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Understanding users' behaviours in relation to concentrated boarding: implications for rail infrastructure and technology

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Abstract. Concentrated boarding describes the phenomenon when rail passengers congregate in certain areas of the platform, such as at main entrances and staircases. This influences the distribution of passengers throughout the carriages, which can negatively affect passenger comfort, safety at the platform train interface, efficiency of the rail network, and the reputation of rail travel as a whole. This project aimed to determine whether concentrated boarding occur in rail stations in the UK in order to understand its relevance for future rolling stock and infrastructure design and its associated manufacturing research. Video recording technology was used to observe the movements of passengers in Oxford Station, and data was collected for nine trains. By reviewing the recordings, the number of passengers boarding through each door of the trains was determined, and the boarding distributions along the length of the platform were plotted. Several reasons for noted trends were offered, and potential solutions proposed. The use of real time information could be invaluable to minimise concentrated boarding, as it would allow passengers to make informed decisions as to where they could board trains to have a better journey experience. These findings indicate the relevance of a human-centred design process, particularly the user research stages in the process of defining priorities for manufacturing and engineering.

Keywords. Station design, Railways, UX, passenger behaviour, platform-train interface

1. Introduction

Railway transportation is one of the most popular methods of transport in the United Kingdom, allowing large numbers of passengers to travel in an efficient and cost effective way. Within England and Wales, there has been substantial growth in the number of passenger journeys across all regions [1]. Transporting such high volumes of passengers provides its own challenges; overcrowding on trains and platforms can often be observed, with passenger numbers growing faster than the increase in service capacity [2]. This can have a further impact on the safety of passengers and staff, and on the finances of the train operating companies.

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A contributing factor to overcrowding in the railway sector is concentrated boarding. This phenomenon is when passengers congregate at access points to station platforms, such as at the ticket barriers, or near staircases, meaning that a high proportion of passengers board using the same doors. This can lead to some carriages being crowded, whilst others remain relatively empty, and lead to a negative customer experience. It could also cause safety concerns at the platform-train interface, as large crowds boarding through one door might cause individuals to trip or slip whilst climbing aboard the train [3]. Another disadvantage of concentrated boarding is the potential financial impact which it might have on the train operating companies. The train dwell time increases if large numbers of passengers are queueing to board, which can have negative financial implications.

Surprisingly, there is little existing literature focusing on the concentrated boarding of passengers. A study carried out in several railway stations in the Netherlands observed that the station infrastructure does appear to cause a concentration in the areas where people board trains [4]. Another study held at eleven Dutch railway stations observed "clear concentrations of waiting and boarding passengers around platform accesses", although no specific figures were provided [5]. One study on the Toronto metro system also yielded results indicating that the position of the station's entrances determines the boarding pattern, with the highest proportion of passengers boarding the first carriage nearest to the station's only transfer and entrance point on all the trains studied [6].

Researchers in the UK asked passengers of the Gatwick Express if they might alter their choice of train or move along the platform, if they had information about crowding via a website, a smartphone app or at the station. Passengers were found to prefer the carriage closest to the exit at the destination station, but non-commuting business travellers expressed a willingness to walk further in order to find an available seat [7].

No published research was found regarding actual observation of railway boarding patterns at mainline railway stations in the United Kingdom. This investigation hopes to establish whether concentrated boarding is prevalent in heavy rail stations. By proving or disproving this theory and evaluating its effects, it is hoped that potential solutions might be considered by railway companies, which would be beneficial to both passengers and the companies. This project has been undertaken as part of the Innovate UK funded CLoSeR Project, which is a multi-partner project set to develop systems that will improve diverse areas of rail travel. By fully understanding the theory of concentrated boarding, the project will be better equipped to design, manufacture and tailor systems to reduce its negative effects from occurring, and improve the experience of rail travel for passengers.

2. Methods

Otherwise known as the bird's eye technique, this style of data collection allows researchers to gather information without direct interference with those being observed [8]. Another method used in several studies of passenger behaviour is video recording. Obtaining recordings allows large quantities of data to be analysed extensively and, when mounted discreetly, cameras are capable of avoiding the 'observer effect' [9]. Unobtrusive observation seemed to be the most appropriate data collection technique in the context of studying concentrated boarding, as it enables large numbers of people to be studied in public spaces, which in turn allows human behaviour on platforms to be studied easily.

Data was collected on-site at Oxford Station. After initial contact with the station manager and a preparatory investigation, the angles of the cameras, their positioning and attachment methods were defined. Eight digital point-and-shot cameras, mounted on small gorilla tripods, were put in strategic places along the length of the platform.

Data was recorded for nine trains, which stopped at Platform 3 from 15:07 to 16:31. Reviewing the videos allowed the numbers of passengers boarding through each door to be counted, and other factors which might have affected the boarding process (such as the loading of bikes or the buffet cart, and the boarding of less mobile passengers) were observed. The following data for each train was recorded in a Microsoft Excel spreadsheet: the number of passengers disembarking and boarding, and any observations of interest. The recordings were also used to determine the number and type of carriages in every train, and the distance along the platform that each train came to a halt.

3. Results

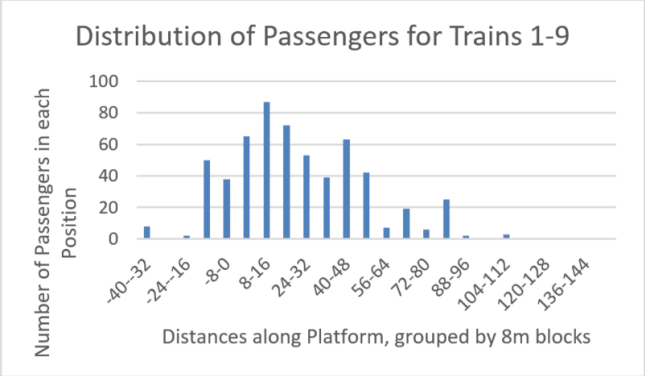

Figure 1. Distribution of all passengers along platform by distance (8 m blocks).

The distances of each door were determined and the data grouped into intervals along the platform, with 0 m taken as the pillar directly in front of the main entrance, the right hand end of the platform (towards the rear of the train) being defined as positive values, and the left hand end of the platform (towards the front of the train) defined as negative values. Figure 1 present the distribution of passengers for all the trains studied. Over 25% of all passengers studied boarded the train in an area of less than 24 m away from the main entrance of the station, with this percentage decreasing towards the extremities of the platform. A reason which might be provided for this is that the trains studied were of differing lengths, and the central portion of the platform would be more likely to be served by a coach and therefore to have the highest density of passengers boarding in this area.

Since trains stopped at different positions, it is necessary for the data from each train to be considered individually, to determine whether the theory of concentrated boarding is correct. Figure 2 displays the position of trains that stopped at that platform, together with the positions of platform details such as furniture, entrances, staircases and structural features.

As can be seen on Figure 2, our results indicate that there is evidence of concentrated boarding. The first example shows that almost 60% of the 102 passengers boarded this

train within 16 m either side of the main entrance, comprising the two first coaches. Fewer than 10% of passengers boarding the back two carriages (to the right on the image). The second example adds evidence of the concentrated boarding, although the last coach was first class. Other particularly problematic service was train 9, which had the first class and the buffet coaches towards the front of the train, stopping near the access to the platform. The next available standard class door was used by 38 passengers (or 32% of passengers boarding). This train composition clearly affected the overall distribution of passengers, especially as this train was at a peak time.

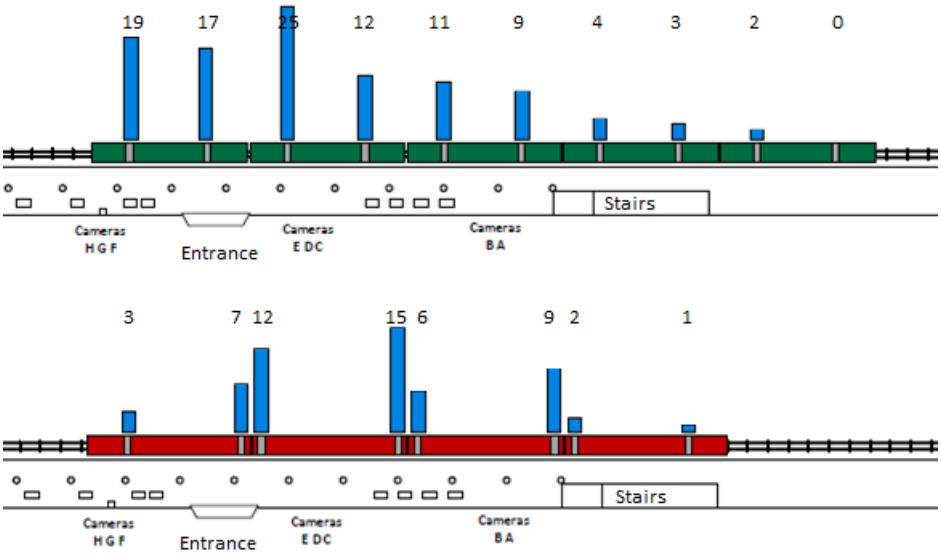

Figure 2. Train 3 (top) and 8 (bottom) as examples of the number of passengers boarding through each door. The front of the train is to the left.

4. Discussion

By analysing the data found and from observing the footage collected, several explanations could be provided for why concentrated boarding occurred at Oxford Station. Some of these decisions could be made on a conscious level, with the passenger choosing a carriage for a specific reason, whilst others might be sub-conscious, with the passenger naturally drawn to the door by which they board, perhaps influenced by the environment around them.

Passengers who travel frequently may choose a particular carriage of the train based on the layout of the station where they will be disembarking. In order to arrive at the destination stations ticket barriers fastest, a passenger might choose to board the carriage that will likely come to a halt closest to the destination station exit [7], [10]. Depending on the proportion of passengers travelling to a specific destination, this factor could affect the possibility of concentrated boarding either way. Another factor influencing the decision of where to board might be the positioning of the first class carriages. The first class area was found at the front of Trains 5, 8 and 9, causing passengers who may have been waiting at the left of the main entrance to have to enter a carriage further back in the train.

It is likely that the most common reason for concentrated boarding is the tendency for passengers to seek convenience, and their unwillingness to walk unnecessarily. As they enter the station, they may wish to rest their legs, and so endeavour to stop walking as soon as they deem appropriate. When the train pulls into the station, the passengers can then board the train at the doors closest to them [11]. Passengers with little experience of boarding trains at a new station may not be aware of where the train is likely to stop at the station. Therefore, they may consciously decide to stand in a central point of the station, thus increasing the likelihood that the train will stop where they have chosen to stand.

It was observed that passengers who arrive at the station later than the train are more likely to board the train at the nearest point. This is a logical concept as, in this circumstance, travellers will put catching the train as a priority, and will consider their further comfort once they are safely on board [6]. The likelihood of concentrated boarding would decrease as the platform gets particularly crowded, forcing people to make full use of the entire length of the platform, or causing people to choose other doors if they observe long queues to board the train through the door where they stand.

Three main strategies can be used to minimise the prevalence of concentrated boarding. These options encompassed changes to the design of rolling stock, station infrastructure and the use of new technology. The type of carriage was seen to have an effect on the distribution of passengers. Trains with doors further apart from each other causes passengers to be more widely distributed (e.g. train 3). The close proximity of doors between adjacent carriages resulted in a higher concentration of passengers boarding in a smaller region (e.g. train 8). Positioning the first class carriages in the centre of trains rather than at either end could make the high concentration of passengers in the centre of the platform to diverge towards the opposite ends of the train.

Changes might also be made to the station infrastructure in order to reduce concentrated boarding. Platform markings can instruct passengers to spread along the full length of the platform. Another option would be to make changes to the exact layout of the station, such as having ticket barriers, stairs and other elements such as furniture, vending machines and waiting rooms more spread out along the length of the platform.

In recent years, Real Time Information has become much more widely used in public transport systems [12], and is a frequent demand from passengers [13]. It could be employed in order to indicate where the train will come to a halt in the station, and also to provide information on seat availability throughout the train, allowing passengers to make informed decisions as to where to position themselves on the platform whilst waiting for a train [14]. Options for sharing this data with rail travellers include through mobile technology applications, or via display boards installed on the platform [15]. Simulations indicate that there is potential for technology to optimise the boarding process and foster a more even distribution of passengers on board of trains [16].

5. Conclusion

This study demonstrated the existence of concentrated boarding and proposed different options that might help to reduce its negative effects. Observing user behaviours proved to be an invaluable research method to inform the design and manufacture of rail systems. Some of these solutions involve infrastructure changes, which would be too costly and would require a certain level of engagement from stakeholders and the public in order to be successful. The most promising option considered was the use of Real

Time Information in order to communicate to the public where seats could be found. If this information is constantly updated and is consistently accurate, it would provide a clear motive for passengers to act to reduce concentrated boarding.

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