Transportation Research Part A 94 (2016) 1–16

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Preferences of travellers for using automated vehicles as last mile public transport of multimodal train trips

Ir. Menno D. Yap [a,b], Dr.Ir. Gonçalo Correia [a,*], Prof.Dr.Ir. Bart van Arem [a]

[a] Delft University of Technology, Department Transport & Planning, Delft, The Netherlands
[b] Goudappel Coffeng, Deventer, The Netherlands

ARTICLE INFO

Article history:
Received 5 May 2015
Received in revised form 6 May 2016
Accepted 1 September 2016

Keywords:
Attitudes
Automated vehicles
Door-to-door
Last mile transport
Stated preference

ABSTRACT

In the recent years many developments took place regarding automated vehicles (AVs) technology. It is however unknown to which extent the share of the existing transport modes will change as result of AVs introduction as another public transport option. This study is the first where detailed traveller preferences for AVs are explored and compared to existing modes. Its main objective is to position AVs in the transportation market and understand the sensitivity of travellers towards some of their attributes, focusing particularly on the use of these vehicles as egress mode of train trips. Because fully-automated vehicles are not yet a reality and they entail a potentially high disruptive way on how we use automobiles today, we apply a stated preference experiment where the role of attitudes in perceiving the utility of AVs is particularly explored in addition to the classical instrumental variables and several socio-economic variables. The estimated discrete choice model shows that first class train travellers on average prefer the use of AVs as egress mode, compared to the use of bicycle or bus/tram/metro as egress. We therefore conclude that AVs as last mile transport between the train station and the final destination have most potential for first class train travellers. Results show that in-vehicle time in AVs is experienced more negatively than in-vehicle time in manually driven cars. This suggests that travellers do not perceive the theoretical advantage of being able to perform other tasks during the trip in an automated vehicle, at least not yet. Results also show that travellers' attitudes regarding trust and sustainability of AVs are playing an important role in AVs attractiveness, which leads to uncertainty on how people will react when AVs are introduced in practice. We therefore state the importance of paying sufficient attention to these psychological factors, next to classic instrumental attributes like travel time and costs, before and during the implementation process of AVs as a public transport alternative. We recommend the extension of this research to revealed preference studies, thereby using the results of field studies.

1. Introduction

In the last years many developments took place regarding automated vehicles (AVs) technology. In fact automated vehicles are expected to become available on the market in the next 10–20 years (Shladover, 2015). Most studies on automated vehicles focus on the vehicle technology in relation to the effect on traffic flow characteristics, road capacity and traffic

* Corresponding author.
E-mail addresses: MYap@Goudappel.nl (M.D. Yap), G.Correia@TUDelft.nl (G. Correia), B.vanArem@TUDelft.nl (B. van Arem).

http://dx.doi.org/10.1016/j.tra.2016.09.003
0965-8564/

safety. The relation between different penetration rates of automated and cooperative transport systems and road capacity has been for example studied by Van Arem et al. (2006), Tampère et al. (2009), Arnaout and Bowling (2011), Shladover et al. (2012), Hoogendoorn et al. (2014) and Schakel and Van Arem (2014). Kesting et al. (2005) also consider the effect of AVs on the capacity drop after congestion. The impact of AVs on traffic stability has, amongst others, been studied by Schakel et al. (2010). VanMiddlesworth et al. (2008) studied AVs in intersections management, whereas Van Driel and Van Arem (2010) considered the effect of AVs on both traffic flow efficiency and traffic safety.

It is however unknown to which extent the share of the existing transport modes will change as result of using AVs as a transit system (Correia et al., 2016). To the best of our knowledge this study is the first where traveller preferences for AVs are explored and compared to existing modes. Thereby its main objective is to position AVs in the transportation market and understand the sensitivity of travellers towards some of their travel attributes. Because there are no fully automated vehicles currently on the market we apply a stated preference (SP) experiment where the role of classic instrumental variables such as travel time and cost are explored. Moreover, due to the fact that these vehicles entail moving on the road network without a driver and entrusting that task to a computer, we expect that psychological factors translated through positive and negative attitudes play an important role in the choice to use automated vehicles. Therefore, in our SP experiment the role of attitudes in perceiving the utility of AVs is particularly explored in addition to these classical instrumental attributes.

Five different levels of automation are defined by Gasser and Westhoff (2012) and SAE International (2014). These 5 levels are driver support (level 1), partial automation (level 2), conditional automation (level 3), high automation (level 4) and full automation (level 5). A higher level of automation entails a less important role for the human driver in the driving task. Our study focuses on AVs which are able to operate according to level 5 automation, meaning that there is a full time performance of an automated driving system for all driving tasks, without any human intervention. In our SP experiment, we also explicitly assume that these vehicles are fully electrically powered, thus representing a lower environmental impact at least at the local level.

The scope of this paper is on studying the potential of AVs for the last mile trips between a train station and the travellers' final destination. We realize that a modal shift from car to trains as main mode on medium-distance (20–40 km) trips is an important policy goal of the Dutch government (Ministry of Infrastructure and Environment, 2015). A higher train usage entails a higher level of sustainability in transportation and can also reduce congestion levels, with its related economic and environmental impacts. Currently, in the Netherlands there is a relatively high share of multimodal trips for medium-distance trips between urban areas. Between the most developed urban areas in the Netherlands, up to 17% of the trips are currently considered as being multimodal (a trip in which a traveller uses at least two different modes) (Van Nes et al., 2014). In multimodal train trips, a relatively high disutility is especially caused by the access and egress trip stage (Hoogendoorn-Lanser, 2005), hence it is hypothesized that providing AVs as egress mode may have the potential to improve the attractiveness of multimodal train trips and to realize a modal shift to the train + AV combination. AVs are thus considered as potential means to increase the attractiveness of the total door-to-door trip, by providing a last mile service which brings travellers from the train station to the front door of their final destination in a sustainable way.

The paper is structured as follows. Section 2 presents the applied methodology to investigate travellers' preferences for using AVs. In Section 3, the survey and sample are shortly discussed. Section 4 shows and discusses the results of the final estimated model. At last, conclusions and recommendations for further research are presented in Section 5.

2. Methodology

2.1. Alternatives and attributes

Public transport (PT) trips usually consist of three stages: access, main part and egress. We define a multimodal PT trip in this paper as a trip where more than one mode is used, with one or more public transport modes being used for the main part of the trip. For each stage different alternatives are available, such as walking, cycling, private car or bus, tram and metro (denoted as BTM) for access; train or BTM for the main stage; and walking, cycling, car-sharing or BTM for the egress part. For all these stages different attributes - like in-vehicle time, waiting time and travel costs - are relevant for multimodal mode choice. The high number of possible combinations of mode alternatives and attributes makes it complex to incorporate all those in one SP experiment in a manageable way. Capturing the attribute sensitivity for all these combinations would lead to a high number of choice sets provided to each respondent, leading to a too complex task for the respondent, or requiring a very large sample of respondents.

In order to reduce this complexity, in our study we focused only on multimodal PT trips where trains are used in the main trip stage. Besides, we only consider trips in the direction going from a home-end origin, to a destination at the activity-end of a trip. As Hoogendoorn-Lanser et al. (2006) indicate, there are differences in mode availability, knowledge and use of multimodal trip alternatives between the home-end and activity-end of a trip. Therefore it is important to explicitly distinguish between the home-end and the activity-end of a trip, since attribute sensitivities can be different on each side of the trip. Consequentially in this study we have only considered the AV as egress transport from the train station to the activity-end destination of the trip. Furthermore, we provided respondents with attributes and attribute levels for the access and main stage of the multimodal rip together, whereas attributes for the egress stage of the trip were disaggregated by mode and explicitly mentioned separately (Fig. 1). This clustering is in line with the scope of the study which is exploring the