CHAPTER 3
CHALLENGES AT A ROUNDABOUT

Muhammad Azam, Sitti Asmah Hassan, Othman Che Puan, and Shaza Farouk Azhari Hassan

3.1 INTRODUCTION

Autonomous vehicles (AV) are considered as a potential solution to improve the future mobility. AVs can perform driving operations without direct involvement of human drivers due to their accurate sensing and navigating capabilities (Rosique et al., 2019).

From the findings of various simulations and test bed studies, it has been established that AVs can alleviate the traffic conditions from the perspective of traffic operations, safety and emissions (Morando et al., 2017; Tomás et al., 2020). The major benefit of AVs is to eliminate accidents caused by human errors. The human errors have been reported as a contributory factor in 93% of the accidents (Aria et al., 2016). The discrete nature of AVs is expected to improve safety and operational conditions of our transport system by eliminating the human errors. However, the actual impacts of this technology are still unknown.

The market penetration rates (MPR) of AVs have been predicted by many researchers. The major benefits of AVs are associated with their higher MPRs which are expected to occur between 2040 to 2060 when AVs will become common and affordable (Litman, 2022). Before the AVs reach to 100% MPR, there will be a transition period where AVs

will share the road space with conventional vehicles (CV) (Aria et al., 2016). The complicated environment created by these vehicles of different autonomy is expected to affect the traffic operations of current traffic streams. Various researchers are working to predict the implications during the transition phase.

This chapter attempts to evaluate the impacts of various penetration rates of AVs into mixed traffic stream. A simulation environment was employed to study operational impacts of AVs by considering the traffic operations at a roundabout under mixed traffic conditions. Several scenarios have been conducted to study different possible combinations of AVs and CVs with varying demand levels. This quantification of operational impacts in context of mixed traffic will help the policy makers to understand the performance of their transport systems during transition period.

3.2 RELATED WORKS

Several studies have investigated the potential impacts of AVs on traffic operations by considering various facility types such as intersections, roundabouts, freeways and urban networks. (Bohm & Häger, 2015; Elawady et al., 2022; Khattak et al., 2020; Morando et al., 2018; Tibljaš et al., 2018). This section mainly discusses the details of the studies involving the AVs' impacts for the case of a roundabout.

For the case of roundabout, Tibljaš et al. (2018) studied the operational impacts of AVs by developing simulation models for four roundabouts in Croatia with modified driving behaviour parameters. The study found an increase in travel speed and decrease in average stop delay with the increase in AVs' proportion. Mohebifard and Hajbabaie (2020) applied the VISSIM model to study operational impacts of CAVs at a roundabout. The study found that CAVs have potential to improve the traffic performance by reducing delays and increasing speed. Another study applied simulation environment to study CAV's impacts at two modern roundabouts (Anagnostopoulos & Kehagia, 2020). The study considered both cautious and aggressive

behaviour for CAVs and found that cautious behaviour deteriorated the traffic performance, whereas aggressive CAVs improved the queue length by 43.7%, travel time by 11.7% and delays by 27.7%. A recent study by Boualam et al. (2022) investigated the impact of various AV penetrations on roundabout capacity. The findings endorsed that the initial 20% and 40% penetration rates of AVs improved the capacities by 10% and 20% respectively.

Based on the findings of the above-mentioned studies, it can be concluded that the AVs have the potential to improve the traffic operations for all type of facilities. However, some studies have showed concerns regarding lower penetrations rates of AVs. Studies have indicated that small penetrations of AVs may deteriorate the traffic conditions (Forrest & Konca, 2007; Tomás et al., 2020). He et al. (2020) also endorsed that lower penetrations rates showed no significant impact on traffic speed for freeway weaving segments. Also, there is a difference in traffic performance when AVs with different aggression levels are introduced in mixed traffic. Mostly, the conservative driving nature associated with cautious AVs have shown deteriorations in performance, whereas aggressive AVs produced the otherwise. Therefore, the impacts of this growing technology are not clear yet and need further investigations.

This chapter investigates the impacts of AVs on traffic operations at a roundabout in Malaysia. Initially, a calibrated model of the selected study site was prepared in VISSIM tool. Then, several scenarios were run on the basis of varying penetration rates of cautious, normal and aggressive AV driving logics.

3.3 METHODOLOGY

The methodology involves three phases; model development and calibration, simulation of AV scenarios, and simulation output and comparison. Figure 3.1 shows the three aforementioned main phases along with steps involved in each of the phases.