OFFICE OF RAIL AND ROAD

Market Study into the supply of automatic ticket gates and ticket vending machines

Safety report – automatic ticket gates

September 2018

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Biography

This report has been prepared by an ORR Inspector who has worked as a Railway Inspector since 2000. He has extensive experience in infrastructure and systems safety and was closely involved in the regulators' oversight of the installations of ticket gates at many UK stations, as well as being involved in the development of the Rail Industry standards and guidance for ticket gates. He currently leads the ORR work on Health and Safety by Design.

1. Introduction

1.1. The Rail Safety Directorate (RSD) in ORR was commissioned by the ORR market study team to produce a report into the relative safety of ticket gates in Great Britain. This work is to support the analysis of outcomes on quality using safety as a metric.

1.2. RSD was instructed to produce a report outlining:

- The history of ticket gates, dating back to when they were first introduced in Great Britain
- Relevant safety legislation and standards, including design and placement of gates
- Basic facets of Great British ticket gates including model types and basic operational principles
- Safety benchmarking on a risk assessment basis
- Horizon scanning and innovation.

1.3. In developing this report, RSD drew on publicly available evidence, evidence gathered by the market study team and their own internal expertise. In addition, RSD (through the market study team) issued seven information requests to TOCs and metro systems to gather specific evidence on safety.

2. History of station gating in the UK

Reasons for gating

2.1. Ticket checks have traditionally been used at railway stations to control access to trains for those with valid tickets from the earliest days of railways. Generally, this took the form of a member of staff checking the tickets of each passenger by eye as they entered or left a specific platform or station. This process has limits on the speed it can process passengers as well as limits on the information that an individual member of staff can memorise on ticket validity.

2.2. With the advent of machine readable tickets the opportunity arose for automation of this process. The magnetic stripe on the back of what are now standard credit-card sized UK paper rail tickets allows for a small amount of key information to be stored to allow electronic validation. These 'APTIS' tickets were introduced in the 1980's and gradually replaced the various forms of paper ticket used up to that time.

2.3. Automation also allows for tickets to be automatically retained at the end of relevant journeys, reducing the risk of them being re-used fraudulently.

2.4. The ubiquity of barriers at both entry and exit to a rail journey can help to reduce ticketless travel and hence revenue loss, though there are a variety of ways in which determined fare evaders can elude the system. The automation of checking does in turn allow the use of staff for revenue protection to be more targeted.

2.5. As well as a way of reducing fare evasion, gates can also be used as a form of crowd control to limit the access into a station or platform. This can be seen in practice in central London LUL[1] stations where reducing access into stations at street level is used as a way of managing potential overcrowding at lower levels in stations.

2.6. Automation does also help to provide a level of objective detailed information on entry and exit levels to stations at the time the gates are in use. This can help in monitoring trends in station usage at specific times, and assist planning of station management and development.

2.7. The development of smartcards of various forms has allowed for more information to be stored and exchanged between 'tickets' and gates that is allowing more sophisticated validation processes and ticket types. It can also provide train operators with better understanding of passenger travel habits.

[1] London Underground Limited

2.8. The whole ecosystem around ticketing continues to evolve as ‘tickets’ move toward software based products held on passengers mobile devices and the types of sale and validation available also expand to fit differing market needs.

Main suppliers

2.9. The majority of the railway and metro station ticket gates in the UK are supplied by Cubic Transportation Systems (Cubic)[2], with a small proportion supplied by Scheidt & Bachmann GmbH (S&B)[3].

Gates

2.10. Ticket gates are normally provided in a station in an array referred to as a ‘gateline’. Within the gateline, there will be a combination of a series of gates for passengers, these may be ‘standard’ or ‘wide aisle’ width and may be single or bi-directional, there may be an associated vehicle gate, a wide aisle gate, and sometimes luggage chutes. What is provided at each gateline is dependent on the station needs and passenger flows.

2.11. Each gateline will also have a local control panel for staff to interact with the system to set the direction of gates or take them out of service.

2.12. In some stations, there may be additional controls in ticket offices or other control rooms that have oversight of gatelines.

2.13. In some stations where there are lightly used gatelines at secondary entrances, there are CCTV assistance points for passengers who have difficulty These link to the main station gateline and allow staff to inspect a passenger’s ticket by CCTV and then remotely open a gate if required. These systems allow the lightly used gateline to be remotely monitored in off-peak periods.

2.14. Each gate is provided with a display toward the passenger showing where it is set for their direction, the convention has settled on a green arrow for gate set in the direction for a passenger to move forward and a red cross for a gate set the opposite way or out of use.

2.15. The displays will also provide additional information to passengers such as warnings on low ticket funds, error codes when tickets are rejected, alerts to expiring travelcards etc. The different types of gates have differing display capabilities largely reflecting the development of display technology over the period that gates have been deployed.

[2] https://www.cubic.com/solutions/transportation

[3] https://www.scheidt-bachmann.de/en/fare-collection-systems/

2.16. At some very busy stations that are subject to large levels of passengers on the concourse the green arrow and red cross are replicated at high level above each gate to allow approaching passengers more advance warning of which gates they should head toward to pass through the gateline. These additional signs can help to reduce passenger flow conflict.

Gates Technology

2.17. Cubic have provided gates in the UK market for many years.

2.18. The early Cubic gate designs used pneumatically operated gate paddles, and forms of these can still be seen at a number of London Underground stations today.

2.19. Cubic have moved on to electrical motor control for gate paddles and this form of operation is also used by the Scheidt & Bachman gates.

2.20. Early forms of the S&B gates used a panel that rotated up and sideways in the vertical plane to open.

2.21. Gates in the UK have tended to make use of a paddle type of gate which is normally closed but swings open when a valid ticket is presented. This preference is rooted somewhat in early safety concerns of HM Railway Inspectorate that gates should be able to be forced through in emergency situations, and also following an incident in the 1980's.

Consent to install gates at stations

2.22. In the UK the bulk of railway stations are managed by the train companies that operate the majority of services from that station. The stations themselves are however generally in the ownership of Network Rail and leased to the train operators.

2.23. A decision by an operator to install gates normally therefore requires the consent of Network Rail, and will also be consulted with any other passenger train operators using the station.

2.24. Until 2006, it was also a legal requirement to obtain the Approval of the Rail Regulator to the installation of ticket gates at a station due to the potential impact on passenger crowding and safety. This duty arose under the Railways and other Guided Transport Systems (Approval of Works, Plant and equipment) Regulations 1996. In these cases, the station operator would prepare a case for the Regulator showing the assessments of passenger flows and risks, and the proposed layout. The Regulator would then normally issue an approval in principle to the scheme and agree a period of trial; this allowed the gatelines to be installed and trialled in real

world conditions. Subject to a successful end of trial report the Regulator would then issue a full Approval for the works.

2.25. This system of approval was abolished in April 2006 when the previous regulations were replaced by the Railways and Other Guided Transport Systems (Safety) Regulations 2006. The new regulations no longer required operators to gain the consent of the Regulator for new or modified works, but required instead that internal company change control systems were robust and if necessary that an independent 3rd party competent person was brought in to advise on projects.

3. Non-station gating

3.1. Gating is used not only in the context of public transport. Various forms of gates can also be seen at sports stadia, office buildings, airports and locations where security is important.

3.2. The type of gate used is often highly dependent on the location, degree of supervision, and type of users; entry to a secure compound may require a full height interlocked turnstile embedded into a fence line, whereas a modern office block might opt for a minimal glazed barrier systems, and a sports stadium for a robust traditional turnstile.

3.3. The larger secure gates and turnstiles can often be problematic in transport situations as they can be difficult to negotiate at other than low speed and present problems for those with anything other than small hand luggage. Traditional turnstiles can operate quickly but also present issues for those with luggage. Both types also present problems for those travelling with children, bicycles and dogs, and are generally not suitable for those in wheelchairs or mobility scooters.

3.4. The minimalist barrier solutions seen in office buildings reflect the relatively secure environment that they operate in and generally offer little hindrance to those wishing to bypass them, though increasingly more secure types with barriers extending over a greater vertical distance are being seen in these situations.

3.5. The minimalist barrier types do little to prevent fare evasion or control crowding and are therefore unlikely to offer the level of security needed for use at most rail stations.

3.6. Barriers for use in office environments are also subject to relatively benign environmental conditions, unlike rail stations, which can see large variations in temperature and humidity levels.

Issues around powered vehicle gates and injuries

3.7. Section 10 below reviews the available data on accidents and injuries that can be linked to automatic ticket gates in UK transport systems.

3.8. In other sectors such as the provision of large automated vehicle gates there have been a number of fatalities, mainly of children, associated with powered gates trapping children where there was no suitable sensor arrangement to detect the trapping and the force of the gate mechanism was high enough to cause a fatal injury.

3.9. The gates and motors used in these vehicle applications are however significantly larger than those in use in passenger ticket gate applications, and while there are

lessons to be learned about the importance of trap detection and force limitation there is no direct link between the types of machines used in the two contexts.

3.10. The Health and Safety Executive has issued guidance[4] and a Safety Bulletin[5] in January 2011.

[4] http://www.hse.gov.uk/work-equipment-machinery/powered-gates/introduction.htm

[5] http://www.hse.gov.uk/safetybulletins/poweredgates.htm

4. Applicable safety legislation

4.1. In the UK the Health and Safety at Work etc. Act 1974 sets the overall framework of law governing how employers should conduct their business to ensure the safety of their staff and other people. Section 2 of the Act deals with duties to employees and section 3 with duties to other people. There are also duties under section 6 of the Act on those who supply equipment.

4.2. The Act also allows the creation of subsidiary legislation, and in the context of ticket gates there are relevant duties under the Management of Health and Safety at Work Regulations 1999 to conduct risk assessments and act on the findings, also there are duties under the Provision and Use of Work Equipment Regulations 1998 (PUWER) regarding the safety of equipment.

4.3. PUWER is considered to implement some of the requirements of the EU Machinery Directive 2006/42/EC.

4.4. Compliance with many aspects of regulations such as PUWER would normally be delivered by ensuring that equipment meets relevant British and European standards, for example on electrical safety.

5. Applicable standards

5.1. At present there is no specific British Standard specifically for ticket gates. However, a number of aspects of the gates will be covered under more general standards. Below the level of a Standard There are a number of guidance documents that deal with ticket gates.

General Standards

5.2. In relation to powered gates, the HSE recommends that forces should be limited to those specified in Annex A of BS EN 12453:2001 *"Industrial, commercial and garage doors and gates. Safety in use of power operated doors. Requirements".* Further information is available on the HSE website[6].

5.3. The forces set out in BS EN 12453:2001 are set over an initial 0.75 second phase when the limit is either 400 N when the gap is up to 500 mm, or 1,400 N when the gap is wider than 500 mm, and then after the initial 0.75 seconds the force should be no greater than 150 N. the standard then indicates that the force should drop to 25 N after 5 seconds.

5.4. In BS EN 81 relating to passenger lifts, there is a limitation in place that the effort needed to prevent the door closing shall not exceed 150 N, i.e. which is the maximum force that a closing door should put onto a passenger. It also sets a maximum imparted kinetic energy of 10 Joules.

5.5. Though the application may be different these can be considered as useful reference values when looking at the similar situation in a ticket gate where the gate paddles might come into contact with a passenger.

Guidance - Mainline Railway Group Standard

5.6. For the UK mainline railway, the Rail Safety & Standards Board publishes a Rail Industry Standard for Automatic Ticket Gates at Stations[7]. This was published in March 2011 and replaced a previous Group Standard and Guidance Note (GIGN7515 and GIRT7015) originally published in February 2003.

5.7. The RSSB standard indicates in section GN45 that:

"In the event that a passenger becomes trapped in the gate paddles, they should not experience a contact force from the gate paddles of greater than 0.49 kN in the

[6] http://www.hse.gov.uk/safetybulletins/electricgates2.htm

[7] https://www.rssb.co.uk/rgs/standards/RIS-7701-INS%20Iss%201.pdf

direction of entry to the 'paid side' of the station or 0.39 kN in the exit direction from the 'paid side' of the station."

5.8. 0.49 kN may also be expressed as 490 N, this should be contrasted with the 150 N allowed for in passenger lift door closing forces. The ticket gate maximum force is therefore set at just over three times that of a lift door but is considerably less than the 1,400 N permitted under the standard for power operated doors and gates.

LUL – Station planning guidelines

5.9. The London Underground Station Planning Standards and Guidelines do not appear to set any recommended maximum force that gates should apply.

6. Design and Placement of gatelines

Mainline – Current Rail industry Standard and the previous Railway Group Standard and Guidance Note

6.1. The RSSB Rail Industry Standard for Automatic Ticket Gates at Stations not only sets out the suggested forces which a ticket gate should apply but also offers considerable guidance on the planning and layout of gatelines within stations.

LUL – Station planning guidelines

6.2. The LUL standard has detailed recommendations in calculating the assumed flow rates of rates and the dimensions of gate lines and their proximity to other station facilities[8].

Department for Transport

6.3. The Department of Transport does not set any specific guidelines or standards for automatic ticket gates, though their publication *"Inclusive Mobility"*[9] notes in section 9.1 *"Many rail systems are becoming closed with barriers at entry and exit points. Standard designs of barriers are not accessible to wheelchair users and are difficult for other disabled people. At each ticket barrier, the availability of assistance for mobility-impaired travellers should be clearly signed, as should an alternative, accessible route through the ticket checking and collection area."*

Planning and layout

6.4. In both the mainline and LUL guidelines there are similar principles on the planning of gateline installations at stations.

6.5. For example, there are assumptions on the minimum distances between gatelines and other station features such as stairs or escalators, the minimum numbers of gates needed to accommodate the volumes of passengers that are needed.

6.6. The development of layouts has to begin with surveys of existing passenger demand and peak flows. These then need to be developed to account for future passenger growth.

6.7. It is important that surveys are conducted over times that are representative of the regular peak passenger levels and this requires knowledge of the specific station

[8] It should be noted that the LUL document is not considered to be a 'public' document so no link is provided to it. ORR has copies of this through regulation and inspection of LUL.

[9] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/3695/inclusive-mobility.pdf

and the passenger mix. For example, surveying a station on a weekend in August if it principally serves a University is unlikely to pick up peak flows, whereas the opposite might be true of a station in a seaside town.

6.8. There are a number of software packages that can then be applied to station layouts to model the flow of passengers to predict where congestion might occur. The different packages vary in their sophistication and approach, but all need to be based on accurate initial data in order to help model potential flows sensibly.

7. Types in use in UK Transport today

7.1. As noted elsewhere in this report the majority of the automatic ticket gates in UK rail and LUL stations are provided by Cubic, and originate from their early pneumatically operated designs, to become the more modern forms of electrically operated gates which come in a 'long' and 'short' configurations.

7.2. The other supplier to mainline operators is Scheidt & Bachman, whose gates are also used by Tyne & Wear Metro and Glasgow Underground.[10]

7.3. All gates currently in use at UK stations accept the standard UK paper credit card sized rail tickets, using the data encoded in the magnetic strip to undertake validation. The standard magnetic strip used on UK tickets accommodates 192 bits (24 bytes) of data in total, though only 152 bits (19 bytes) are used for ticket information, the remainder being used for headers etc.

7.4. Gates in the LUL network and at various stations in the South of England (notably within the TfL Oyster zones) have been equipped with contactless card readers. These use both Radio Frequency Identification (RFID) and / or the Near Field Communications protocol (NFC) depending on the type of card or device being used.

7.5. Some TOCs have also chosen to add QR code readers[11] to their gates where these codes are used on their print at home rail tickets or mobile applications.

7.6. There are therefore currently three main forms of ticket validation across the UK, paper ticket, barcode and contactless.

7.7. A range of smart card ticket options exist across the UK operators, with little or limited interoperability between them. For example, the Oyster card implementation in London[12], and the various forms of ITSO compatible card[13].

[10] https://www.scheidt-bachmann.de/fileadmin/downloads/en/fare-collection-systems/FareGo/Flyer_FareGo_Gate_PG40_E.pdf

[11] A QR code is a square barcode

[12] https://tfl.gov.uk/fares-and-payments/oyster/what-is-oyster

[13] https://www.itso.org.uk/about-us/what-is-smart-ticketing/

8. Gateline operational principles

8.1. Each station gateline installation will comprise an array of gates, usually capable of operating bi-directionally, with a mix of standard width aisles and wide aisle gates. Some older gatelines still have wide manual gates rather than automatic wide aisle gates. Some installations also incorporate separate luggage apertures alongside the automatic gates.

8.2. Each gateline is also provided with a local control unit to allow staff to view status messages and set the direction and function of gates. This will also normally incorporate an emergency plunger that can be used to put all gates into the open position.

8.3. Each station will have linked to the gateline a main computer system for the collation of data from the gates.

8.4. Dependent on the size, complexity and specific installation details of a station there may be multiple separate gatelines, requiring separate local control panels, some with panels installed in station control rooms with separate emergency open plungers.

8.5. Regardless of the type of ticket or validation process there is a generic process to the operation of automatic gatelines. A passenger presents a ticket, the gate reads the ticket information, and then a validation check is undertaken to ensure that it is valid for travel. If the ticket is valid then the gate will open to admit the passenger.

8.6. Validation processes can capture a range of ticket problems and (intentional and accidental) abuse of tickets. For example, a common validation process is to check for ‘pass back’, that is the event where a person passes through the gate with a valid ticket then physically passes that ticket back to a second person who then tries to use it to pass through the gate. By recording the serial number of the ticket the gate can directly block that type of abuse.

8.7. Simple checks such as the date on which the ticket is valid are also commonly used, both with single journey tickets and season tickets.

8.8. As the passenger passes through the automatic gate, a series of sensors in the walls of the gate aisle will track their movement to ensure that the gate does not close on them, but does close to prevent a second person from tailgating the first. Conventionally wide-aisle gates are configured with longer opening times to make these safer for passengers travelling with small children or luggage, hence the importance of these types of passengers being directed to the wide-aisle gates rather than the standard type.

8.9. In systems such as those used by Transport for London, a slightly different form of validation can be applied to passengers. In these systems, the user can present either a bank debit card or a system specific card that allows a cash sum to be debited from an account related to the journey undertaken. This requires the passenger to 'touch in' and to 'touch out' at each end of their journey so that the ticketing system can calculate the appropriate fare and then debit this from the customer's account.

8.10. These systems can accommodate varying degrees of sophistication. For example, the TfL system aggregates passenger's journeys made using the same card when a number of separate trips are taken and if the level of fares charged is greater than the equivalent travelcard allowance, then the fare debited from the customer's account is capped at the travelcard fare. This 'capping' can be done on a daily basis or for longer time periods.

8.11. This process does require additional levels of communication between the gateline and back office systems to ensure card identity data is passed between the gate and systems to check available stored value and validity.

8.12. On the mainline railway Chiltern Railways is currently operating a trial of a 'post pay' system where passengers use a smartphone application to start and end their journeys (either by contactless validation at a ticket gate or using a 'start journey' function in the app for stations without gates) and on the basis of which they are billed for the best value fare for the journeys they have made. This still works within the established national fares structure helps to ensure that passengers should receive the most cost-effective ticket for the journeys they have made.

9. Assessment of relative risk

9.1. ORR RSD team has sampled the hazard and risk assessments of a number of operators of automatic ticket gates in the UK. The issues flagged by the operators at their stations with ticket gates are consistent though understandably some are very location specific.

9.2. In the majority of cases risk assessment outcomes across the operators were consistent in terms of 'scoring' of relative risk. In most cases, risks were judged to be low outright, or after the application of control measures. In a few specific cases risks were flagged as 'medium' but all the instances noted were location specific, for example a particular station with a known level of anti-social behaviour had a medium risk for staff assault which lead to the identification of the need for additional staff with support from security staff or British Transport Police at certain times.

Incident history

Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR)

9.3. In the 2016-17 reporting year there were 22,355 RIDDOR reportable incidents across the mainline railway, London Underground and other transport modes to passengers, staff and members of the public.

9.4. A review of accidents and incidents that meet the threshold for reporting under RIDDOR for the last five years shows only five incidents that can be directly linked to automatic ticket gatelines in some way.

9.5. The threshold for reporting an injury in RIDDOR does require that for a member of the public that they are known to have needed hospital treatment, and for staff that they are off work for at least seven consecutive days or meet one of set of specific injury types. Further details on RIDDOR are available in ORR's guidance document[14].

9.6. The low levels of reports that can be linked to ticket gates may reflect that there could be a larger number of much more minor injuries such as bruising, small cuts, verbal assaults on staff etc. that fall below the report threshold. The statistical returns required under the RIDDOR legislation are not intended to capture this type of minor injury information however.

[14] http://orr.gov.uk/__data/assets/pdf_file/0010/2332/riddor-guidance.pdf

Levels of usage

9.7. A broad review of data held by ORR indicates that at present passenger journeys currently being undertaken in the UK annually across all transport systems through stations that involve ticket gates is around 10 billion journeys.

Injury levels relative to usage

9.8. As noted the number of reportable injures related to automatic gatelines in some way is low at only five reports over the last five years. Comparing this to the number of gateline interactions over that period estimated at circa 20 billion per annum this suggests an extremely low injury per use level.

9.9. Basing performance on this type of data is however risky. The Health and Safety Executive document "Reducing Risks, Protecting People" says:
"[HSE's risk assessment procedures] do not take 'absence of evidence of risk' as 'evidence of absence of risk', although they recognise that persistent absence of evidence of risk, notwithstanding appropriate and thorough efforts to find it, may be indicative"

9.10. Historical data can be useful but where there is the potential for rare infrequent incidents, it must be used with care. Given the caveat above, it does appear however that automatic ticket gates present a very low level of risk to staff and to the public who use them.

10. Future developments

Move to mobile devices and contactless – reader technologies

10.1. The increasing prevalence of smarter mobile telephone devices and the applications that they can support is enabling more sophisticated app-based ticketing solutions. At present, the deployment of these is operator specific.

10.2. Mobile devices that support the NFC protocol are required for some application types, while other will display a QR code on the device screen.

Gateless gatelines

10.3. Some suppliers are moving toward ticket applications that require a passenger's mobile device to have an open communications protocol that allows station detection equipment to register a passenger moving through the station and onto a train. Where a passenger has a valid pre-purchased ticket registered in the application, the app and station systems will work together to track the passenger onto the train. The intent is then that passengers without tickets, or invalid tickets will be flagged to station staff who can then approach them. The systems promise a less physically intrusive ticket inspection and validation process, though this will come at the expense of a greater level of passenger tracking and identification. The privacy issues of this remain to be explored.

RSSB research programme

10.4. The RSSB has a useful report with a comprehensive background to the history of UK ticketing, the technologies involved and future potential developments.[15]

10.5. RSSB have also produced a report in the potential for gate-less gatelines.[16]

[15] https://www.rssb.co.uk/horizonscanningcontent/s244-new-ticketing-technologies-report.pdf

[16] https://www.rssb.co.uk/horizonscanningcontent/s151-gate-less-gate-lines-v1.pdf

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