



## Determinants of crash numbers and types at turbo roundabouts in Germany

<sup>1\*</sup> Kollascheck, A., <sup>2,4</sup> Bärwolff, M., <sup>2</sup> Gerike, R., <sup>3</sup> Schmitz, J., <sup>3</sup> Geistefeldt, J.

\*lead presenter

<sup>1</sup> armin.kollascheck@tu-dresden.de, Dresden University of Technology, Germany

<sup>2</sup> Dresden University of Technology, Germany

<sup>3</sup> Ruhr University Bochum, Germany

<sup>4</sup> Die Autobahn (Federal Motorway Operator), Germany

### INTRODUCTION

Turbo roundabouts are a relatively new and specific type of roundabout with a non-concentric circulatory roadway that has multi-lane sections. In contrast to conventional roundabouts, turbo roundabouts have one or more entries and exits with multiple lanes. In the two-lane entries of turbo roundabouts, road users must choose the lane depending on their destination and are therefore pre-sorted. New lanes are added at the inside of the circulatory roadway to avoid lane changes on the circulatory roadway and therefore reduce the crash risks. In general, a higher capacity for turbo roundabouts than for two-lane and especially for single-lane roundabouts was found in previous studies (VASCONCELOS et al., 2011 and FORTUJIN et al., 2015). Studies in the Netherlands (FORTUJIN, 2009 and VOS, 2016) and in the Czech Republic (SKVAIN et al., 2017) revealed a significant reduction in the number of crashes with injuries in before-after analyses of different types of intersections that were converted to turbo roundabouts. However, due to the novelty of turbo roundabouts, the number of studies on road safety at this type of intersection is still very limited. The aim of this study is to analyse traffic safety at all existing turbo roundabouts in Germany and its interdependence with motorised traffic volumes, design, and operation of the different turbo roundabouts.

### RESEARCH METHODOLOGY

Based on a systematic search of turbo roundabouts in Germany, 32 turbo roundabouts were identified in December 2021. Out of those, crash data was available for 25 sites, which form the sample for this study. A comprehensive macroscopic crash analysis was carried out based on four years of crash data at these 25 turbo roundabouts, which were grouped according to the diameter of the circulatory roadway, the type of markings between the circulatory roadway lanes, the existence of sidewalks, and the number of arms. All crashes recorded by the police were taken into account, including crashes with only soft or heavy property damage. The number of crashes per motor vehicle and the proportion of different crash types were calculated and analysed for every subgroup. In addition, the dependence of the crash numbers and types on infrastructural and operational characteristics of the turbo roundabout was investigated.

### RESULTS

The determined crash rates for the 25 analysed turbo roundabouts in Germany range from 0.2 to 2.2 crashes per million motor vehicles with a mean value of approximately 1 crash per million motor vehicles. Possible reasons for this wide range of crash rates are the random nature of crash frequencies, which usually follow a poisson or negative binomial distribution, and also



the diversity of the turbo roundabouts in the sample in terms of traffic load, design, and operation. Crash models show significant effects of lower motorised traffic volumes, lower speed limits, and smaller radii of the entry, which all three reduce crash numbers. No significant influence is found for other characteristics such as the diameter of the circulatory roadway, the number of arms or the duration of existence.

The determined proportion of crashes involving personal injury is low, at around 25%, regardless of the diameter of the circulatory roadway, the type of markings between the circulatory roadway lanes, the existence of sidewalks, and the number of arms. The proportion of crashes involving heavy personal injury is 2%. In comparison to the overall German crash statistics, the proportions of crashes related to rush hour, weekends, darkness, and wet road conditions of the turbo roundabouts analysed is unremarkable. However, crashes caused by a conflict between vehicles entering the roundabout and vehicles on the circulatory roadway have a striking high proportion of 49% in the total number of crashes. Two-lane entries at continuous two-lane circulatory roadways are particularly prone to crashes. Crashes due to lane changes or cutting of the inner circular lane account for 22%, which is a significant proportion of the total number of crashes. Crashes caused by lane changes related to incorrect lane selection on the entry account for at least 8% of the crashes on the 25 analysed turbo roundabouts.

#### DISCUSSION AND CONCLUSION

The study shows which conflicts are the main cause for crashes at a large sample of turbo roundabouts. While most of the crashes involve only property damage or light personal injuries, there is still potential to further improve road safety at this type of intersection, which requires further investigations. Because the second most frequent cause of crashes at the 25 analysed turbo roundabouts is lane changing on the circular roadway, which is only divided by markings between the parallel lanes at the sites in the sample, physical lane dividers such as curbs as used in the Netherlands could potentially prevent crashes.

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