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Typical cruising speed of speed pedelecs and the link with motor power as a result of a Belgian naturalistic cycling study

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1 INTRODUCTION

Electric bicycles are on the rise. In 2015, 6.54% of the bicycles sold in Europe provided electrical assistance [1]. Belgium is traditionally one of the frontrunners, with an e-bike market share of 39.2% in 2016 [2]. Most e-bikes are classical pedelecs, limited in the European Union to a maximum assistance speed of 25 km/h and a maximum continuous rated power of 250W [3]. More recently, speed pedelecs were introduced, exceeding these limitations with a maximum assistance speed of 45 km/h and a typical maximum continuous rated power of 350W or 500W. These electric two-wheelers have a high potential for attracting the younger consumer while lengthening the active commuting range up to 40 km [4]. Speed pedelecs are challenging the traditional boundaries between the 'bicycle' and 'moped' vehicle category, due to their increase in power and speed, making it complicated for legislators, who generally try to place speed pedelecs in one of these existing categories. The European legislator, imposing the technical vehicle regulations, found a compromise by classifying them as *"cycles designed to pedal"* in the L1-B category for *two-wheel mopeds* [3, 5]. Each European member state has to implement these regulations in their national legislation and are facing similar classification questions. Important responsibilities of the national member states are defining appropriate helmet specifications, insurance requirements and assigning speed pedelec users a place on the road. The final consideration triggers the recurring question *"Should speed pedelec users be allowed to use cycle lanes or should they use the roadway?"*. To make a statement on these discussions, a valuable parameter to take into account is the operating speed of the speed pedelec. In this work, the cruising speed is defined as "the speed at which most of the distance is covered" and it is suggested as the most appropriate parameter to take into account. Preliminary results of a Belgian naturalistic cycling study with more than 40 speed pedelec users are presented, including the correlation between the cruising speeds of different types of speed pedelecs and the maximum continuous rated power of these cycles.

2 CYCLING SPEED

With the introduction of the electric bicycle, research on operating speeds of (e-)bikes became increasingly important. Some recent studies have already included a few speed pedelecs [6, 7, 8]. In the German Naturalistic Cycling Study [6], the mean speed of different two-wheelers is investigated, resulting in a mean speed of 24.5 km/h for a speed pedelec and 17.4 km/h for a traditional pedelec. In a Dutch naturalistic cycling study [7], a mean speed of 30.1 km/h for speed pedelecs and 20.9 km/h for traditional pedelecs were measured. Whether the mean speed is the correct variable to take into account when making a statement on the speed of (speed) pedelec users is questionable. Yet another, Dutch study, carried out by an engineering consultancy company, revealed an average cruising speed of 35.2 km/h [8]. The Dutch researchers defined cruising speed as *'the speed that a speed pedelec user is riding if there are no external factors that are influencing its velocity'.* This seems to be a step in the right direction, but it is very labor-intensive to process on-road measurement data following the roadmap they described.

For the Belgian naturalistic cycling study presented here, two approaches of the term "cruising speed" were compared: 1) the speed at which is cycled most of the time 2) the speed at which most distance is covered. The first approach is based on 'the time during which the speed pedelec users ride at a certain speed'. For the cruising speed defined on a distance base, the distance covered at each speed is calculated. In both cases, the cruising speed is the speed with the highest frequency. The difference in the two approaches is shown in Figure 1. These speed distributions are obtained from one test person, who covered a distance of 1540 km during the project. His mean speed is 35 km/h, which does not seem to be a relevant parameter in describing the speed of this vehicle. For most speed pedelec users, there is not much difference between the two approaches, for the continuation of this paper, the distance based cruising speed will be used.

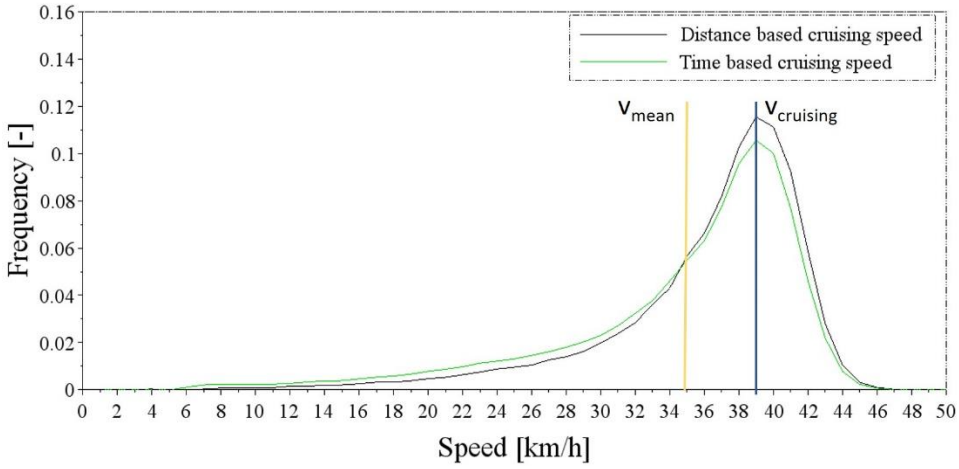

Figure 1: Normalized speed distributions based on time and distance

3 PRELIMINARY MEASUREMENT RESULTS AND DISCUSSION

More than 40 speed pedelec users were tracked during the course of this research via the following smartphone applications: *Runkeeper* for Android and iOS users and Cycle Tracks GPS for Windows Phone users. Currently, the data of 31 speed pedelec users has been processed. The raw gps-data was exported from the cyclists smartphone, processed by a Kalman filter and subsequently the standstills were removed. Finally, the cruising speed of all speed pedelec users were determined and are visualized in Figure 2. It can be observed that there is a great variety in cruising speed between the different test persons. One of the possible explanations for this speed variety is a difference in the motorization of their vehicles. For now, the primary models available on the European market are 350W and 500W. The influence of other parameters, such as trajectory, are being researched. Figure 3 illustrates that the cruising speed of the different speed pedelecs is related to the maximum continuous rated power

of the motor. The plot depicts a different range of cruising speed according to the motor power. An important consequence of this variability is that a simple "yes or no answer" on the question whether speed pedelec users should be allowed to drive on cycle lanes, is not possible. A possible solution is to leave the choice between roadway and cycle lane in clearly defined situations to the speed pedelec user, as it is currently the case in Belgium in areas with a speed limit of maximum 50 km/h. Further research on relevant parameters assessing the use of speed pedelecs is ongoing.

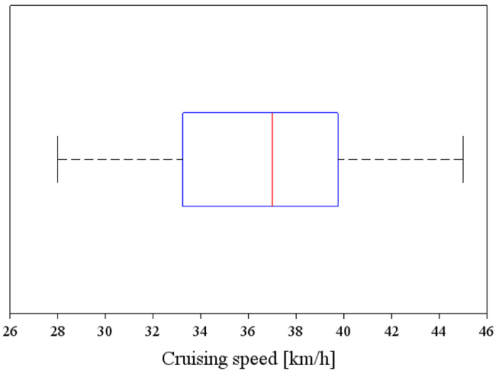

Figure 2: Cruising speed range for 31 test persons

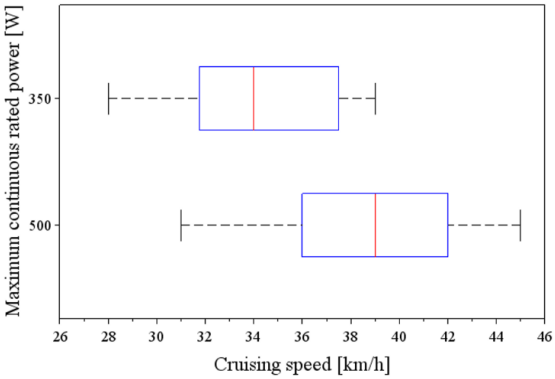

Figure 3: Cruising speed ranges for 350W and 500W speed pedelecs

4 CONCLUSIONS

Speed pedelecs are breaching the traditional boundaries between bicycles and mopeds and are therefore making it necessary to have an adapted legislation. A crucial parameter to take into account is the vehicle speed. In earlier research this was mainly the mean speed of e-bike users. In this research, the cruising speed, as the speed at which most distance is covered, is suggested. The preliminary results of a Belgian naturalistic cycling study with over 40 participants reveals a great variety in cruising speeds of different speed pedelec users. This variety can be partly related to a difference in the maximum continuous rated power provided by the electric motors of the various speed pedelec models.

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