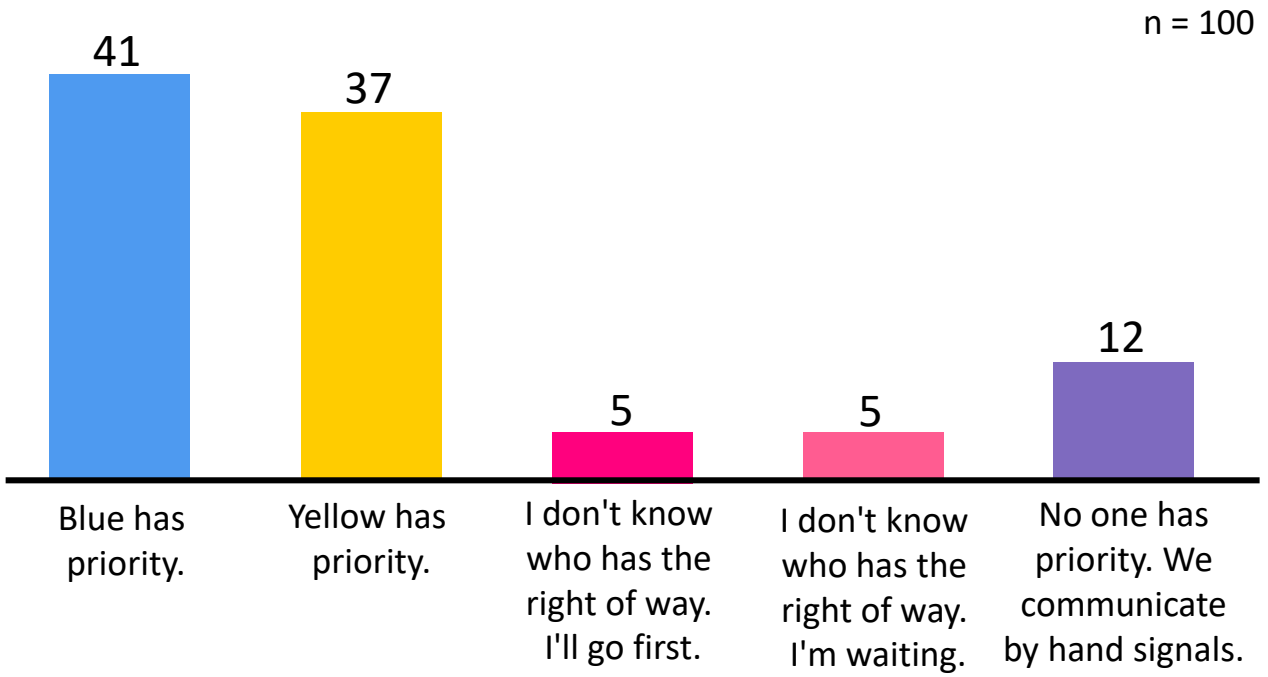
Further Studies: Why are they doing this?

Question



Imagine you are the yellow cyclist. You are crossing the intersection at a green light and are about to head north. A cyclist (blue) approaches from the right and also wants to cycle north. What would you do?

Results



- **Non-representative survey of 100 DLR colleagues**
  - **46% waiting, 42% riding, 12% unknown**

→ **Further studies to identify the motivation of cyclists are planned.**

Outlook

Further Study: Same crossing scenario without bicycle path

- Analysis of 10 days in Braunschweig without bicycle path (18.09. - 28.09.2019)
- 40 interactions found
  - of which 52.5% granted right of way and 47.5% right of way not granted

Thank you for your attention!

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Appendix

Table 1: Interacting crossing cyclist pairs with speed: |v|, mean of minimum distance: $d_{min,mean}$ and (p) PET

Scenario	C_{EW}	C_{SN}	(p)PET_{min} in s	(p)PET_{mean} in s	$d_{min,\,mean}$ in m	C_{EW} |v| in m/s	C_{SN} |v| in m/s
Crossing with	Bicycle path	Foot-path	0.80 (n = 24) -0.95 (n = 24)	2.03 ± 0.76 -1.84 ± 0.51	6.03 ± 2.47 4.13 ± 1.62	2.40 ± 1.11 2.83 ± 1.13	4.20 ± 0.83 3.36 ± 0.88
		Bicycle path	1.15 (n = 15) -1.25 (n = 17)	2.40 ± 0.79 -1.84 ± 0.50	3.97 ± 2.47 3.84 ± 1.67	2.32 ± 0.97 3.26 ± 1.17	2.30 ± 1.37 2.37 ± 1.04
Crossing without	Bicycle path	Bicycle path	0.00 (n = 6) -0.4 (n = 10)	1.44 ± 1.05^{+} -1.97 ± 1.34^{+}	3.75 ± 2.35 3.42 ± 1.90	2.19 ± 0.40 2.71 ± 1.46	2.57 ± 0.94 2.34 ± 0.72