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How do cyclists interact with automated buses? An overview of research findings

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Introduction

An increasing number of automated (mini)bus systems is entering our roads, often driving in mixed traffic environments including cyclists. What are cyclists' opinions and experiences when interacting with these automated vehicles and what is the impact on the behavior and safety of cyclists?

This study aimed to identify knowledge gaps on the interaction of cyclists with automated buses by making an inventory of available research. We conducted a systematic literature review by searching literature databases. In addition, we report some first results from currently running real life projects in the Netherlands and Norway where the interaction of cyclists with automated vehicles is relevant.

Method

Systematic literature review

Step		April 2019 results	October 2019 results
1	Google Scholar search	378	466
2	Duplicate removal	275	351
3	Title filtering	43	68
4	Abstract filtering	12	27
5	Whole text reading	9	21

Table 1. Approach of the systematic review performed in this study. The last two columns show the search results in April 2019 and October 2019, respectively.

WePod and cyclists in the Netherlands. Picture: TU Delft

Video recordings of cyclists interacting with the automated shuttles in Oslo

Interviews with cyclists in Oslo

Results: cyclist interactions with AV-shuttles

Empirical studies from interviews, focus group discussions, surveys, and (video) observations directly addressing the interactions of cyclists and AV shuttles: CityMobil2, EU [1,8]; Appelscha case study, NL [4]; GATEWAY London, UK [7]; WePods, NL [5,11,14,19]; Autobus, Norway [2]; ARIBO, USA [17].
Study on passenger opinions about cyclists interacting with AV shuttles were investigated [10].

- The AV shuttles are not mature; they stop when any object (e.g., road users, static object, etc.) is within a certain distance from the bus [2,4]
- Cyclists seldom force the bus to stop [2,5,8,19]
- Buses' speed is slow, often slower than cyclists' speed
- AV shuttles' abrupt breaking can cause the cyclist to perform unexpected moves [2]
- A common observation is that cyclists ride alongside (left or ride) or overtake the AV shuttle, which can cause abrupt braking (too short distance to shuttle) [2,4 8,19]
- Cyclists cross very short distance ahead of the AV shuttle [2,8]
- Shuttles often drive on existing infrastructure, sharing the road with cyclists [1,2,5,8,10,12,14]; or use the cycle track [4]
- Cyclists' opinions and safety perceptions become more positive after having interacted with AV shuttles [2,12,14]
- Interactions change: cyclists give less often way to the AV shuttles over time [2]
- Infrastructural characteristics (e.g. markings, shared or separate road) influence observed interactions, which appear to be more risky on shared narrow roads [1,2,4,8]
- The safety of cyclists (and other road users outside the AV shuttle) is more of a concern to passengers than their own personal safety [10]

There are other studies of cyclists' decisions when approached by an automated vehicle - not being an AV shuttle bus - using photos depicting various situations [6,15], animated video clips [18] or in virtual environments [11]. Yet other studies have focussed on cyclists' needs for dedicated cycle facilities [3], communication and design requirements for safe interactions of AVs with vulnerable road users [9, 16, 20], and a survey among cyclists on actual experiences with AVs [13]. Experience and expectations about AV behaviour influence cyclists' decisions.

Conclusions

The interaction of cyclists with automated buses, from the cyclists' perspective, is **not a common research topic** yet. Very few studies have actually observed how cyclists react to automated shuttles or have asked their opinions. And those studies having cyclists included, generally have very **few cyclists** included. Therefore knowledge is scarce and many research gaps remain. To date the Norwegian Autobus study appears to be the most extensive study, including over 400 interviews with cyclists about their actual experiences with AV shuttles and hundreds of observed interactions with cyclists [2].

The findings so far indicate that the slow speed of the AV shuttles both contributes to safe interactions and gives rise to unsafe situations, e.g. when cyclists with higher speeds overtake the shuttles or ride alongside the shuttles. Critical situations occur e.g. on narrow stretches of road, when cyclists pass closely, making the AV shuttle to abruptly break and stop, and when AV shuttles make right-hand turns. Results so far indicate that experience over time changes behaviour of the cyclists, the safety implications of which need to be studied further. Also infrastructural design and road markings and communication directed to cyclists needs further study. The current slow speed and frequent unexpected stops, particularly in city centres with a lot of cyclists (and pedestrians), appear not to be attractive for neither passengers nor cyclists.

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