



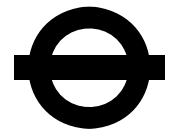
**Project:** Increased Warning Tone Duration on Victoria Line 09TS (PVEC3148)  
**Document number:** PVEC3148-TR-011

## Victoria Line Door Chimes Trial – Final Report

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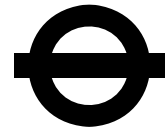
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## 1. EXECUTIVE SUMMARY

London Underground (LU) was required by the DfT to conduct a trial in order to demonstrate the negative impact on safety resulting from extending the door closure chimes to 3 seconds. This report discusses the findings of this trial.

3 seconds door closure chimes is required by the Rail Vehicle Accessibility Regulations (RVAR) in order to provide equal access to the LU network to passengers with disabilities. LU's preferred approach is to retain the existing  $1.75 \pm 0.25$  seconds door chimes.

LU experience has indicated that the door chimes acts as a 'hustle alarm' encouraging passengers to rush towards the train and increase the risk of slipping, tripping and getting struck or trapped by the doors. Therefore, LU believe that increasing the door chimes duration would increase this effect and increase the associated safety risk. There would also be capacity disbenefit as the door chimes make up a portion of the dwell time which is critical to minimise in order to provide a high capacity railway.

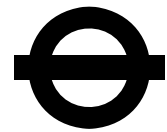
The methodology of the trial was to consider and assess the impact of the following factors, and that they should be considered in that order:

1. Safety
2. Accessibility
3. Capacity

The evidence collected/derived by this trial has shown:

1. Overall safety risk increases due to the increase in the number of door strikes
2. Regardless of whether a passenger considers themselves to have a disability, the safety risk of other passengers rushing or running on the platform is considered a greater risk than the risks associated with the doors closing
3. Though impact on capacity should not be a primary consideration in this trial, there will be a potential loss of capacity by increasing door chime duration and therefore dwell times.

It is recommended that door chimes on all London Underground passenger rail vehicles remain as existing  $1.75 \pm 0.25$  seconds.



### 3. GLOSSARY AND ABBREVIATIONS

DfT	Department for Transport
ERA	European Railway Agency
LU/LUL	London Underground (Limited)
PRM TSI	Persons of Reduced Mobility Technical Standard for Interoperability
RVAR	Rail Vehicle Accessibility (Non-Interoperable Rail System) Regulations
TSI	Technical Standards for Interoperability

### 4. TERMINOLOGY

There are two tones on rail vehicles related to door movement. There is a tone that sounds when the doors start opening. There is a different tone that provides a warning that the doors will close. The warning duration is defined as the time between the start of the tone and the start of the doors moving. The door closure warning tone duration is referred to in this document as 'door chimes'.

### 5. PURPOSE OF THIS DOCUMENT

The purpose of this document is to:

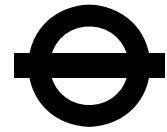
- Summarise the research conducted regarding door chimes
- Summarise the findings of the Victoria line Door Chimes trial
- Conclude and make a recommendation for the LU standard for door chimes duration

### 6. DOOR CHIMES BACKGROUND & HISTORY

The provision of door chimes started to become good practice in the early 90s. LU included the provision of door chimes in the 67TS/72TS refurbishment during (1991/1992). The door systems on these stocks are pneumatic, where the sound of the discharge of the compressed air provided some warning prior to the closing of the doors. After a series of workshops to determine door chimes duration for modern stock, it was agreed to have a common duration of approximately 1.75 seconds.

Railway Group Standard (RGS) GO/OTS300 was published in 1993, recommending door chimes duration of 3 seconds. Though RGSs are not applicable to LU, during the following refurbishment (73TS in 1995/1996) 3 second door chimes were specified. However, after a short period of time in service, the decision was made to change to approximately 1.5 seconds. Anecdotal evidence (Dom Borgese, Doors Principles Engineer and Malcolm Dobell, ex-Head of Train Systems) suggests that the decision was based on an increase of door trapping incidents on this line (in particular at South Kensington) and that the number of incidents improved after changing to the shorter duration. As such, the roll out of new fleets and refurbishments included 1.75 ±0.25 seconds door chimes, resulting in a network wide standard.

In 1998, the Rail Vehicle Accessibility Regulations (RVAR) were published, including a requirement for 3 second door chimes. This standard did apply to LU rolling stock, but only for trains that first enter



service after 1998. The first LU stock that had to comply with these regulations was 09TS on the Victoria line. Before delivery of these trains (2008), LU decided that 3 seconds was not appropriate for the Victoria line railway, and a temporary exemption was granted to allow LU to conduct a trial to evaluate impact. The trial was not conducted and further temporary exemptions were granted until, in May 2015, the Department for Transport stated that a further temporary exemption would only be granted if it could be demonstrated that the trial was going to be conducted. In the meantime, a second stock that required RVAR compliance was introduced into service from 2012, S stock. This stock had temporary exemptions granted based on the need for a consistent duration for all stocks and to await the results of the 09TS trial. In 2010, RVAR was republished including a time limit on compliance: all trains (whether built since the inception of RVAR or not) shall comply by 1<sup>st</sup> January 2020.

A timeline of these events is shown in Appendix A.

## 7. DEVELOPMENT OF RELEVANT STANDARDS

The Disability Discrimination Act 1995 (DDA) formerly made it unlawful to discriminate based on disability in employment, the provision of goods, services, education and transport. The Railway Vehicle Accessibility Regulations 1998 then came into force to specify the minimum standard of rail vehicle to comply with the DDA 1995. This was applicable to rail vehicles used on railways, tramways, monorail systems or magnetic levitation systems brought into use after 31<sup>st</sup> December 1998.

In 2002, the European Union Agency for Railways (formerly known as the European Railway Agency) published the first Technical Specifications for Interoperability (TSIs). The purpose of these specifications was to standardise European railways, to facilitate interoperability, as mandated by EU Directives. Covering accessibility is the PRM (Persons of Reduced Mobility) TSI which came into force in 2008. With this, the requirements in the PRM TSI superseded the requirements in RVAR 1998 for heavy rail vehicles. Hence, RVAR remained to cover light rail vehicles (London Underground, Tyne and Wear metro, the Docklands Light Railway in addition to smaller railways such as airport movers).

When the Equality Act 2010 replaced the DDA 1995, RVAR 2010 came into force. This was applicable to any rail vehicle not covered by the PRM TSI. All rail vehicles are required to comply by 2020 regardless of age.

### 7.1 Pertinent Door Chimes Requirements

The development of RVAR was undertaken by a committee of railway companies, with an approach that appears to have been through consolidation of relevant standards. The consolidation of these standards resulted in a requirement for 3 seconds of warning prior to door closure. It does not appear that London Underground were consulted on this development.

The development of the PRM TSI requirements took a similar approach, but with a larger number of standards to consolidate and stakeholders to consult and satisfy. This resulted in the requirement for 2 seconds of warning prior to door closure. Figure 1 shows the requirements for the two standards for the doors open chimes and door close chimes and their relative durations.

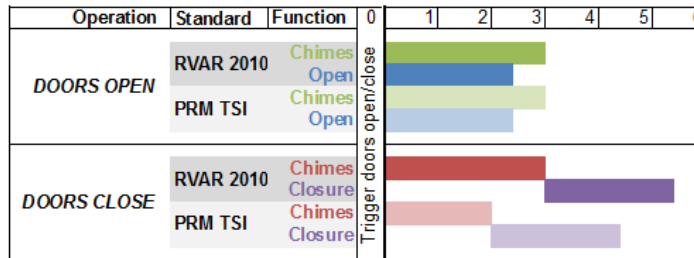
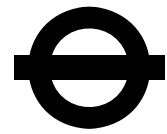


Figure 1: A graphical representation of the duration of the chimes and the door movement requirements in RVAR and PRM TSI

## 8. PLATFORM TRAIN INTERFACE AND DOOR RISKS

The purpose of door chimes is to warn passengers to keep clear of the moving doors before being struck or trapped. For both the ‘door strike’ and ‘trapping’ safety risks, the primary risk mitigation is observation of the platform train interface (PTI) by the train operator who only closes doors when he/she sees a clear PTI. The door chimes provide further mitigation for passengers who are not on the train but possibly near the doors, those who decide to board late, and those who are alighting late (all of whom are not visible to a train operator viewing the PTI).

However, anecdotal evidence (Dom Borgese) suggests that the door chimes affect customer behaviour which increases other safety risks: slips and trips on the platform, pushing of other passengers, and late boarding resulting in getting struck by the doors or getting trapped. When the duration of the door chimes is long enough for passenger’s to realise they have time to board, the door chimes act as a ‘hustle alarm’ rather than a warning.

London Underground’s approach is, overall, to minimise the impact of the following risks:

1. Door closure risks
2. Hustle effect risks

Figure 2 shows the risks that make up these two sets.

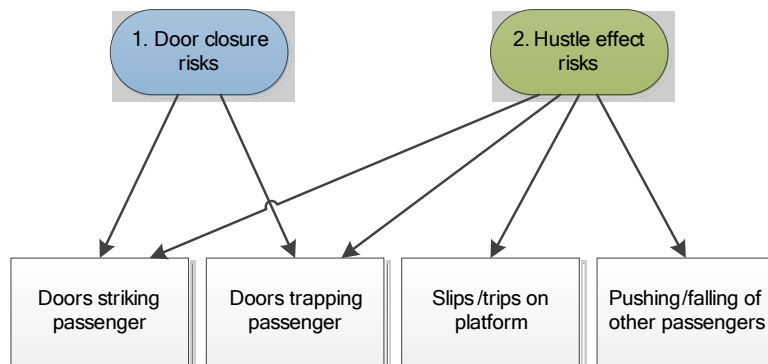


Figure 2: Two groups of risks associated with the door closure sequence

In theory, the door closure risks decrease as the door chimes duration increases, as longer door chimes gives more time to clear the doors to a point where everyone has safely boarded or alighted. Conversely, hustle effect risks theoretically increase with longer door chimes, as passengers will start running for the train doors from further away as the door chime duration increases.

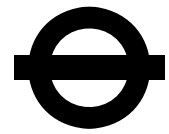


Figure 3 shows a simple schematic illustrating how these risks could be balanced, resulting in lowest overall safety risk. As shown, the lowest overall risk is where the two lines intersect.

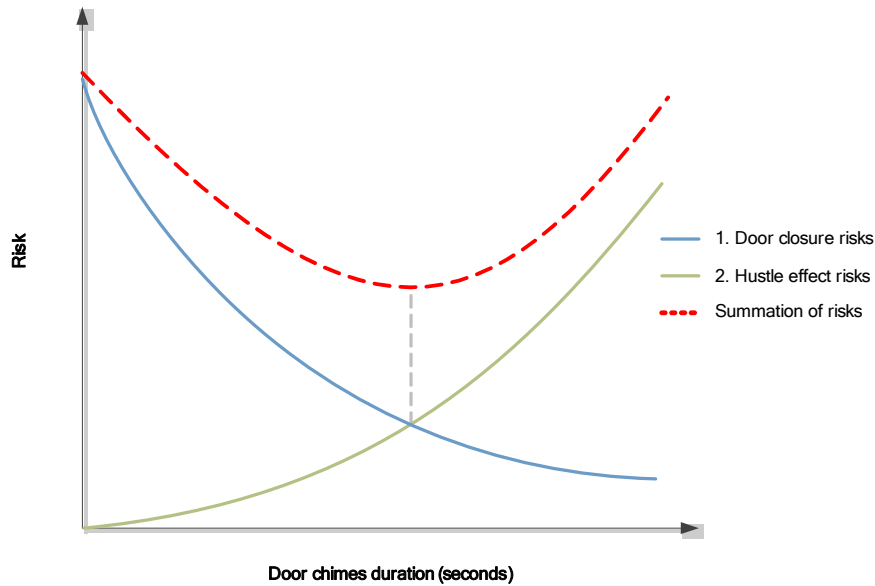


Figure 3: A schematic of how the balance of the two types of risks can result in the lowest overall risk

## 9. IMPACT OF DOOR CHIMES ON CAPACITY

A high capacity railway aims to get trains as frequent as possible. All London Underground lines are considered high capacity railways, but Victoria line has the highest train capacity: 36 trains per hour (tph) (i.e. 1 train every 100 seconds).

When each train enters a platform, there is a sequence of events that is required to occur in series (see Figure 4). Each train in a series follows this sequence, and so the total duration of this sequence determines the maximum number of trains that can run in an hour (the tph)

One of the events in this sequence is the door chimes duration, therefore an increase in this duration results in either fewer trains per hour, or the need to reduce the duration of another event. It is assumed that all other events are at their minimum possible duration (as TfL invest in order to improve capacity) and so the only event that can be reduced is the recovery.

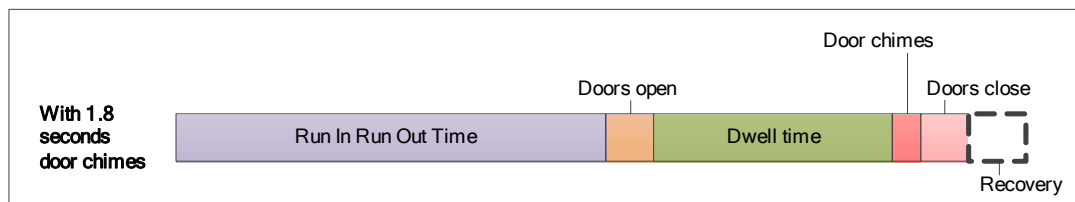
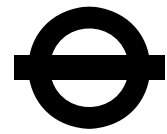


Figure 4: The sequence of events when a train arrives in the platform



The recovery event is 'spare' time in the railway to allow the trains to 'catch up' when there are service perturbations, such as staffing issues or passenger action. Reduction in recovery results in more difficulty for the trains to 'catch up' and therefore a higher likelihood of delays and lateness.

The additional 1.2 seconds of the door chimes will reduce the recovery time available, but if the 'hustle effect' results in more door obstructions, then the decrease in recovery time will be even greater. If the recovery time cannot be reduced any further, then the railway has to operate at a lower capacity, and therefore deliver fewer trains per hour.

## 10. TRIAL METHODOLOGY

Discussions with the Department for Transport (DfT) and Office for Rail and Road (ORR) during the original exemption applications were based on the theory described in Section 8. The DfT and ORR required a trial of 3 second door chimes before they were prepared to consider a permanent exemption.

The trial methodology was to install 3 second door chimes onto all Victoria line trains and to measure the impact on:

1. Safety
2. Accessibility
3. Capacity/service

As the theory related to passenger behaviour, it was a requirement for passengers to 'learn' (even if subconsciously) that the door chimes had increased. Hence, the requirement for all trains to be modified and for a duration of at least 6 months.

All service trains were modified by 8<sup>th</sup> August 2017. The trial started on 9<sup>th</sup> August 2017 and was concluded on 8<sup>th</sup> February 2018.

### 10.1 Measures

#### 10.1.1 Orbita

The Victoria line trains are fitted with a monitoring system which monitors doors, amongst other train systems. The monitoring system transmits event data to a shore system (Orbita). Some of the events recorded can be used as a proxy for passenger behaviour. The most pertinent event was "Door # not closed" (where # represents the door position), which is triggered when the door (at position #) takes longer than 8 seconds to close.

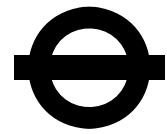
Other Orbita events were monitored but were less pertinent and the results proved to be less useful.

This measure mostly contributed to demonstration of the hustle effect and therefore contributed to understanding of the safety implications of a change to 3 seconds.

#### 10.1.2 Platform Observations

In order to validate the Orbita data as a proxy for passenger behaviour resulting in door incidents, some platform observations at key locations were conducted. The locations were selected based on the Orbita data collected in order to indicate where the highest number of door ('not closed') incidents were occurring and therefore increase the likelihood of observing a door incident.





## 10.1.3 Report PTI incidents

When an incident on LU trains or premises is reported, it is recorded on an incident database. Relevant incident categories were monitored before and during the trial to understand if the number had increased. This would contribute to the safety aspect of the trial. However, the number of reported incidents was low and a comparison was not statistically useful for this work. The data was used to provide understanding of the type of incidents that occur.

## 10.1.4 Boarding Trains Questionnaire

A questionnaire was designed to understand how passengers respond to door chimes and the safety risks they perceive when boarding trains. This was distributed to as many passengers as possible via disability groups and staff.

## 10.1.5 Service metrics

Service metrics were monitored and analysed. However, these metrics are correct to a tolerance of approximately 5 seconds and therefore it was suspected that these metrics would not provide the resolution needed to measure the impacts of the door chimes increase (of approximately 1.2 seconds).

## 11. RESULTS

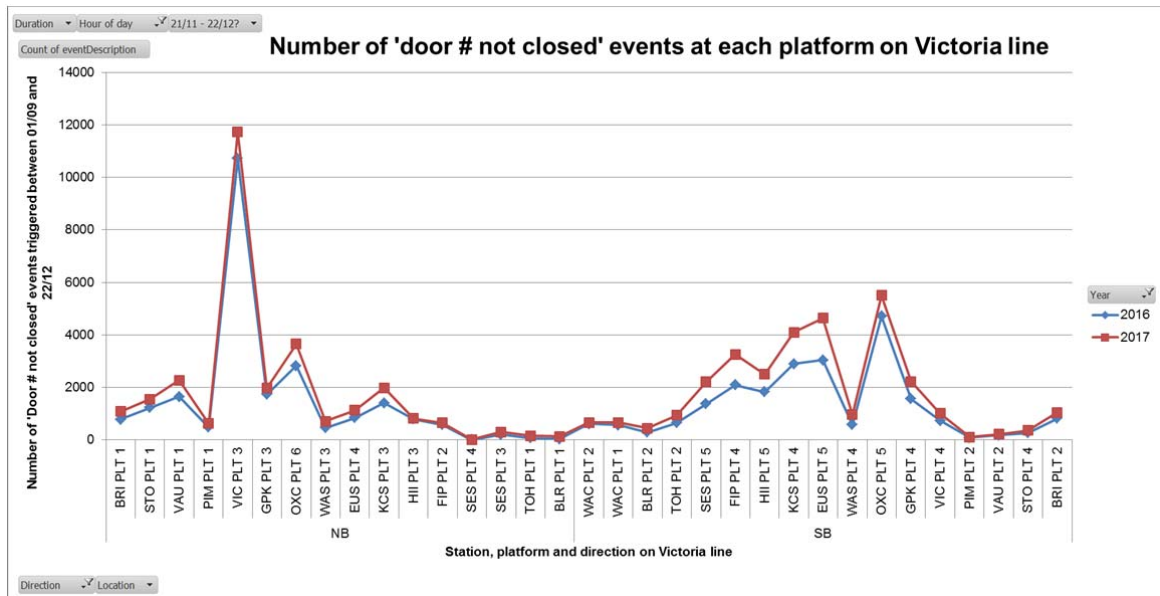
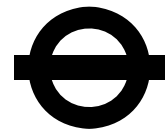
### 11.1 Orbita – “Door # not closed” events

Due to seasonal variability in passenger demand, the ‘door # not closed’ event cannot be compared between days, weeks or months; they can only be compared to the approximate same period in the previous years. Also, the data in the summer months, and January are often not used as passenger loading is significantly lighter than the remainder of the year. Therefore, the trial data covers the period of 1<sup>st</sup> September 2017 to 22<sup>nd</sup> December 2017. This is then compared to data from previous years. The three sets of data available to facilitate this analysis is:

1. Trial Data (2017): 01/09/2017 – 22/12/2017. 3 seconds door chimes.
2. Baseline Data (2016): 01/09/2016 – 22/12/2016. 1.8 seconds door chimes.
3. Baseline Data (2015): 22/11/2015 – 22/12/2015. 1.8 seconds door chimes. (This dataset is not as complete as the other years. Therefore, this can provide additional baseline data when needed, but only between the available dates.)

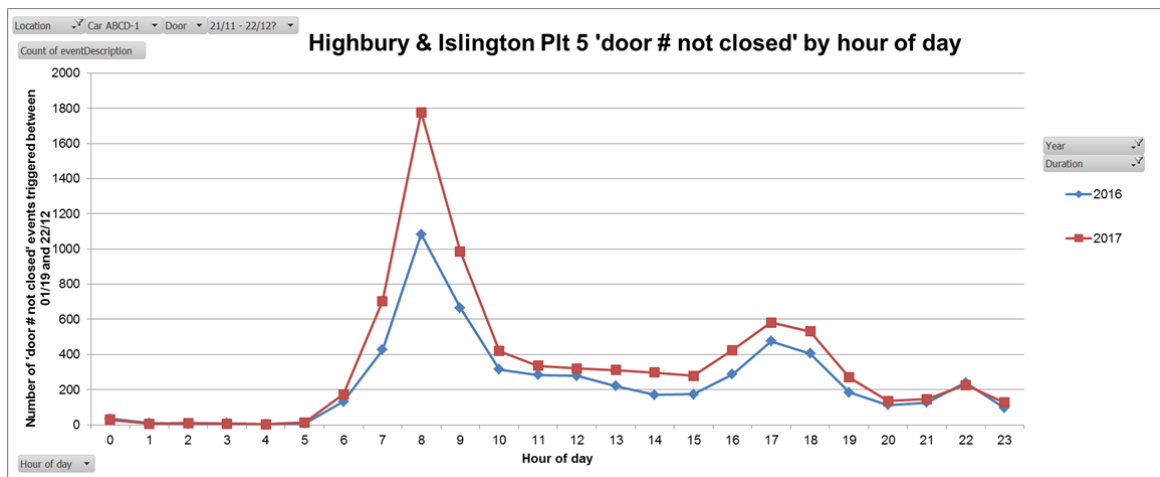
Each dataset is used as absolute figures, and not normalised to account for train capacity or passenger demand. Passenger demand is approximately the same for all three datasets, with a small decrease during 2017. Train capacity has a small increase during 2017 with the introduction of 36tph, but the increase is very small (1.9% on weekdays, and 2% on Saturdays).

Comparing the complete 2017 dataset with the 2016 dataset shows increases in ‘door not closed’ events at certain locations, see Figure 5. The increase observable between Seven Sisters and Euston on the Southbound, is mostly due to an increase in the morning peak. The increase between Kings Cross and Victoria on the Northbound is mostly due to an increase in the evening peak.



**Figure 5: The total number of 'door # not closed' events recorded between 01/09 and 22/12 for both 2017 (trial) and 2016 (baseline) datasets**

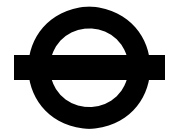
For example, Figure 6 shows how the number events change throughout at the day at Highbury and Islington platform 5 (southbound).



**Figure 6: The total number of 'door # not closed' events recorded between 01/09 and 22/12 at Highbury & Islington platform 5 for both 2017 (trial) and 2016 (baseline)**

An increase of events can be observed in both peaks and inter-peak but is most significant during the morning peak. When looking at similar graphs for other platforms, most showed consistent small increases with some significant increases at certain times of day. The only locations where this is not observed is when the number of incidents is low.

During the trial, it was noted that there is a natural pick up of more door 'not closed' events by virtue of the fact that the door close sequence has been increased with the longer door chimes. Appendix B



describes the work conducted to determine the impact this has on the results, and concludes that this effect accounts for some of the increase but not all of the increase of door 'not closed' events.

Therefore, it can be concluded that the number of door incidents has increased due to the longer door chimes.

## 11.2 Platform Observations

In order to support any data collected to demonstrate that there is a safety risk, platform observations were carried out. This involved identifying key platforms, the key doorways on that platform and then observing every train that departed in an hour, noting down any obstruction detection incidents.

Platform observations took place at the following locations and times:

1. Oxford Circus Platform 5 – 19th October 2017 (5pm to 6pm)
2. Euston Platform 5 – 21st January 2017 (8am to 9am)
3. Euston Platform 5 – 1st February 2018 (8am to 9am)
4. Euston Platform 5 – 1st February 2018 (3pm to 4pm)
5. Highbury & Islington Platform 5 – 1st February 2018 (8am to 9am)

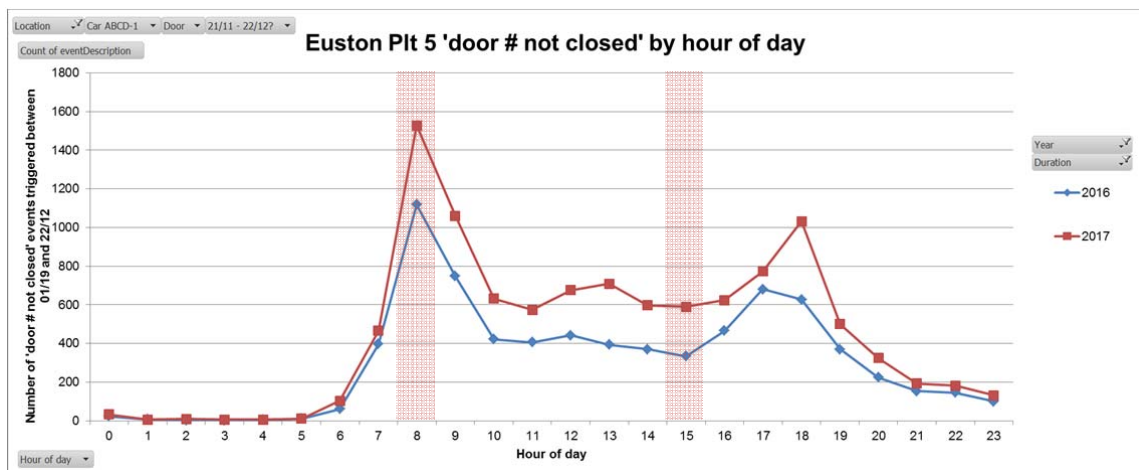
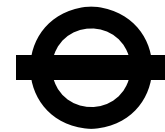
In total, 183 departures were observed and recorded.

The platform observations established that passenger door obstruction incidents resulted in triggering an Orbita event in most cases and therefore the event data can be used as a proxy for this type of passenger behaviour. Also, the observations showed that there are two broad types of door obstruction:

- Type 1: Passenger already on train, and door grazes them or gets obstructed by bag, coat or part of their back
- Type 2: Passenger trying to board late and gets struck or trapped by doors

Only Type 2 door obstruction poses a safety risk. During very busy periods, more of the first type of door obstruction was visible, as the platform would be so congested that no passenger could run towards the doors or would attempt to board late. However, during lighter loading periods, the second type of door obstruction was prevalent.

Figure 7 shows Euston platform 5 (southbound) throughout the day. Like Highbury & Islington, it shows significant increase during peaks, but also shows significant increase between peaks in addition to this. The highlighted regions show the time of day that the platform observations were conducted.



**Figure 7: The total number of 'door # not closed' events recorded between 01/09 and 22/12 at Euston platform 5 for both 2017 (trial) and 2016 (baseline)**

At Euston between 8am and 9am, platform observations showed that Type 1 of door obstructions dominated the data. However, between 3pm and 4pm, Type 2 of door obstructions dominated; between these hours, the platform is not congested and therefore it was observed that passengers are much more likely “push their luck” and board the train late in the door close cycle.

At Euston, the specific location on the platform observed was chosen where the data showed the highest number of door obstructions, which is also next to the main entry/exit where there are cross passages to escalators and to the Northern line. This results in the train being visible and the door chimes audible from a distance that encourages passengers to run.

Conversely, at Oxford Circus platform 5, an entrance to the platform (from the Central line) is at the head end of the train with approximately 5m between the point of recognising there is a train in the platform and the first doorway. This distance is too great to run if the door chimes begin to sound and therefore a passenger is less likely to run for the doors (and if they do, they won't reach it in time to obstruct the doors). Figure 8 shows the events that occurred against time of day at Oxford Circus platform 5. Despite the number of events being larger than those at Euston, only a slight increase compared to 2016 has been measured. This demonstrates that the impact on the 'hustle effect' may be less prevalent at stations where the layout and congestion levels prevent running towards the train.

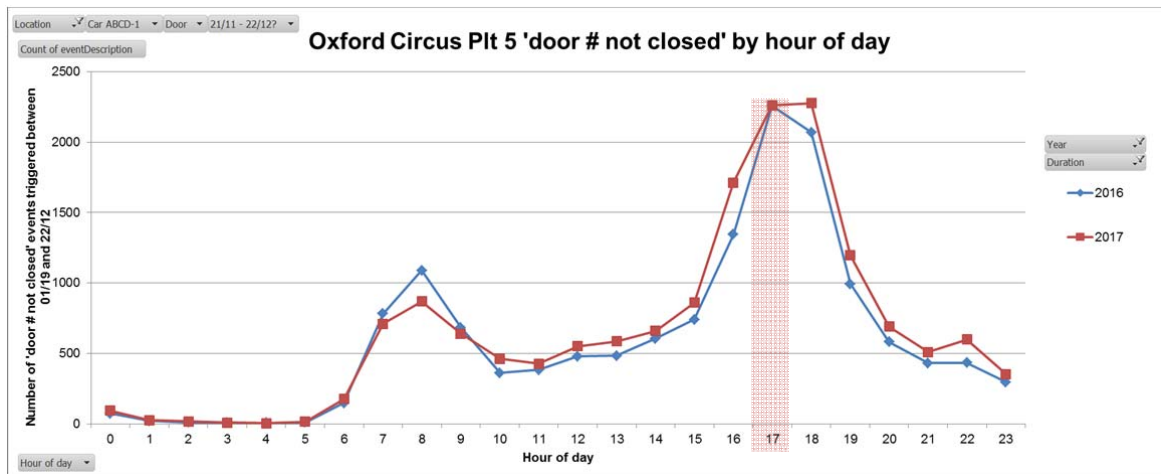
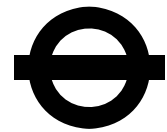


Figure 8: The total number of 'door # not closed' events recorded between 01/09 and 22/12 at Oxford Circus platform 5 for both 2017 (trial) and 2016 (baseline)

The Orbita data combined with platform observations demonstrates that door obstructions are more likely to increase with door chime duration in certain areas and at particular times where passenger numbers are significant, congestion is low and the point of access to the platform allows passengers to see or hear the train in the platform.

## 11.3 Boarding Trains Questionnaire

The questionnaire was designed to answer the following questions:

- Whether passengers use the door chimes to stand back or hustle into the train
- What safety risks passengers perceive when boarding trains
- Whether passengers want the duration of door chimes to increase
- Whether any passengers had noticed a change in behaviour since the trial started
- Whether the answer to these questions differs depending on whether the passenger considers themselves to have a disability

The questionnaire was constructed in several parts in order to prevent later questions affecting the answer to earlier questions. In the part relating to their typical behaviour, the questions were situational and weren't focused on the door chimes alone so as to not put too much focus on them.

216 responses were received, which is considered sufficient to gain some understanding, but is a very small sample compared to the approximate 75million passenger journeys on the Victoria line during the trial. None of the questions in the questionnaire were mandatory and so some respondents skipped questions. Broadly, there were about 150 responses that were 'useable' for the pertinent questions.

Figure 9 shows how respondents say they behave when they see a train waiting to depart with results for both those that considered themselves to have a disability and those who did not. This shows that those who do not consider themselves to have a disability are more likely to rush towards the train than to wait for the next train.

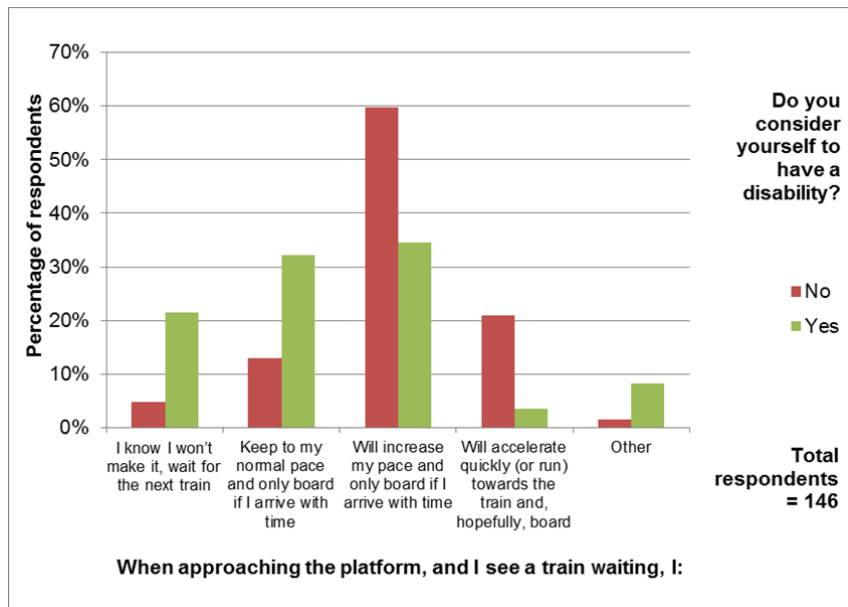
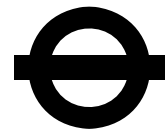


Figure 9: Responses to Question "When approaching the platform, and I see a train waiting, I:"

Figure 10 shows the answers to how passengers behave when they've been waiting for the train, are in the process of boarding and hear the door chimes. Similarly, those that consider themselves to have a disability are more likely to play it safe and stop boarding.

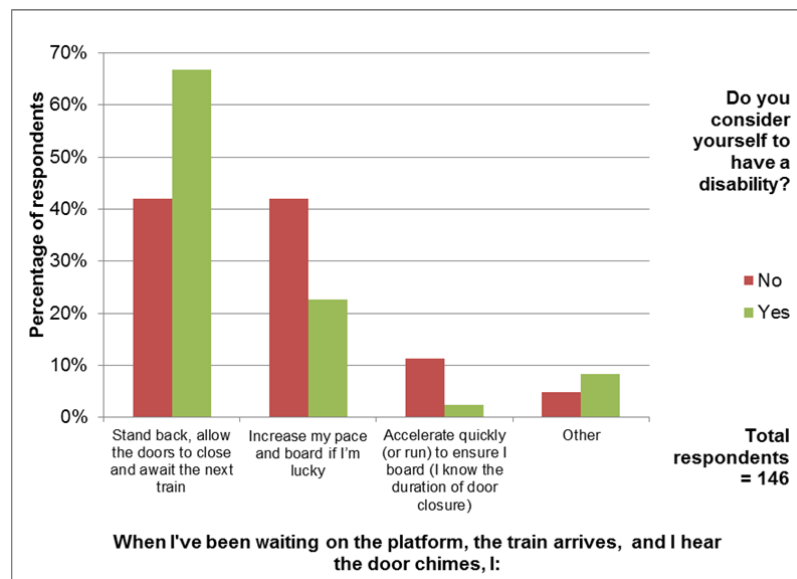
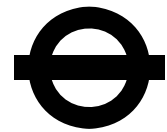


Figure 10: Responses to Question: "When I've been waiting on the platform, the train arrives, and I hear the door chimes, I:"

When asked which aspects of boarding the train make the passenger feel unsafe, whether or not the passenger considered to have a disability, the results were broadly the same (Figure 11). For note, of the 106 respondents to this question, 77 considered themselves to have a disability and 29 considered themselves to not have a disability. The risks highlighted in blue are those associated with 'door closure



risks' (as discussed in Section 9) and those highlighted in green are those associated with the 'hustle effect risks'.

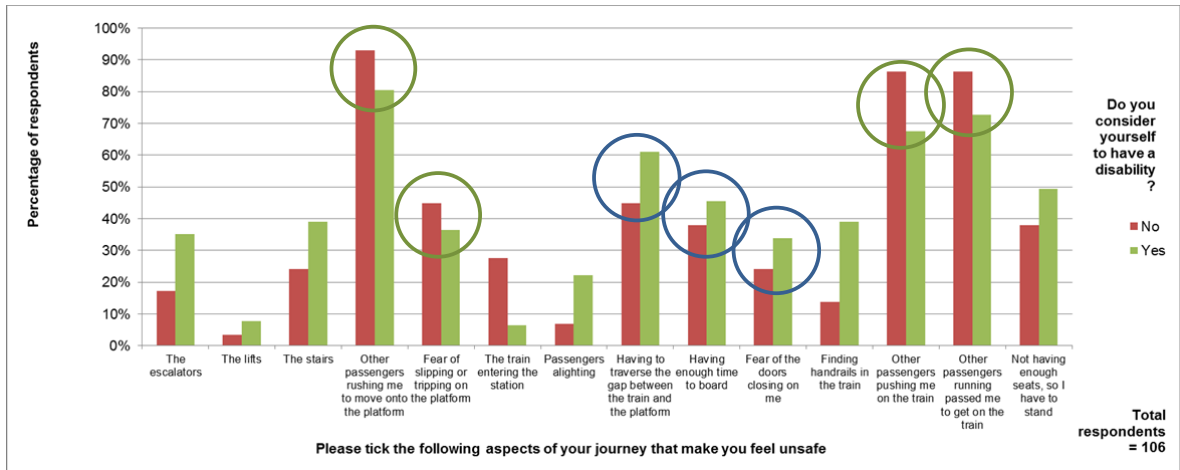


Figure 11: Responses to the Question "Please tick which aspects of your journey make you feel unsafe"

With the exception of 'fear of slipping and tripping on the platform', all the 'hustle effect risks' are perceived to be bigger safety risks to all passengers than the 'door closure risks'. Though there is a slight difference between which group of people perceived a risk to be higher compared to the other group, amongst the respondents who considered themselves to have a disability the risks associated with other passengers were still perceived to be bigger risks than the 'door closure risks'. The pertinent risks are shown in Figure 12 in order of perceived safety risk.

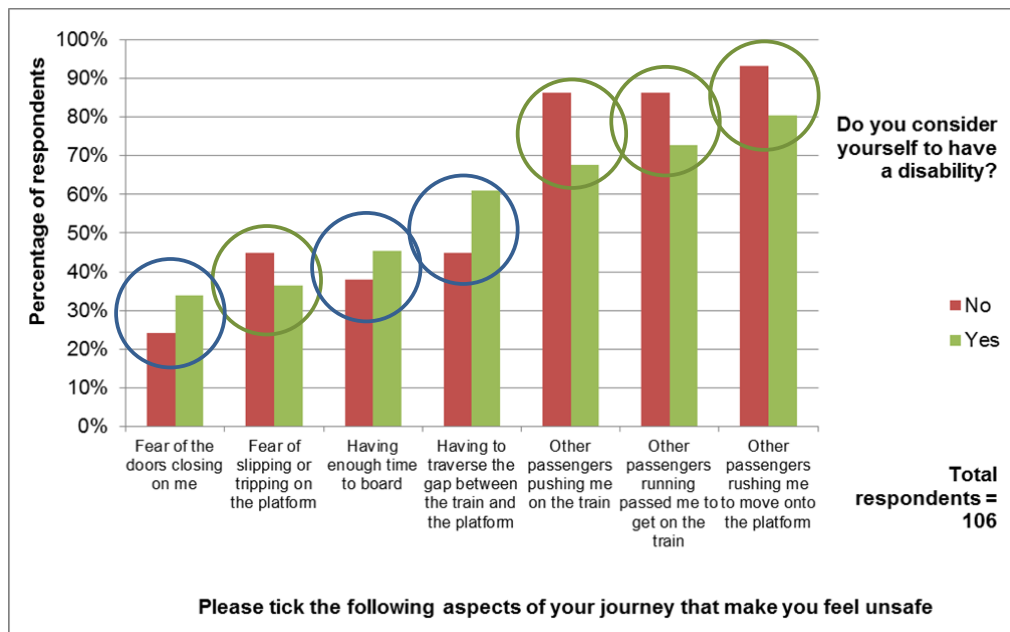


Figure 12: An extract of the responses to the Question "Please tick which aspects of your journey make you feel unsafe", to only show the risks associated with 'door closure risks' and 'hustle effect risks'.

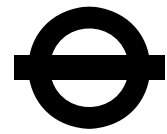


Figure 13 shows the results to the question “would increasing the door chimes make you feel more safe?”. This shows that those who consider themselves to have a disability are more likely to say ‘yes’ than those who do not have a disability. Even without presenting the consequences of increasing the door chimes (decrease in train capacity and potential ‘hustle effect risks’), only a small majority responded with ‘yes’.

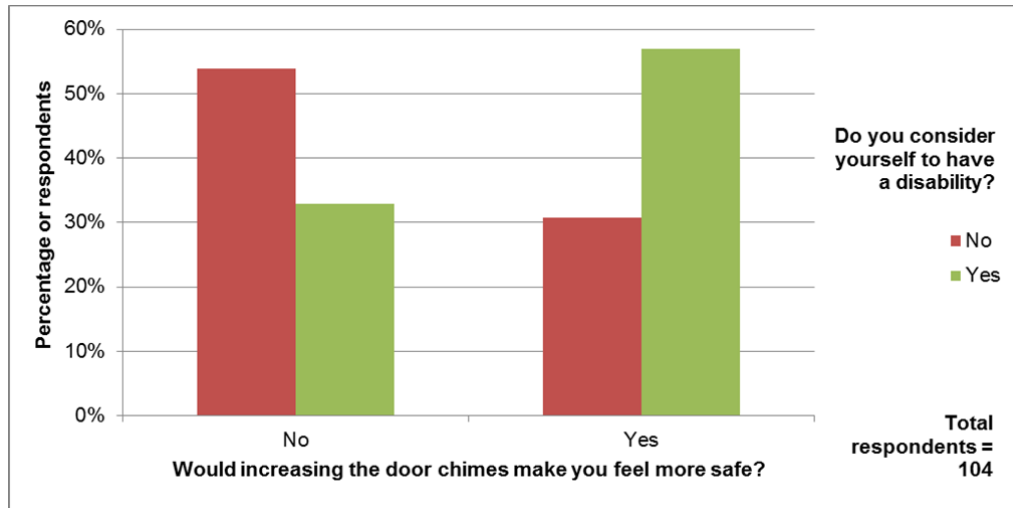


Figure 13: Responses to the Questions "Would increasing the door chimes make you feel more safe?"

## 11.4 Reported PTI incidents

As discussed in Section 10.1.3, the number of reported pertinent incidents is low and so cannot be used for comparative purposes. However, they have been analysed to give an understanding of the reported incidents.

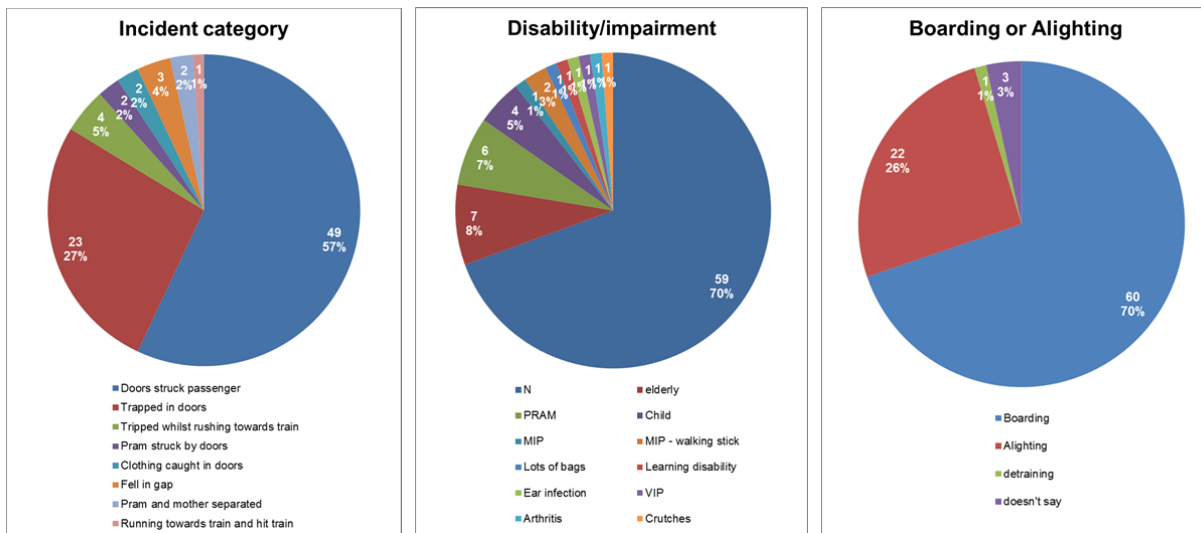


Figure 14: Categorisation of relevant reported incidents



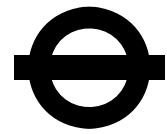


Figure 14 shows that the most common incidents reported, that are related to door chimes, are of being struck or trapped in the doors and whilst boarding. Though it is not a requirement to ask a passenger whether they consider themselves to have a disability or not, it is noted if it is relevant to the report. In the figure, 'N' represents no disability or if no disability was mentioned.

This analysis supports the logic that the risks associated with door closure (strike and trapping) are most common whilst boarding and therefore, could be impacted by the hustle effect.

## 12. DISCUSSION

The agreed methodology for the Victoria line door chimes trial was to consider the following three factors in this priority order:

1. Safety
2. Accessibility
3. Capacity

### 12.1 Safety

The Orbita data analysed shows an increase in door obstruction events associated with longer door chimes. Some of these may be due to more events being recorded due to increasing the time to complete the door close sequence. However, by analysing the event durations, there is evidence to suggest that there is an increase in genuine door obstructions.

This is supported by platform observations which indicate that the 'hustle effect' is most prevalent at locations where the train is visible from a cross passage or access point and at times when congestion is low and there is a clear route to run to the train. Therefore, at these locations and times the Orbita data shows that the 'hustle effect' has increased with the longer door chimes.

The questionnaire showed that passengers perceive the biggest safety risks are associated with the behaviour of other passengers, and that these are higher than those risks associated with door closure itself.

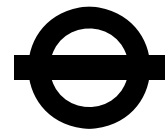
### 12.2 Accessibility

The questionnaire showed that some risks are more of a concern to passengers who consider themselves to have a disability over those who don't. These include risks associated with rushing towards the train when door chimes sound, and the train doors closing. As a result, those who consider themselves to have a disability are more likely to feel that longer door chimes will make them feel more safe.

However, when asked which aspects of their journey make them feel unsafe, all respondents broadly agreed that risks associated with the 'hustle effect' are more of a concern over other risks. This was irrespective of whether they considered themselves to have a disability or not.

This validates London Underground's approach of balancing the 'door closure risks' and the 'hustle effect risks', without any indirect discrimination against those with a disability.

It also highlights how much other people's behaviour affects how safe LU's passengers feel, and therefore any change to the railway that would increase this concern would be considered unfavourable.



## 12.3 Capacity/service

The service metrics are unable to show with any certainty that the increase in door chimes has impacted the service either directly or indirectly, but this was predicted due to the lack of resolution provided by these metrics.

However, an increase in door chimes will theoretically always negatively impact a high capacity railway. Though capacity should not be provided at the expense of accessibility or safety, evidence suggests that safety and potentially accessibility are negatively impacted by longer door chimes and consequently, the benefits of increased capacity (associated with shorter door chimes) are significant.

## 12.4 Impact on other LU stocks

LU's approach is to manage passenger behaviour and the safety risk associated with the door chimes by having a consistent duration on all trains on the network. Though the Victoria line has different features and constraints, it is thought that there are comparable aspects to all LU lines. On the Victoria line platforms, for example, entry via cross passages from escalator lower concourses is the layout for the majority of platforms. Though a majority like this may not be the case for other lines, they are still present, in addition to other layouts such as cross-island interchanges. The timetable of the Victoria line is the highest capacity timetable of all LU lines, however, this is considered to minimise the 'hustle effect' as passengers may be less inclined to rush towards the train when there is another train in 100 seconds. Stations like Euston and Victoria are 'gateway' stations between LU and the mainline, where users are often unfamiliar with the network, unsure of when the following train may arrive and therefore might be more inclined to rush towards the train. Therefore, it is concluded that the results of this trial are relevant to other LU lines.

On 72TS the door chimes are provided simply due to the time it takes for the doors to start moving; as the door system is pneumatic it results in a slight variability of door chime duration before the doors begin to close.

On more modern stocks, the door chimes duration is managed using relays which would need adjusting if the door chimes duration was changed. There is less variability in these stocks.

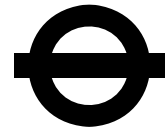
On post-1998 rolling stocks (09TS and S stock), the door chimes duration is a parameter on the software of the control unit and so door chimes duration can be managed via a software update. This parameter is only configurable to 0.1 seconds.

Regardless of the chosen door chimes duration, it is recommended that a consistent approach is taken across all stocks.

However, it should be noted that some variability will be experienced and that a tolerance may need to be included reflective of the door closure and door chimes mechanism(s).

## 12.5 Origin of 3 seconds

Both the DfT and LU have looked into where the requirement for 3 second door chimes was derived and both have reported that no research can be found. It appears that it was originally thought of as a 'good idea' and no work has ever been done to validate this requirement. At the time of RGS development, risk assessments were unlikely to have been carried out and therefore has not been justified in risk terms.



This is supported by the fact that the PRM TSI has a different requirement for door closure duration (which is 2 seconds). This does not appear to have been based on risk, as often access to the train can be more challenging with larger steps and sometimes steps to get into the vestibule.

It is concluded that there is no evidence to suggest that either 3 seconds or 2 seconds door chimes provide improved accessibility.

## 13. CONCLUSION & RECOMMENDATION

The evidence collected/derived by this trial has shown:

- Potential safety risk improvements associated with longer warning to clear the doors before closure is outweighed by the actual and perceived safety risks associated with increased tendency to rush towards and get caught in the doors that are closing.
- Those who consider themselves to have a disability and those who do not consider themselves to have a disability agree that the 'hustle effect' risks are their greatest safety concerns, and those associated with door closure itself are of a lesser concern. Therefore, this balance of risk applies equally and there is no indirect discrimination.
- Any theoretical negative impact on capacity and longer door chimes is not a primary consideration. However, because safety has been shown to be negatively impacted and the balance of risks applies equally regardless of disability, then the potential loss of capacity is a valid consideration.

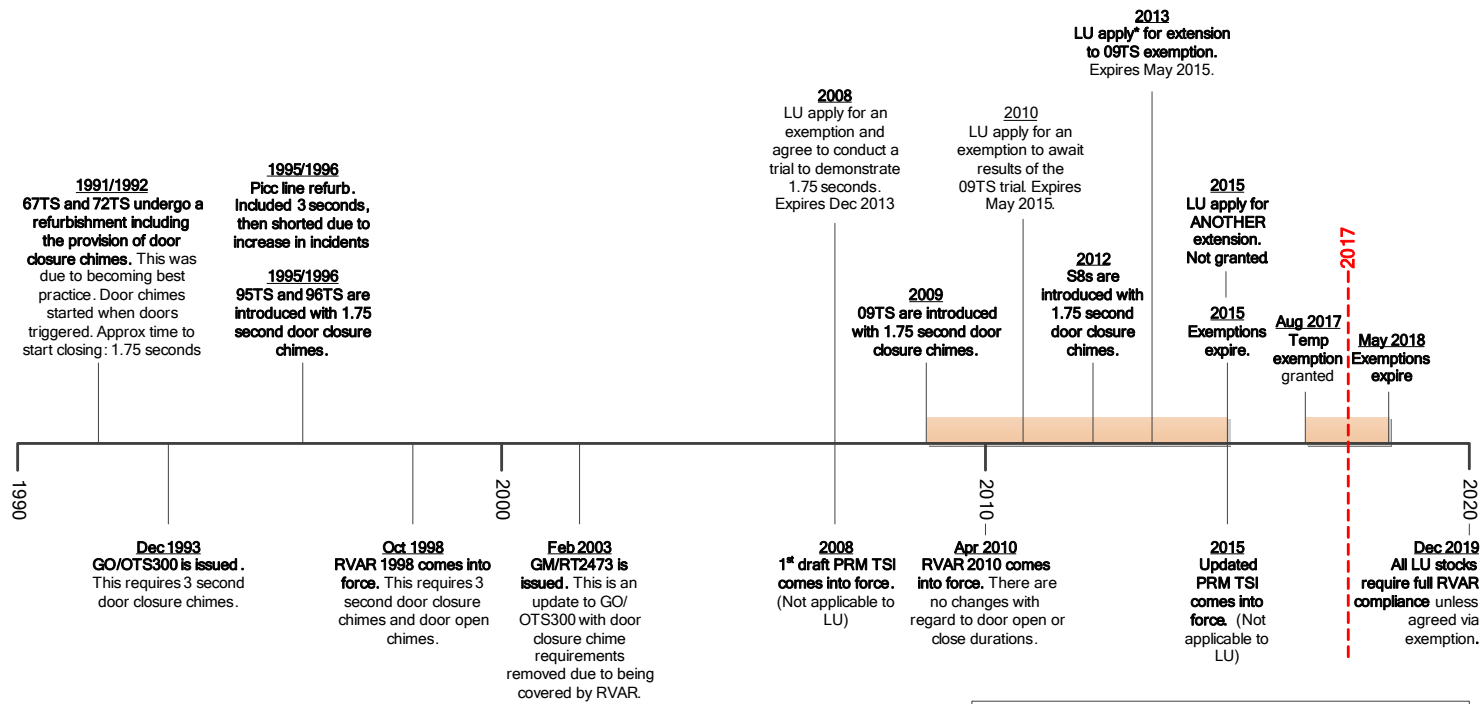
These conclusions were presented to the DfT on 6 February 2018, where they confirmed that an exemption would be considered.

It is recommended that door chimes on all London Underground passenger rail vehicles remain as existing, which is  $1.75 \pm 0.25$  seconds.

It is recommended that an application for exemption by March 2018.



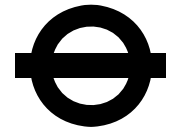
## 14. APPENDIX A



**Time period covered by exemption**

Grounds of all previous exemptions have been on the basis of LU's hypothesis of causing a 'hustle alarm' effect. DfT and LU agreed that this should be test via a trial. Time limited exemptions granted to await results of the trial

\* LU claim that it is unsafe to conduct the trial and present service modelling. They ask for a permanent exemption DfT extends to the same time period as S8 and again asks for a trial to be conducted. ORR does not support the extension at all due to the lack of trial data



## 15. APPENDIX B

### 15.1 Door close duration increase

Mid-way through the trial, it was noted that the probability of triggering the ‘8 second’ event is likely to increase simply by increasing the door chimes duration. A normal closing door operation takes approximately 4.5 seconds from pressing the ‘door close’ button to receiving confirmation the doors have proven closed (includes the 1.8 seconds door chimes). Adding the 1.2 seconds on the door chimes (to make 3 seconds total duration), therefore means normal door operation increases to 5.7 seconds. When there is an obstruction during door closure, this triggers obstruction detection where the door reverses, pauses then closes slowly. The time it takes for the door to complete this cycle depends on where in the door closure cycle the obstruction is detected. With 1.8 second door chimes, the door closure sequence with one cycle of obstruction detection can take between 7.8 seconds and 9.2 seconds. With 3 seconds door chimes, this increases to between 9.0 and 10.4 seconds. Therefore, there is a small number of incidents that previously might not have triggered an Orbita ‘8 second’ event that with 3 seconds door chimes will now trigger an event.

The effect was tested on a non-service train and measured with both 1.8 second door chimes and 3 second door chimes, and it was found that obstructions within 10cm from the door closed position are the only obstructions that would be missed with 1.8 seconds that then are captured with 3.0 seconds. Theoretically, the obstructions that trigger this type of event are most likely due to bags and coats getting caught when a passenger is already in the train and therefore this isn’t the ‘type’ of incident that would demonstrate the hustle effect anyway. However, this type of incident could explain part of the large increases in incidents during the peaks, where trains are often full and so coats and bags getting caught is not uncommon.

In order to understand if there is a safety risk increase, it is desirable to differentiate this effect from any genuine increase in door incidents. Each Orbita event has a ‘duration’ associated which is approximately the duration for which the conditions are true. For ‘Door # not closed’ this would approximately relate to the time over 8 seconds that the doors remain open. However, Orbita does not log an event duration of less than 2 seconds (for any event, not just door related events) due to limitations in the Orbita system. This is shown in Figure 15, which is a simplistic schematic of how Orbita event durations may relate to the time it takes to close the doors.

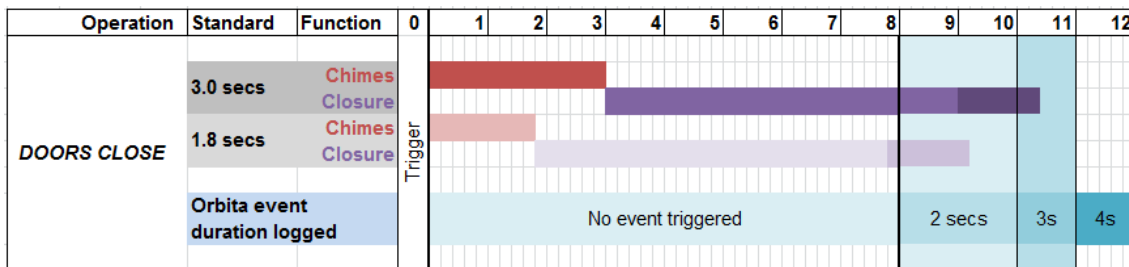
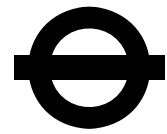


Figure 15: The range of possible closure times with a single obstruction detection cycle, and the categorisation of event durations

At Highbury & Islington, the durations can be seen to have increased for all durations logged until approximately 6 seconds, see Figure 16. If we assume that the natural pick-up of additional events



would result in a duration of 2 seconds (because if was any longer, then it would've been picked up in both cases), then the events with duration of 2 seconds have to be used with caution. Figure 16 shows that the number of Orbita events increases for all other durations, most notably at 3 seconds. Therefore, it is deduced that the natural pick up of additional events accounts for only a portion (and potentially small portion) of the increase.

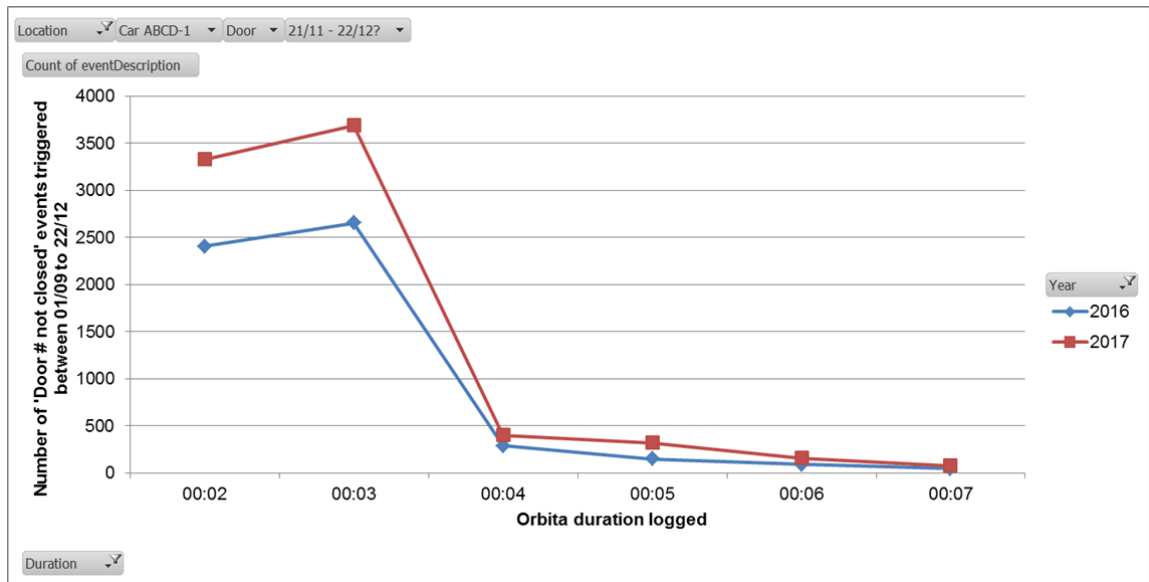


Figure 16: The number of Orbita events triggered against the duration that was logged