Optimizing urban road cross-section's design to accommodate safe autonomous vehicle- cyclist interactions: A bicycle simulator study

[1]*Amira Hammami, [1]Attila Borsos, & [1]Ágoston Pál Sándor.
*hammami.amira@hallgato.sze.hu
[1] University of Gyor, Hungary

- **Introduction**

The optimal shape of a shared road between AVs and cyclists is still unknown. In this sense, research on the coexistence of AVs and cyclists has revealed two directions. While the first direction advocates for mixed traffic, the second one suggests that AV implementation reinforces the concept of lanes separation for different road users. Since AVs are known for their lane-keeping algorithm accuracy and their perceptual capabilities, one of the commonly recommended scenarios was to implement narrower lanes for AVs and repurpose the saved space for cycling paths. However, none of the studies have investigated this concept experimentally.

Aim

The aim of the study is to investigate the impact of reducing lane width for AVs and freeing up space for cycling paths using a bicycle simulator study and to optimize the cross-section dimensions to accommodate safe autonomous vehicle-cyclist coexistence.

Objectives

- To assess the influence of AVs' presence on the perception of safety and comfort by bicyclists on different types of bicycle infrastructure.
- To assess the correlation between the perception of safety and comfort of bicyclists with bike lane widths under different AV market penetration rates (MPR).

- **Research methodology**

Bike simulator design

The bike simulator used in the study was developed at the University of Gyor, Hungary. The physical bike is attached to a motion platform to provide a certain level of tilting for a realistic cycling experience. To display the virtual environment, the physical bike is surrounded by three monitors.

Experiment design

The infrastructure object of the experiment is a 200m long straight road section. The route segment in the virtual environment is a replication of Szövetség UT, which is a shared road (with sharrow) in Hungary.
The investigated scenarios are:

- One sharrows design and two designs of separated lanes with 3 AVs MPRs (9 scenarios);
- Two designs of separated lanes with a wider bike lane and 100% AVs MPR (2 scenarios).

In total 11 scenarios are provided for each participant.
The following table includes the characteristics of scenarios.

Table.1 Scenarios description

	Scenarios				
Features	**A**	**B**	**C***	**D**	**E***
Infrastructure descriptions	Road with sharrows	AVs and bike separated lanes by continuous coloured lines.			
Pavement marking	Sharrows every 50 m 	Yellow continuous line, no coloured pavement for cyclist 		Yellow continuous line; Red bike lane 	
Lane width	Total 4m	AVs L_w =2.75m Bike L_w =1.25m	AVs L_w =2.5m Bike L_w =1.5m	AVs L_w =2.75m Bike L_w =1.25m	AVs L_w =2.5m Bike L_w =1.5m
Traffic composition	AV penetrations rates (0%; 50%; 100%)				
Traffic volume	Moderate				
Speed limit	50km/h				

*Scenarios investigated for only 100%MPR

Data collection

Qualitative and quantitative measurements are collected during the experiment. Qualitative measurements include the gaze rate and the questionnaire answers. To this end, the participant has to wear an eye camera to record the gaze rate, and after each scenario, the participant has to evaluate the experiment using a questionnaire survey. The quantitative measurements include the speed and the trajectory. Two Arduino Uno microcontrollers are used to capture data from sensors attached to the bike. The first Arduino is used to determine the velocity of the bike using one HAL sensor and nine magnets distributed equally on the back wheel. The second Arduino uses a potentiometer to measure the rotational angle of the steering wheel. Trajectory data are recorded in the simulation.

Participants

A total of 50 volunteers are involved in the experiment. The participants are mainly students and faculty staff members. The participants should be familiar with the Hungarian cycling infrastructure, have at least one year of cycling experience, and not suffer from physical or health issues. The experiment includes participants who have previously participated in the validation study of the bike simulator at the university and have shown an interest in contributing to future experiments.

- **Expected results**

The experiments will be carried out from July. It is expected that the findings will indicate an adequate and safe design scenario accommodating AVs and cyclists from the perspective of cyclists in Hungary. Results may depend on different factors, such as familiarity with the bike simulator, cycling experience, how well the environment is represented, infrastructure preferences, understanding of the technology of autonomous vehicles, trust in this technology, etc. Findings should be considered by urban planners and policymakers in future infrastructure reshaping.