Guidance on the Application of Selective Door Operation Systems

Issue record

<table>
<thead>
<tr>
<th>Issue</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>April 2008</td>
<td>Original document</td>
</tr>
</tbody>
</table>

Superseded documents

This Railway Group Guidance Note does not supersede any other Railway Group documents.

Supply

Controlled and uncontrolled copies of this Railway Group Guidance Note may be obtained from the Corporate Communications Department, Rail Safety and Standards Board, Evergreen House, 160 Euston Road, London NW1 2DX, telephone 020 7904 7518 or e-mail enquiries@rssb.co.uk. Railway Group Standards and associated documents can also be viewed at www.rgsonline.co.uk.
# Guidance on the Application of Selective Door Operation Systems

## Contents

<table>
<thead>
<tr>
<th>Section Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitions</td>
<td>5</td>
</tr>
<tr>
<td>Abbreviations and acronyms</td>
<td>7</td>
</tr>
<tr>
<td>Part 1 Introduction</td>
<td>8</td>
</tr>
<tr>
<td>1.1 Purpose of this document</td>
<td>8</td>
</tr>
<tr>
<td>1.2 Copyright</td>
<td>8</td>
</tr>
<tr>
<td>1.3 Approval and authorisation of this document</td>
<td>8</td>
</tr>
<tr>
<td>1.4 Background to the production of this document</td>
<td>8</td>
</tr>
<tr>
<td>1.5 Content and structure of this document</td>
<td>9</td>
</tr>
<tr>
<td>1.6 Next steps</td>
<td>9</td>
</tr>
<tr>
<td>Part 2 Overview of SDO systems</td>
<td>10</td>
</tr>
<tr>
<td>2.1 Background to SDO systems</td>
<td>10</td>
</tr>
<tr>
<td>2.2 Description of SDO systems</td>
<td>10</td>
</tr>
<tr>
<td>2.3 Relationship to door control</td>
<td>11</td>
</tr>
<tr>
<td>2.4 Operational considerations</td>
<td>11</td>
</tr>
<tr>
<td>2.5 Special operating scenarios</td>
<td>11</td>
</tr>
<tr>
<td>2.6 Impact of SDO systems on dwell time</td>
<td>12</td>
</tr>
<tr>
<td>2.7 Degrees of automation</td>
<td>12</td>
</tr>
<tr>
<td>2.8 Reliability of operation</td>
<td>14</td>
</tr>
<tr>
<td>2.9 Maintenance and testing principles</td>
<td>14</td>
</tr>
<tr>
<td>2.10 Stakeholder roles</td>
<td>14</td>
</tr>
<tr>
<td>Part 3 Functions and interfaces</td>
<td>16</td>
</tr>
<tr>
<td>3.1 System boundary and interfaces</td>
<td>16</td>
</tr>
<tr>
<td>3.2 General</td>
<td>16</td>
</tr>
<tr>
<td>3.3 Primary functions</td>
<td>17</td>
</tr>
<tr>
<td>3.4 Implementation of functional requirements for manual, ASDO and FASDO systems – normal operation</td>
<td>18</td>
</tr>
<tr>
<td>3.5 Degraded mode (SDO system failure)</td>
<td>18</td>
</tr>
<tr>
<td>3.6 Degraded mode (other system failures)</td>
<td>19</td>
</tr>
<tr>
<td>3.7 SDO system interfaces</td>
<td>19</td>
</tr>
<tr>
<td>Part 4 Architectures</td>
<td>21</td>
</tr>
<tr>
<td>4.1 Criticality of positioning and location detection accuracy</td>
<td>21</td>
</tr>
<tr>
<td>4.2 Criteria for choice of architecture</td>
<td>22</td>
</tr>
<tr>
<td>4.3 Manual system architecture</td>
<td>23</td>
</tr>
<tr>
<td>4.4 ASDO system architecture</td>
<td>23</td>
</tr>
<tr>
<td>4.5 FASDO system architecture</td>
<td>27</td>
</tr>
<tr>
<td>Part 5 Application design considerations and implementation</td>
<td>29</td>
</tr>
<tr>
<td>5.1 General</td>
<td>29</td>
</tr>
<tr>
<td>5.2 Location</td>
<td>29</td>
</tr>
<tr>
<td>5.3 Eurobalise technology and protocol</td>
<td>32</td>
</tr>
<tr>
<td>5.4 Train crew interface</td>
<td>33</td>
</tr>
<tr>
<td>5.5 Data management system</td>
<td>34</td>
</tr>
<tr>
<td>5.6 On-train equipment</td>
<td>34</td>
</tr>
<tr>
<td>5.7 Implementation</td>
<td>35</td>
</tr>
<tr>
<td>Appendices</td>
<td>36</td>
</tr>
<tr>
<td>Appendix A</td>
<td>36</td>
</tr>
<tr>
<td>Appendix B</td>
<td>40</td>
</tr>
<tr>
<td>Appendix C</td>
<td>42</td>
</tr>
<tr>
<td>Appendix D</td>
<td>45</td>
</tr>
<tr>
<td>Appendix E</td>
<td>54</td>
</tr>
<tr>
<td>Appendix F</td>
<td>59</td>
</tr>
</tbody>
</table>
# Guidance on the Application of Selective Door Operation Systems

## Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Dwell time events</td>
<td>12</td>
</tr>
<tr>
<td>Table 2</td>
<td>Stakeholder roles in relation to SDO systems</td>
<td>15</td>
</tr>
<tr>
<td>Table 3</td>
<td>Extent of automation of functions</td>
<td>18</td>
</tr>
<tr>
<td>Table 4</td>
<td>Disadvantages and advantages of spot transmission and satellite based location</td>
<td>30</td>
</tr>
<tr>
<td>Table 1E</td>
<td>Human Error Probability (HEP)</td>
<td>55</td>
</tr>
<tr>
<td>Table 2E</td>
<td>Hazardous events</td>
<td>55</td>
</tr>
<tr>
<td>Table 3E</td>
<td>Safety integrity levels</td>
<td>56</td>
</tr>
<tr>
<td>Table 4E</td>
<td>Summary of the results of the indicative safety analysis undertaken to establish SIL for a generic SDO system</td>
<td>58</td>
</tr>
</tbody>
</table>

## Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Interfaces to SDO systems</td>
<td>16</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Criticality of positioning</td>
<td>21</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Manual SDO system architecture</td>
<td>23</td>
</tr>
<tr>
<td>Figure 4</td>
<td>ASDO system architecture using GNSS-based locator</td>
<td>24</td>
</tr>
<tr>
<td>Figure 5</td>
<td>ASDO system architecture using GNSS-based locator and RFID</td>
<td>25</td>
</tr>
<tr>
<td>Figure 6</td>
<td>ASDO system architecture using Eurobalise</td>
<td>26</td>
</tr>
<tr>
<td>Figure 7</td>
<td>FASDO system architecture</td>
<td>27</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Geometry for RFID</td>
<td>32</td>
</tr>
<tr>
<td>Figure 1A</td>
<td>Examples of existing systems on Network Rail controlled infrastructure</td>
<td>36</td>
</tr>
<tr>
<td>Figure 1E</td>
<td>Block diagram representation of the features considered in the hazard scenarios for a generic SDO system</td>
<td>56</td>
</tr>
<tr>
<td>Figure 1F</td>
<td>Train crew’s MMI interface</td>
<td>59</td>
</tr>
</tbody>
</table>

## References

| References | 61 |

These tables and figures provide a structured overview of the application of selective door operation systems, including detailed data on dwell time events, stakeholder roles, extent of automation, and various aspects of safety analysis and system architectures. The references at the end of the document guide readers to further reading on the subject.
Guidance on the Application of Selective Door Operation Systems

Definitions

Balise
A balise is an electronic beacon or transponder placed between the rails of a railway, usually used as part of an Automatic Train Protection System. Eurobalise is a balise used within the European Train Control System.

Correct Side Door Enable (CSDE)
Correct Side Door Enable (CSDE) is an additional facility to inhibit door release if the train crew attempts to manually operate door release for the non-platform side. By definition, this function is included in Fully Automatic Selective Door Operation (FASDO) but the function is an option for some ASDO systems.

Degraded
Reduced operation, due to failures either of the Selective Door Operation (SDO) system or systems interfaced to the SDO system.

Enable
Allow a door to be released.

European Train Control System (ETCS)
European Train Control System (ETCS) is the train control system which is part of the European Railway Traffic Management System (ERTMS). It is mandated under the Control Command Signalling Technical Specifications for Interoperability for High Speed and Conventional Rail.

Inhibit
Prevent a door from being released.

Normal
The usual or expected state of the SDO system operating when there are no SDO system failures and no failures of systems interfaced to the SDO system.

Radio Frequency Identification (RFID)
Radio Frequency Identification (RFID) is an electronic identification device consisting of tag and reader.

Release
Allows those power doors which are enabled to be opened.

RFID tag
An electronic identification device. Where there is no requirement for variable data it does not have its own power source.

Selective Door Operation (SDO)
Opening of power doors selectively and inhibition of the remaining doors, either manually by the train crew (Manual SDO system) or automatically (ASDO or FASDO systems) and further defined as follows:

• Automatic Selective Door Operation (ASDO)
An Automatic Selective Door Operation (ASDO) system automatically determines the doors to enable for opening at a given station platform. It also instigates audio/visual announcements informing passengers where doors remain closed and directing passengers in adequate time to alight the train through vehicles where doors are opened. The role of the train crew is limited to correctly positioning the train and then operating the door release buttons, confirming from Selective Door Operation (SDO) system indications that the correct doors are being selected. Manual override is necessary under abnormal or fault conditions.
Guidance on the Application of Selective Door Operation Systems

- **Fully Automatic Selective Door Operation (FASDO)**
  A Fully Automatic Selective Door Operation (FASDO) system provides ASDO functionality but without the need for any manual (train crew) intervention, except under abnormal or fault conditions. It decides which doors to enable for opening at a given station platform and releases them when the train comes to a stop at a valid stop position. If the driver stops at an invalid stop position for a given length of train, then the doors are not released and the train crew is warned. It also instigates audio/visual announcements informing passengers where doors remain closed and directing passengers in adequate time to alight the train through vehicles where doors are opened. It is capable of providing alternative selections and corrective information in case of a platform change.

- **Manual SDO**
  Manual (SDO) is any system where the decision rests solely with the train crew on which part of the train the doors are to be released for opening, the operation of those doors and the audio/visual announcements informing passengers where doors remain closed.

**Train**
A group of vehicles which may include individual vehicles or units formed to make up the operational train.

**Train crew**
For the purposes of this document this is the driver and the guard (train manager).

**Train data management system**
A system capable of informing train crew of the status of trainborne systems.

**Unit**
A permanently coupled group of vehicles.

**Vehicle**
An individual vehicle or car of any train formation.
Abbreviations and acronyms

ALARP  As Low As Reasonably Practicable
ASDO  Automatic Selective Door Operation
ATO  Automatic Train Operation
CCF  Common Cause Failure
COTS  Commercial Off The Shelf
CSDE  Correct Side Door Enable
DfT  Department for Transport
EMC  Electro-Magnetic Compatibility
ERTMS  European Railways Traffic Management System
ETCS  European Train Control System
FASDO  Fully Automatic Selective Door Operation
FDM  Frequency Division Multiplexing
FWI  Fatalities and Weighted Injury
GNSS  Global Navigation Satellite System, for example GPS
GSM  Global System for Mobile communications
HMRI  HM Railway Inspectorate
IDU  Intelligent Display Unit
LUL  London Underground Ltd
MMI  Man-Machine Interface
ORR  Office of Rail Regulation
OTMR  On Train Monitoring Recorder
PIS  Passenger Information System
PRM  Persons with Reduced Mobility
RFID  Radio Frequency Identification
ROGS  Railways and Other Guided Transport Systems (Safety) Regulations 2006
RVAR  Rail Vehicle Accessibility Regulations 1998
SDO  Selective Door Operation
SIL  System Integrity Level
TASS  Tilt Authorisation/Speed Supervision
THR  Tolerable Hazard Rate
TMS  Train Management System
ULI  Universal Location Identifier
WIFI  Wireless Fidelity
Part 1  Introduction

1.1  Purpose of this document
This document is intended to assist railway undertakings and infrastructure managers in selecting and implementing Selective Door Operation (SDO) systems appropriate for specific applications. The factors which determine the level of functionality of SDO systems appropriate to a particular application are also considered, subject to the further research described in section 1.6 and Appendix D.

1.2  Copyright
Copyright in the Railway Group documents is owned by Rail Safety and Standards Board Limited. All rights are hereby reserved. No Railway Group document (in whole or in part) may be reproduced, stored in a retrieval system, or transmitted, in any form or means, without the prior written permission of Rail Safety and Standards Board Limited, or as expressly permitted by law.

Rail Safety and Standards Board members are granted copyright licence in accordance with the Constitution Agreement relating to Rail Safety and Standards Board Limited.

In circumstances where Rail Safety and Standards Board Limited has granted a particular person or organisation permission to copy extracts from Railway Group documents, Rail Safety and Standards Board Limited accepts no responsibility for, and excludes all liability in connection with, the use of such extracts, or any claims arising there from. This disclaimer applies to all forms of media in which extracts from Railway Group Standards may be reproduced.

1.3  Approval and authorisation of this document
The content of this document was approved by:

Multifunctional Standards Committee on 25 March 2008

This document was authorised by RSSB on 05 April 2008

1.4  Background to the production of this document
A Selective Door Operation (SDO) system in its most basic form is a means of enabling only those power doors which give access to platforms and inhibiting those which do not. This allows passenger trains with power doors to be used safely on platforms which are shorter than the trains.

There are various options available regarding the type of SDO systems providing differing levels of functionality and automation; this guidance note assists in the selection of a suitable system in line with cost and operational considerations.

There is a desire within the rail industry for a national framework for SDO systems to be established. This is addressed in this document by identifying both a set of generic requirements against which any SDO system can be assessed for fitness of purpose, and specific target system architectures for implementing SDO systems. Such a framework should be helpful to those extending the application of existing systems, as well as those introducing SDO systems to a route or a train fleet for the first time.

Research designated T686 and titled: Production of an Industry Standard of Use of Selected Door Operation (SDO) in the UK was commissioned by RSSB on behalf of the GB railway industry to identify the preferred solutions for SDO systems. It is on the output from this research that this guidance note is largely based.
1.5 **Content and structure of this document**

This document identifies requirements and issues which should be considered when assessing the applicability of **SDO systems** to a specific route. Further guidance is then provided by defining five target **systems** to meet the range of requirements likely to arise.

Specifically this guidance note sets out the application of **SDO systems** to the GB rail network in the following structure:

a) An overview of **SDO systems** focussing on the operational principles of such **systems** (set out in Part 2)

b) The functions and interfaces of **SDO systems** in relation to train crew, passengers and the infrastructure that should be addressed in the selection of a specific system architecture (set out in Part 3)

c) Information relating to the system architectures that meet the functionality and interface information set out in previous sections. Five architectures are described, in addition to the criteria for the selection of each (set out in Part 4)

d) Specific design and implementation information to facilitate the installation and operation of the architectures set out in the previous section (set out in Part 5).

1.6 **Next steps**

At the time of writing, further research proposals have been approved to address the following:

a) Trial of Radio Frequency Identification (RFID) for **Selective Door Operation** (SDO), designated T771. It has been identified that it may also be necessary to carry out integration trials for Radio Frequency Identification (RFID) / Global Navigation Satellite System (GNSS) **systems** that comprise the overall system proposed by this document

b) Criteria for the Application of **Selective Door Operation**, designated T769, which addresses the potential operational performance and safety risks that may be introduced by the introduction of **SDO systems**.

The remits for both research proposals for this work are reproduced in Appendix D of this document.

Additionally, RSSB is currently undertaking a risk analysis on **SDO systems** to establish the appropriate System Integrity Levels (SILs). These are currently based on provisional analysis carried out as part of the aforementioned research project T686, and which is summarised in Appendix E.

It is expected that an element of the guidance set out in this document will become mandatory requirements in a Railway Group Standard (most likely as a reissue of **GM/RT2473**: Power Operated External Doors on Passenger Carrying Rail Vehicles) and amendment to **GE/RT8000**: Rule Book. This includes interface requirements between the train and any infrastructure based equipment. For those requirements not meeting the decision criteria set out in the Railway Group Standards Code the option of their inclusion in a Rail Industry Standard is available.

It is additionally anticipated that the output from the two research projects T769 and T771, and the risk analysis based on the **systems** described in this document will contribute to future changes to Railway Group Standards and further revision to this guidance note.

Feedback to RSSB via the Senior Project Manager, Control, Command and Signalling and Energy Delivery Unit, from users of this document is welcome in advance of the aforementioned revision.
Part 2 Overview of SDO systems

2.1 Background to SDO systems

2.1.1 It is not uncommon for passenger trains to stop at platforms shorter than the trains; a practice that has occurred for many years.

2.1.2 When slam doors were in use the passenger alone was responsible for deciding when to open the door and there was no indication given to help in the decision.

2.1.3 The introduction of power operated doors has given the impetus to provide a means of controlling safe access for passengers to/from the platform. This can be achieved by use of an SDO system.

2.1.4 SDO systems have been in use in Great Britain for several years, but to date no single system has emerged as the ‘ideal’ solution. The level of automation and technology utilised has varied considerably.

2.1.5 Demands on the passenger-carrying capacity of the railway are predicted to increase in the future. SDO systems allow improved utilisation of stations, trains and pathways to be achieved within a relatively short timescale, without waiting for expensive and time-consuming projects to extend platforms or increase the number of train movements.

2.1.6 There is a desire expressed within the rail industry for a national framework for SDO systems to be established. This guidance note has been written as a contribution to this framework.

2.2 Description of SDO systems

2.2.1 An SDO system is a means of enabling those power doors on a passenger train that give safe access for passengers to/from the platform and inhibiting those that do not.

2.2.2 The SDO system application is a supervisory application. It is not controlling the train to a stopping point (as in automatic train operation). It is a system that, if defined conditions are fulfilled, enables certain doors for opening.

2.2.3 The four basic functions of any SDO system are:

1. Identifying the location
2. Inhibiting those doors which do not give safe access to/from the platform
3. Enabling those doors which give safe access to/from the platform
4. Triggering appropriate information to passengers.

2.2.4 The way in which these functions are met depends on the technology chosen. The most basic (manual) system relies on a member of the train crew carrying out the function of identifying the location themselves and choosing the doors to inhibit. Passenger information is provided by a member of the train crew. The most sophisticated systems carry out the functions set out in 2.2.3 entirely automatically.

2.2.5 The selection of the type of SDO system is subject to a range of technical, operational and cost benefit criteria.

2.2.6 This document sets out guidance on the provision of manual and automatic SDO system functions.
Guidance on the Application of Selective Door Operation Systems

2.3 **Relationship to door control**

2.3.1 This document does not include guidance on door control systems. The boundaries of the SDO system are set out in Part 3. It is assumed that the basic door system is in compliance with Railway Group Standards, Technical Standards for Interoperability (TSIs) and EN 14752:2005 Railway Applications, Body Entrance Systems.

2.4 **Operational considerations**

2.4.1 As previously stated in section 1.6, research has been commissioned to lead to an understanding of the limiting factors associated with the implementation of SDO systems at stations with regard to the behaviour of passengers and the occurrence of undesirable incidents (delays or accidents). The remit for this work is reproduced in Appendix D.

2.4.2 This research is intended to provide criteria to determine where SDO systems is appropriate against the alternative of extending the platforms or of operating shorter trains more frequently.

2.4.3 SDO system functionality should be driven by normal safe driving practice, as set out in GE/RT8000: Rule Book, which ensures that the train crew are not overloaded or distracted by a large volume of 'secondary' workload, such as having to make routine passenger announcements. The role of the train crew’s SDO system activities should be seen in this light.

2.5 **Special operating scenarios**

2.5.1 It should be recognised that not every station situation is identical or straightforward. It is important that systems should cope with specific and individual situations. The following events represent a selection of the particular situations that should be taken into account in the design of the SDO system.

2.5.2 **Use of SDO on multiple unit trains without interconnecting gangways**

2.5.2.1 Consideration should be given to the use of SDO on multiple unit trains not fitted with inter-unit gangways. This might lead to a situation where passengers in one section of the train were completely unable to move to a part of the train where doors were available for egress to the platform. This is likely to be unacceptable both in respect of customer service, and safety, since the response of passengers in such a situation cannot be assured.

2.5.3 **Access for persons of reduced mobility (PRM)**

2.5.3.1 Operators have a statutory obligation to take into account the needs of those with reduced mobility; this applies to boarding and leaving the train. It should therefore be considered important to ensure that PRM customers do not find themselves unable to egress the train at their destination because they are either unable to move through the train to a safe alighting point or, due to sensory impairment, are unaware that an SDO system is utilised on their train or are unable to recognise instructions relating to an SDO system.

2.5.4 **Joining and splitting in a platform**

2.5.4.1 A joining service should take account of a train already berthed at the platform, in particular, if the combined trains have a length longer than the platform. Attention should be given to splitting, as the newly formed train in the rear needs to operate an SDO system to ensure that doors not adjacent to the platform continue to be inhibited.

2.5.5 **Reversing stations**

2.5.5.1 A further difficulty arises at stations where trains reverse their direction of travel (due to termination or to take an onward route at certain junction stations). This
Guidance on the Application of Selective Door Operation Systems

affects both the selection of the doors to be enabled/inhibited and the information given to passengers.

2.6 Impact of SDO systems on dwell time

2.6.1 The response time of any door control system affects the dwell time at a station platform. Dwell time depends upon the typical sequential events outlined below in Table 1 and the introduction of automation to an SDO system changes the timing of one of these events. Train crew intervention in manual SDO systems introduces a similar further delay, although the actions vary from system to system.

2.6.2 The volume of passengers alighting or joining also affects dwell time if a limited number of doors is available for use under an SDO system.

2.6.3 These effects on dwell time should be included on any assessment of the appropriateness of SDO systems, and should be understood by those manufacturing an automatic system.

<table>
<thead>
<tr>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train stopped</td>
</tr>
<tr>
<td>Train crew checks SDO system interface</td>
</tr>
<tr>
<td>Train crew presses door release buttons on the correct side</td>
</tr>
<tr>
<td>Door release lights illuminated</td>
</tr>
<tr>
<td>Door release system command and control</td>
</tr>
<tr>
<td>Doors begin opening, time to fully open</td>
</tr>
<tr>
<td>Passengers alight</td>
</tr>
<tr>
<td>Passengers boarding</td>
</tr>
<tr>
<td>Train dispatch – identify if it is safe to close doors</td>
</tr>
<tr>
<td>Operate door close</td>
</tr>
<tr>
<td>Communicate door close through train and response time of door system</td>
</tr>
<tr>
<td>Hustle warning</td>
</tr>
<tr>
<td>Door close phase</td>
</tr>
<tr>
<td>Door interlock communication</td>
</tr>
<tr>
<td>Driver response time to interlock, or two bells. Driver then takes traction</td>
</tr>
</tbody>
</table>

Table 1 Dwell time events

2.7 Degrees of automation

This section sets out the operational view of automating SDO system functions.

2.7.1 Manual SDO systems

2.7.1.1 In manual operation, a member of the train crew enables the operation of doors according to the station and platform length. The driver is responsible for stopping at the platform location that corresponds to the train formation. In the event of an excessive error, the train crew take appropriate action through the public address and the SDO system to enable passengers to disembark safely.
Guidance on the Application of Selective Door Operation Systems

2.7.1.2 Possible appropriate scenarios applicable to manual SDO systems include limiting door operation:
   a) To one vehicle only
   b) To doors forward of a control point manned by the train guard
   c) To one or more units within a multiple unit train.

2.7.1.3 It is generally recommended that manual SDO systems are not used for trains utilising Driver Only Operation (DOO) and that the guard is given a role in selecting or confirming the doors to be opened.

2.7.1.4 It is recommended that a consistent method of operation is adopted within fleets to avoid risk of error caused by confusion of staff or customers. For example, it would generally be undesirable if at some stations, passengers are expected to alight from the front part of a train, but at other stations on the same route or network they were expected to alight from the rear.

2.7.2 Automatic Selective Door Operation (ASDO)

2.7.2.1 The basic level of automation for an ASDO system is:
   a) The train detects by some form of positioning system which particular station it is in
   b) On the approach, the system triggers passenger information announcements for scheduled stops
   c) The train crew confirms that the correct stopping point has been achieved
   d) The doors appropriate to the train length, the particular station, and optionally platform stopping position are enabled automatically
   e) The train crew releases the doors
   f) The system is inherently fail-safe so that, in the event of loss of position detection, no doors will be enabled
   g) The train crew monitor the operation of the system and, in the event of an anomaly, revert to a manual override system, with suitable announcements over the public address to ensure that passengers can still be allowed to egress the train without excessive delay, even if the ASDO system malfunctions.

2.7.2.2 Correct side door enable (CSDE) is an option for an ASDO system. With this option, power doors on the opposite side of the train to the platform are also inhibited. The ASDO system either selects the side of the train to be opened automatically without the need for selection by the train crew or, alternatively, verifies the selection by the train crew, dependent on the design of the system.

2.7.2.3 It is an operating decision to determine which exceptional train movements should be accommodated within the automatic system.

2.7.2.4 Manual override should be included within the system to overcome fault situations.
Guidance on the Application of Selective Door Operation Systems

2.7.3 Fully Automatic Selective Door Operation (FASDO)

2.7.3.1 The involvement of the train crew is reduced as automation is extended to include:

a) Verifying that the stopping point is correct within a defined tolerance, and then

b) Releasing the doors.

2.7.3.2 CSDE, as set out in 2.7.2.2, is normally inherent in any FASDO system.

2.7.3.3 Additional functionality can be included for exceptional cases to enable only those doors adjacent to the platform if the stopping point is incorrect.

2.7.3.4 As with ASDO systems, it is an operating decision to determine which exceptional train movements should be accommodated within the automatic system.

2.7.3.5 Manual override should be included within the system to overcome fault situations.

2.8 Reliability of operation

2.8.1 The introduction of an SDO system can lead to a level of complexity with the potential to cause problems. Appendix B provides a list of lessons learnt and issues arising from existing systems. This should be taken into account in the introduction of such systems.

2.9 Maintenance and testing principles

2.9.1 Role of design

2.9.1.1 Maintenance and testing contribute to meeting reliability targets for a system in service. These targets should be achieved by placing maintainability at the heart of the design process.

2.9.2 Built-in self-test

2.9.2.1 For automated SDO systems, it is recommended that automatic self-testing should be included.

2.9.3 Auto-diagnosis

2.9.3.1 For automated systems, SDO system facilities should include fault auto-diagnoses. When a fault is detected, the unit concerned should be identified and a fault code assigned. This information should be made available to the staff responsible as part of the train’s standard maintenance facilities. This guidance extends to on-train detection of failures of any infrastructure equipment used for the SDO system function, such that a report is logged by the on-train system where it is possible to detect any infrastructure equipment that is missing or failed.

2.9.3.2 Specific information relating to testing and maintenance is set out in Appendix C.

2.10 Stakeholder roles

2.10.1 Table 2 illustrates the stakeholders to whom SDO systems apply and the nature of their roles in the overall application.
## Guidance on the Application of Selective Door Operation Systems

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Role in relation to SDO systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure manager</td>
<td>• To co-operate with railway undertakings to agree the interface between the trainborne and infrastructure parts of the SDO system</td>
</tr>
<tr>
<td></td>
<td>• To provide and maintain the infrastructure part of the SDO system if fitted trackside</td>
</tr>
<tr>
<td></td>
<td>• To co-operate with the railway undertakings in order to jointly accept the SDO system in accordance with the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS)</td>
</tr>
<tr>
<td>Station manager (this includes train operators when responsible for this infrastructure manager role)</td>
<td>• To provide the infrastructure to support SDO systems, for example RFID tags</td>
</tr>
<tr>
<td></td>
<td>• To maintain the infrastructure associated with SDO systems</td>
</tr>
<tr>
<td>Railway undertakings</td>
<td>• To co-operate with the infrastructure manager and station managers in agreeing which stations will be provided with SDO systems</td>
</tr>
<tr>
<td></td>
<td>• To provide and maintain trainborne SDO system equipment</td>
</tr>
<tr>
<td></td>
<td>• To operate the system</td>
</tr>
<tr>
<td></td>
<td>• To co-operate with the infrastructure manager in order to jointly accept the SDO system in accordance with the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS)</td>
</tr>
<tr>
<td>Rolling-stock owners</td>
<td>• To carry out some of the above activities for which railway undertakings are responsible for, as established by contract</td>
</tr>
<tr>
<td>Suppliers</td>
<td>• To provide SDO systems in accordance with infrastructure managers and railway undertakings requirements</td>
</tr>
<tr>
<td></td>
<td>• To carry out some of the activities for which railway undertakings are responsible for, as established by contract</td>
</tr>
<tr>
<td>ORR</td>
<td>• To provide guidance to infrastructure managers and railway undertakings to assist with the acceptance of the system through the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) to SDO systems</td>
</tr>
<tr>
<td>Passengers</td>
<td>• To comply with instructions generated for their information as a result of the application of SDO systems</td>
</tr>
<tr>
<td>Major railway projects</td>
<td>• To specify SDO systems</td>
</tr>
</tbody>
</table>

**Table 2  Stakeholder roles in relation to SDO systems**
Guidance on the Application of Selective Door Operation Systems

Part 3 Functions and interfaces

3.1 System boundary and interfaces

3.1.1 The system boundary and interfaces of SDO systems are represented in Figure 1 below. A description of the interfaces is set out in section 3.7.

![Diagram of System Boundary and Interfaces]

- Out of scope for this document
- Partially addressed in this document
- Addressed in this document

Figure 1 Interfaces to SDO systems

3.2 General

3.2.1 The functional requirements set out in Part 3 should be met by operational rules, by technical means or a combination of both. In this context the SDO system comprises both equipment and the train crew.

3.2.2 These functional requirements are generic and derived from a safety analysis carried out as part of the research project set out in section 1.4. However, safety analysis specific to each SDO system project should always be carried out.
Guidance on the Application of Selective Door Operation Systems

3.2.3 Target architectures for manual, ASDO and FASDO system arrangements are set out in Part 4.

3.2.4 An override facility should always be provided so that passenger access and egress remains possible during system failures and unplanned operations.

3.3 Primary functions

3.3.1 General requirements

3.3.1.1 The primary function can be broken down into the following categories and are detailed in the following sections. Some of these actions are carried out by the train crew on manual systems:

a) Recognising the next station
b) Recognising the platform to be used
c) Recognising the train length
d) Detecting when doors should be enabled
e) Providing information to the passengers
f) Verifying the operational state of the SDO system equipment on-train.

3.3.2 Recognising the next station

3.3.2.1 On ASDO or FASDO systems, the SDO system recognises the stations where SDO is required to operate and requires an input to activate it when on the approach to a station where the train should stop.

3.3.2.2 Stopping patterns may be adjusted during the train service in response to operating incidents. Where the recognition of the next stop is automated within the system, the SDO system should take account of such adjustments. Where there is an associated Passenger Information System (PIS) which provides announcements to support the SDO system, this should also be adjusted. Alternatively, SDO systems at non-scheduled stops should be managed manually by the train crew.

3.3.3 Recognising the platform to be used

3.3.3.1 In most cases all of the platforms in regular use at a particular station will be of similar length. However, where this is not the case it may be desirable for the SDO system to vary the numbers of doors enabled according to the individual platform used. Technical solutions to permit this are discussed in section 4.2.7.

3.3.4 Recognising the train length

3.3.4.1 In order to determine which doors are not located adjacent to a platform, that is, when the train is longer than the platform, the train length data should be made available to the system and train crew.

3.3.5 Detecting when doors should be enabled

3.3.5.1 Doors located adjacent to the platform should be enabled when the train has come to a rest at the correct stopping point on a unit, vehicle or doorway basis. The correct stopping point should be defined over a range, in order to accommodate driving and distance measuring tolerances.

3.3.6 Providing information to the passengers

3.3.6.1 It is recommended that the SDO system arrangements should trigger appropriate passenger information. It is further recommended that in vehicles that are not enabled, the direction to the nearest doors that are enabled should be given. The status of doors: released/not released should be clearly indicated.
Guidance on the Application of Selective Door Operation Systems

3.3.6.2 Information on those doors being inhibited and those to be released should be given on the approach to the station before the train has come to a halt at the platform. It is recommended that announcements should be both visual and audible.

3.3.7 Verifying the operational state of the SDO system equipment
3.3.7.1 The train crew should be made aware of the availability of the SDO system and supporting information systems.

3.4 Implementation of functional requirements for manual, ASDO and FASDO systems – normal operation
3.4.1 Table 3 sets out the extent to which the functions set out in section 3.3 are able to be automated in normal modes of operation to provide systems corresponding to basic ASDO and FASDO classifications. These classifications are not absolute and are used to give a conceptual view of the extent of the automation that can be employed.

<table>
<thead>
<tr>
<th>Ref</th>
<th>Function</th>
<th>Manual</th>
<th>ASDO</th>
<th>FASDO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Recognising the next station</td>
<td>Manual</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
<tr>
<td>2</td>
<td>Recognising the platform</td>
<td>Manual</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
<tr>
<td>3</td>
<td>Recognising the train length</td>
<td>Manual</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
<tr>
<td>4a</td>
<td>Detecting where doors should be enabled</td>
<td>Manual</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
<tr>
<td>4b</td>
<td>Detecting when doors should be released</td>
<td>Manual</td>
<td>Manual</td>
<td>Automatic</td>
</tr>
<tr>
<td>5</td>
<td>Providing information to passengers</td>
<td>Manual and/or automatic</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
<tr>
<td>6</td>
<td>Verifying the operational state of the equipment</td>
<td>Automatic</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
</tbody>
</table>

Table 3   Extent of automation of functions

3.5 Degraded mode (SDO system failure)
3.5.1 The potential failures of SDO systems that would lead to degraded mode working are:
   a) Loss of train positioning information
   b) Incorrect train positioning information
   c) Malfunction of the SDO system controller.
Guidance on the Application of Selective Door Operation Systems

### 3.6 Degraded mode (other system failures)

3.6.1 If the automatic PIS system has failed, then special announcements are made, as per the railway undertaking operating procedures.

3.6.2 If the door control system has failed then a contingency plan should be in place, as set out in GO/RT3437: Defective On-Train Equipment.

### 3.7 SDO system interfaces

#### 3.7.1 Introduction

3.7.1.1 The interfaces to the SDO system are set out in Figure 1. They are:

a) Door control system – interface only addressed in this document

b) Train crew door control interface including the SDO system

c) Positioning system

d) Passenger information system.

#### 3.7.2 Door control system

3.7.2.1 The interface between the SDO system function and the door control system are the enable signals that the SDO system provides to the door system.

3.7.2.2 For FASDO systems there is also a door release signal.

#### 3.7.3 Train crew door control interfaces including the SDO system

3.7.3.1 The train crew interface consists of information that the SDO system is releasing correctly, information as to the doors being released at a particular platform and the override facility.

3.7.3.2 Control arrangements:

a) The SDO system controls and indications should not distract the train crew’s attention. Unless a critical failure is indicated they should normally be blank when not required

b) The stopping information, to the extent known to the SDO system logic, should be displayed to the train crew. For example, in an ASDO system this could be the name of the station and the train length. In a FASDO system, this could include the platform identity.

3.7.3.3 Manual override:

a) Manual override is required in the following situations:

i) Emergency evacuation

ii) SDO system failure

iii) Normal stopping point not available.

3.7.3.4 The manual override arrangements should provide for:

a) The train crew to select for release individual doors/vehicles in any combination

b) The use of override to be logged either in the SDO system, a train data management system and/or OTMR. It is recommended that where possible further information should be considered. Requirements for OTMR are set out in GM/RT2472: Data Recorders on Trains – Design Requirements
Guidance on the Application of Selective Door Operation Systems

c) The process to be simple and achievable in a timely manner
d) Limiting the opportunities for error. The process should be subjected to human factors analysis
e) Management arrangements to be in place for full training on the system to maintain train crew familiarity with particular emphasis on the manual override facilities as they may not be used very often
f) Passengers to be advised of the location of the doors enabled by the override process. This could be achieved manually.

3.7.4 Positioning system

3.7.4.1 Train crews should be made aware of the use of an SDO system at each location. It may be appropriate to provide an SDO reminder on platform stop markers at locations where SDO systems are required to be used. The design requirements of platform stop markers are set out in GI/RT7033: Lineside Operational Safety Signs.

3.7.4.2 Basic ASDO systems require information on stopping points.

3.7.4.3 FASDO systems require data on any stopping points, and the allowable tolerance for each stopping point at each station by train class and length.

3.7.4.4 The interface to the train data should provide train length, usually by number of vehicles (for ASDO and FASDO systems).

3.7.4.5 Optionally, the positioning system may provide data directly concerning stations/platforms to the trainborne SDO system equipment.

3.7.5 Passenger information – general

3.7.5.1 The objective should be to provide information for passengers in a standardised format, which is suitable for routine operations. The language used to identify each vehicle should use a consistent reference system (for example numbering or alphabetical). The names, context and content of any information should be consistent across the system. The information should be free from jargon, conform to human factors good practice, and be tested on the user population before implementation. The PIS when working with ASDO systems require the identity and location of the next scheduled station.

3.7.5.2 The potential sources of SDO system information to the public include:

a) Customer information when booking and at stations
b) Passenger announcements over the public address, and visually on the train
c) On indicators at the doors.

3.7.6 Passenger information when boarding a train

3.7.6.1 It is normally required that existing Passenger Information Systems (PISS) provide information concerning station calling patterns. The PIS should emphasise where SDO systems affect a journey.

3.7.6.2 Where appropriate, inside the train, information should be provided to advise the passenger that they are in the correct part of the train for particular station(s) that have short platforms and, if relevant, that they are not in the correct part of the train. This should be repeated during the journey.

3.7.6.3 On approach to a station, passengers should be warned in due time of the doors to be used.
Part 4 Architectures

4.1 Criticality of positioning and location detection accuracy

4.1.1 The position of the train should be reliably and accurately established, in order that doors are only released where they are adjacent to a platform area where boarding/alighting is permitted.

4.1.2 The criticality of positioning relates to the frontmost and the rearmost doors to be enabled. All doors not adjacent to the platform should be inhibited. This is shown in Figure 2 below:

Figure 2 Criticality of positioning

4.1.3 Platform stop markers are typically used to assist the driver in positioning the train correctly.

4.1.4 With manual SDO systems, if the train is positioned incorrectly, it is possible for the train crew to inhibit extra doors which are not adjacent to the platform.

4.1.5 With an ASDO system, it is important for the train to be stopped in the correct position to ensure that the doors automatically selected for enabling are adjacent to the platform area where boarding and alighting is permitted.

4.1.6 A manual SDO system does not detect the location of the train.

4.1.7 For an ASDO system in its most basic form, the system should only need to know which station the train is in to determine which doors to be enabled/inhibited, unless platforms at that station are of unequal length.

4.1.8 If the platforms are of unequal length, then the ASDO system should also either need to know at which platform the train has stopped, in order to determine the correct doors to enable/inhibit, or to use the shortest platform length for the whole station.

4.1.9 ASDO systems may optionally check the stopping position. This requires a more accurate location detection than simply determining the station and platform, as shown in Figure 2 above.
Guidance on the Application of Selective Door Operation Systems

4.2 Criteria for choice of architecture

4.2.1 An ASDO system is the preferred architecture for new stock.

4.2.2 Many older systems operate manual systems and, for compatibility with existing fleets, it may prove to be an appropriate architecture on a cost benefit basis.

4.2.3 FASDO systems have only been applied to metro operations where ATO is a prerequisite for this type of operation. The ATO system provides accurate location information.

4.2.4 There are three distinct target architectures for ASDO systems in this Part 4 that use different types of position detection. They are:

1. ASDO system architecture using Global Navigation Satellite Systems (GNSS) based locator
2. ASDO system architecture using GNSS-based locator and Radio Frequency Identification Device (RFID)
3. ASDO system architecture using Eurobalise.

These target architectures have been selected on the basis that it is expected that the fitting of GNSS-based locators will be widely adopted for other purposes. In due course, trains and track will be ERTMS-ETCS fitted and, where additional infrastructure is required, RFID meets the criteria of low cost, flexibility, reliability and low intrusion.

4.2.5 These architectures may be combined in pairs or all together where the train operates across different infrastructure solutions.

4.2.6 Full information on GNSS is set out in GE/GN8578: Guidance on the Use of Satellite Navigation (due for publication in late 2008).

4.2.7 Coverage of satellites by train-based GNSS equipment is not possible for all locations on the railway due to use of underground stations and other infrastructure which may block the satellite signal. If coverage is effective for all stations on a route and the appropriate part of the approaches to the stations, then the ASDO system architecture using a GNSS-based locator may prove to be suitable. However, if coverage is poor, for example due to station canopies, then an alternative for those stations and/or the approach is to make use of RFID technology to augment the GNSS-based locator. Such augmentation is also suitable where it is necessary to identify individual platforms or there is a requirement to add the option of checking the stopping position.

4.2.8 Where ETCS is fitted and in use on particular routes, then the ASDO system architecture using Eurobalise should be used because the appropriate positioning equipment is, by definition, already fitted. Other routes and trains already fitted with Eurobalise and Eurobalise readers respectively may also utilise this architecture depending on business considerations. In both cases additional balises may be required to provide sufficient accuracy for SDO applications.
4.3 Manual system architecture

4.3.1 The target architecture for a manual system is shown in Figure 3 below:

![Diagram of Manual SDO system architecture]

Figure 3 Manual SDO system architecture

4.3.2 A manual SDO system consists of an interface to the train crew so that they can select specific doors or sets to lock out, and then uses a logic unit, which may take the form of simple switches, to send door enable signals which can be unit, vehicle or door specific.

4.4 ASDO system architecture

4.4.1 Generic aspects of ASDO systems

4.4.1.1 A station list is integral with an ASDO system to determine which doors to enable and which to inhibit at a particular station. Similarly, data on the train consist configuration is integral. The ASDO system controller utilises the positional information to determine which doors to enable/inhibit based on the station list and the train consist configuration data. It indicates the doors to be enabled/inhibited to the train crew via the train crew SDO system interface, and the door enable signals are sent to the door control system in a similar way to the manual SDO system. The ASDO system triggers announcements to be made using the PIS. In the event of failure of the ASDO system, the train crew applies a manual override.
Guidance on the Application of Selective Door Operation Systems

4.4.1.2 In the following figures the tachometer, balise reader and ETCS controller are systems which are external to the SDO system, but the SDO system utilises positional data from these systems.

4.4.1.3 A dotted line is shown between the tachometer and GNSS-based locator. This represents an optional input from the train’s tachometry system to the GNSS locator, as set out in GE/GN8578: Guidance on the Use of Satellite Navigation (due to be published late 2008).

4.4.1.4 The figures do not show off-line data sources and the data could be provided in real time from a balise or RFID tag.

4.4.2 ASDO system using GNSS only

4.4.2.1 The target architecture for an ASDO system using GNSS only is shown in Figure 4 below:

![ASDO system architecture using GNSS-based locator](image)

Figure 4  ASDO system architecture using GNSS-based locator
4.4.2.2 An ASDO system using a GNSS-based locator only is a limited form of ASDO where the sole form of position data is GNSS.

4.4.2.3 Where GNSS coverage is good at all stations, but not along the whole route, the primary impact is likely to be on the ability of the system to provide appropriate PIS announcements. A tachometer input may provide sufficient accuracy for the system to overcome this problem, as the position information for such purposes can accommodate an error of several hundred metres without compromising the PIS functionality. This is one possible solution to deal with this issue.

4.4.2.4 It is recommended that consideration is given to including station sequence logic within the controller to further validate positional information.

4.4.3 ASDO system using GNSS and RFID

4.4.3.1 The target architecture for an ASDO system using GNSS and RFID is shown in Figure 5 below:

![ASDO system architecture using GNSS-based locator and RFID](image-url)

Figure 5  ASDO system architecture using GNSS-based locator and RFID
Guidance on the Application of Selective Door Operation Systems

4.4.3.2 An ASDO system using GNSS and RFID is a form of ASDO where the position data is obtained from both GNSS with RFID. As outlined in section 4.4.2 an additional option of tachometer input should be considered. The RFID allows an exact position to be determined for the following circumstances:

   a) Where GNSS data is unreliable, due, for example, to poor direct access to satellites because of a station canopy

   b) Where platform specific information is needed because of unequal length, or

   c) Where CSDE is required.

4.4.3.3 The RFID reader is on the train and the RFID tags are mounted on the infrastructure; otherwise, this architecture works in a similar way to the ASDO system using GNSS-based locator only.

4.4.4 ASDO system using Eurobalise

4.4.4.1 The target architecture for an ASDO system using Eurobalise is shown in Figure 6 below:

![ASDO system architecture using Eurobalise](image-url)

Figure 6  ASDO system architecture using Eurobalise
Guidance on the Application of Selective Door Operation Systems

4.4.4.2 An ASDO system using Eurobalise is a form of ASDO where the SDO position and system data is obtained from Eurobalises utilising an on-train Eurobalise reader. This utilises either an ERTMS/ETCS system or another system utilising Eurobalises, for example Tilt Authorisation/Speed Supervision (TASS).

4.4.4.3 It is necessary for balises to be positioned sufficiently close to, but before the required stopping point for, all stations where an SDO system is required, in order to meet the accuracy requirements specific to the SDO system application. This is likely to require balises additional to those used for other applications, such as ERTMS-ETCS; otherwise, the system operates in a similar way to any other ASDO system architecture.

4.4.4.4 This target architecture should provide the required positional accuracy to facilitate Correct Side Door Enable (CSDE).

4.5 FASDO system architecture

4.5.1 The target architecture for a FASDO system used in association with ATO is shown in Figure 7 below:

![Figure 7 FASDO system architecture](image-url)
Guidance on the Application of Selective Door Operation Systems

4.5.2 A FASDO system requires an accurate stopping position for the train and, to-date, applications have tended to be associated with ATO. The ATO necessarily has accurate position and train configuration information; therefore, the SDO system itself is simple, albeit by being interfaced to a complex ATO system.
Part 5 Application design considerations and implementation

5.1 General

5.1.1 The railway requires a system configuration that is generally applicable over the network. This permits rolling-stock to be moved to different duties. Where there are specific, more demanding performance requirements, these should be achieved by a system design that does not invalidate the general application. It is envisaged that this guidance note will contribute to a standard approach which will facilitate this aim.

5.2 Location

5.2.1 General location considerations

5.2.1.1 The ASDO and FASDO systems depend upon location technology. The two established location techniques on the railway are spot transmission devices such as RFID and Eurobalise, as compared to GNSS-based equipment which provides more continuous location information. Table 4 sets out the advantages and disadvantages of each.

5.2.1.2 To choose between these, or a combination of the two, the requirements of the railway should be understood. These are, within the performance requirements:

a) Independence of rolling-stock from infrastructure configuration

b) Minimum infrastructure equipment

c) Cost

d) Minimum maintenance and repair demands.

<table>
<thead>
<tr>
<th>Location technology</th>
<th>Disadvantages</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot transmission</td>
<td>Requires infrastructure</td>
<td>Can transmit data</td>
</tr>
<tr>
<td></td>
<td>May require track access for maintenance</td>
<td>Provides dependable precision (\sim 2) m if the number of transmission points is adequate and the distance from the last transmission to the stopping point is 50 m or less</td>
</tr>
<tr>
<td></td>
<td>Data change requires access</td>
<td>Works above ground and sub-surface</td>
</tr>
<tr>
<td></td>
<td>Must be placed before the stopping point</td>
<td>Unambiguously identifies which track the train is on</td>
</tr>
<tr>
<td></td>
<td>Achievable accuracy depends upon the distance from the transmission point to the stopping point</td>
<td></td>
</tr>
</tbody>
</table>
Guidance on the Application of Selective Door Operation Systems

<table>
<thead>
<tr>
<th>Location technology</th>
<th>Disadvantages</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite - based location</td>
<td>Works standalone only with a clear view of the sky</td>
<td>No infrastructure required</td>
</tr>
<tr>
<td>(GNSS)</td>
<td>Sub-surface requires additional sensors</td>
<td>Train remains independent of infrastructure</td>
</tr>
<tr>
<td></td>
<td>Does not provide sufficient discrimination to identify which track the train is on</td>
<td>Low life cycle costs</td>
</tr>
</tbody>
</table>

Table 4  Disadvantages and advantages of spot transmission and satellite based location

5.2.1.3  The case studies set out in Appendix A indicate that a basic ASDO system can operate with a precision of about 100 m. FASDO system applications can require precision of 5 m with 95% availability, or better.

5.2.1.4  Spot transmission can support the locator function, as well as the transmission of data. The transmission of data is not a necessary requirement. There are two recommended alternatives:

a)  RFID tags, and

b)  Eurobalise.

5.2.2  Global Navigation Satellite System (GNSS) technology

5.2.2.1  Because of its usefulness for other on-train functions the trend is for all future trains to be fitted with a GNSS sub-system, as set out in GE/GN8578: Guidance on the Use of Satellite Navigation (due to be published late 2008). Before contemplating another technology for SDO systems, the project should take a view on:

a)  The life cycle cost to the railway of a non-standard SDO system implementation, and

b)  The cost to the project of an implementation that complies with the guidance set out in this document with the cost of creating or modifying another system.

5.2.2.2  FASDO system applications require a greater accuracy, and the ATO system requires less discontinuity. Where sub-surface applications are not required, and with a clear view of the sky, a GNSS-based locator can be expected to provide adequate consistency in performance with very occasional use of manual operation. Sub-surface operations cannot use a GNSS-based location and spot transmission then becomes necessary.

5.2.3  Eurobalise

5.2.3.1  Eurobalise is a European standard for spot data transmission and location of trains for safety-critical purposes; the standard specifies that the Eurobalise reader shall be able to read a Eurobalise telegram at speeds up to 500 kph.

5.2.3.2  Eurobalise readers are generally designed to be integrated as part of an ETCS on-train system; hence installing an on-train Eurobalise reader is unlikely to be cost-effective other than in the context of ETCS application (either current or
Guidance on the Application of Selective Door Operation Systems

planned). Where trains and infrastructure are both ETCS-fitted, the marginal cost of supporting SDO is low.

5.2.3.3 The required accuracy for ETCS odometry measurement, as derived from ERTMS/ETCS – Class 1, Performance Requirements for Interoperability, SUBSET-041 v2.1.0, is ± (5 m + 5% of distance travelled since the previous Eurobalise), that is to say, ±10 m accuracy from a Eurobalise 100 m away, ±15 m accuracy from a Eurobalise 200 m away, etc. Eurobalises should therefore be placed as appropriate to achieve the (location-specific) accuracy required. In practice, therefore, extra Eurobalises may be required to support SDO application on an ETCS-fitted route.

5.2.3.4 Eurobalises themselves are inexpensive, require no other supporting equipment, and require little maintenance; it could therefore be cost-effective to use Eurobalises for SDO location determination on a route where all trains are ETCS-fitted, even where there is no other ETCS infrastructure.

5.2.3.5 Exceptionally, Eurobalise readers have been integrated with non-ETCS on-train systems. The marginal cost of supporting SDO with such systems would be higher than where the train and infrastructure were ETCS-fitted if the on-train system required modification and/or a greater number of SDO-specific Eurobalises were required.

5.2.4 Radio Frequency Identification (RFID) Tag technology

5.2.4.1 RFID is a relatively low-cost system to provide precision spot location and data transmission.

5.2.4.2 The Radio Frequency Identification (RFID) reader should be mounted on the train with the RFID tags on the infrastructure.

5.2.4.3 It is recommended that in order to minimise power consumption on a train the RFID reader should be of as low power as possible consistent with its working requirements. A key consideration for retrofit is the spare capacity of the train auxiliary supply.

5.2.4.4 A research project is being undertaken to determine relevant parameters of the RFID technology, as described in section 1.6. This section will be updated accordingly when the research is complete, and in future revisions to this guidance note.

5.2.5 RFID protocol

5.2.5.1 At present there is no commonly adopted air interface standard for use of RFID.

5.2.5.2 The standard BS EN/ISO 18000: Information technology – Radio frequency identification for item management, is the recommended basis for standardisation of RFID, but further work is required to ensure that compatibility between readers and tags from different suppliers can be achieved without compromising the low cost of these components.

5.2.5.3 The industry benefits by having a choice of reader suppliers, and can tolerate differences in the electrical interfaces and protocols between the reader and associated ASDO system equipment.

5.2.6 RFID geometry

5.2.6.1 The proposed geometry for the RFID tags and readers is as set out in Figure 8 below and is subject to change, dependent upon the results of the RFID trials.

5.2.6.2 In this scenario, it is important to ensure that the RFID reader reads the tag on platform 2 and not the one on platform 1. This requires careful attention to
Guidance on the Application of Selective Door Operation Systems

operating ranges to ensure that the tag on platform 2 is read reliably and the one on platform 1 is either not read or specifically ignored.

![Image of Geometry for RFID](image)

**Figure 8  Geometry for RFID**

5.2.6.3 Advantages of RFID proposed location:

a) It is protected from damage due to track works, stone blowing and tamping

b) Better weather protection, unlikely to suffer from settlement of snow or flooding

c) It is more environmentally protected, less chance of dirt and oil contamination

d) It is potentially accessible from the platform, or at least accessible for radio testing

e) It is possible to identify platform side with high integrity

f) The platform invert location offers better potential for ‘fit and forget’ long-term deployment, particularly where the tag is entirely passive.

5.2.6.4 Disadvantages of RFID proposed location and their mitigation:

a) Radio transmission needs careful regulation. Transmission power and receiver sensitivity may be controlled to limit the range, but this also constrains the ability to read the tag at speed. Ultra and Super high-frequency radio do not propagate through the train or through platforms (assuming solid brick/ballast/concrete). Some island platforms are open underneath; the tag can therefore be mounted on a vertical metal plate to shield radio reception from the rear

b) Two readers are required on each driving vehicle of the train, one on each side. Some designs can mitigate this by using one reader and multiplexing between two antennae.

5.3 Eurobalise technology and protocol

5.3.1 The implementation of Eurobalise should follow the application of Eurobalise within the national programme for implementation of ERTMS-ETCS.

5.3.2 Whereas location information is specific to ETCS, information on selective door operation is not and requires additional packets of information.
Guidance on the Application of Selective Door Operation Systems

5.3.3 An application for change has been made to the ERTMS-ETCS specifications for version 3.0.0 to incorporate selective door operation data in Packet 68. If a GB application is required before version 3.0.0 is available, Packet 44 can be used.

5.3.4 SDO system data would be communicated in Packet 44 of the Eurobalise protocol, as set out in GE/RT8064: European Train Control System – The Management of Packet 44.

5.4 Train crew interface

5.4.1 This section is divided into two sub-sections. The first sub-section considers operations where the driver is responsible for releasing the doors, the second (guard release of doors) considers where guards/train managers are responsible for releasing the doors.

5.4.2 Driver release of doors

5.4.2.1 ASDO system:

a) For ASDO system application, driver release is viewed as the method of control. A Man Machine Interface (MMI) can be provided both on trains with and without a train data management system option to provide information to the driver on door status and controls. It is recommended that standard colours and controls should be provided as set out in Appendix F. On trains without a train data management system, the SDO system logic and/or computer for controlling selective door operation can be incorporated into this MMI unit.

b) Where a Eurobalise system is used and a train data management system is not provided on the train, consideration should be given as to whether the logic/computing requirements for controlling selective door operation can be incorporated into the on-train ERTMS equipment.

c) The door release push buttons should be used to release the doors whether all doors or only selected doors are being released. The doors selected by the ASDO system and changes to this selection under degraded/failure conditions should be indicated on the screen.

5.4.3 Manual SDO system

5.4.3.1 Switches should be provided in the cab or at the guard’s door control panel that provides all the required SDO system options for that train. An indicator should be provided to show the doors selected for release before release of the train doors occurs. Where cost effective, a colour screen should provide this indication and use the standard colours as set out in Appendix F. This interface can allow a change of selection to be facilitated in abnormal conditions where the train has overrun its stopping position.

5.4.3.2 The door release push buttons should be used to release the doors, whether all doors or only selected doors are being released.

5.4.3.3 The system should be configured so that the doors can only be enabled from a release panel in the part of the train where the doors are required to open.

5.4.4 FASDO systems

5.4.4.1 FASDO systems are likely to be provided as additional functionality of an ATO/ERTMS implementation and therefore the equipment design considerations should consider the most cost-effective method of providing FASDO systems with the ATO. The provision of a colour screen MMI using the standard colours, as set out in Appendix F, is recommended.
Guidance on the Application of Selective Door Operation Systems

5.4.5 Guard release of doors

5.4.5.1 In normal operation it is recommended that guard release of doors is not applied to FASDO and ASDO systems as this prolongs dwell times without adding safety benefit.

5.5 Data management system

5.5.1 FASDO and ASDO systems may depend upon a number of different items of on-train data, for example:

a) Latitude/longitude location of stations (central point), together with a definition of the approach area

b) Station names

c) Possible next stations

d) Individual platforms and stopping points, where appropriate

e) The interface to the passenger information system defining when and where announcements are to be made in relation to the SDO system

f) Train consist data

g) Quality of expected GNSS coverage

h) How long station is/how many doors can be opened

i) Length of platform which is usable.

5.5.2 Consideration needs to be given as to how the data is uploaded to the train.

5.5.3 When events occur that require the stopping pattern of trains to be changed, it is usually necessary to carry out changes to a fleet’s FASDO data systems simultaneously or on an overnight basis. Such events that may necessitate such changes include timetable changes, engineering works and the opening of new stations. It is therefore recommended that the required facilities are provided to update the FASDO data systems at all stabling locations along the route.

5.5.4 The on-train database also has to be updated if the GNSS signal should be lost at a particular platform, which may occur due to building work over a station platform not undertaken by the railway. Further changes may be necessary.

5.5.5 Additionally, the train should download information on loss of RFID/tags or GNSS signal at a platform, in order that investigations can be undertaken and the appropriate action taken, as required.

5.5.6 The management arrangements for the databases should ensure that the change control and validation of new or updated databases ensures that they remain fit for purpose.

5.5.7 Data gathering on a new system or extension should include assessment of a number of items, including station locations, platform lengths, relevant signals and platform stop markers.

5.6 On-train equipment

5.6.1 This section considers three possibilities for the fitting of on-train equipment: new vehicles for a new fleet, vehicles that are to be modified to provide ASDO systems, and new vehicles that have to work with existing fleets.
5.6.1.1 New vehicles for a new fleet:

It is anticipated that most new vehicles will incorporate a train data management system of some type. Consideration should be given to using this system for ASDO system applications, due to the likely cost benefit this gives. Careful consideration should be given to determine whether the train data management system is capable of providing the required system integrity level for ASDO systems. If the on-train data management system is not able to provide the required level, then an additional system (as set out below, under modified trains) should be provided.

5.6.1.2 Modified vehicles:

On the basis that door control, including SDO system functions, is performed from the driving position of the train, an MMI, incorporating the driver’s screen and computer for the SDO system in a combined unit, is viewed as the best option.

In terms of transmitting the information along the train, use of trainwires/unitwires or a Frequency Division Multiplexing (FDM) system over the audio pair, may provide more cost-effective equipment than the fitting of a bespoke communication system along the train.

5.6.1.3 New vehicles to work with existing fleets:

Where new vehicles have to work with existing fleets some flexibility in applying the recommendations set out in this guidance note may be appropriate.

5.7 Implementation

5.7.1 Pre-service test

5.7.1.1 It is recommended that all the infrastructure work should be completed (for example, fitting RFID tags) and at least one train (longest configuration) should be delivered to allow a pre-service test to be undertaken where operation at each site is tested to ensure that adequate data is available and is being used in the correct way.

5.7.2 Database

5.7.2.1 A method of checking and updating the data, as set out in section 5.5, should be in place before any scheme is implemented.

5.7.3 Battery capacity

5.7.3.1 On modified vehicles, consideration should be given as to whether additional auxiliary power supply capacity should be provided on the train to allow an SDO system to be successfully implemented.

5.7.4 Location information – other uses

5.7.4.1 Consideration should be given as to whether the location information is to be used by other systems on the train, either at present or in the future and, if so, it would be advantageous that consideration be given to using a defined protocol for this data as an output of the ASDO system equipment.
Appendix A  Case studies of existing systems

There are a number of Selective Door Operation (SDO) systems currently in use on the GB railway network. This appendix sets out a brief description of a selection of those systems and their application. Figure 1A shows the range of applications from manual to ASDO systems which these represent.

A.1 Class 465/466 Networker
A.1.1 The Networker fleet consists of a family of similar designs: Class 465, including variants, and Class 466. A semi-automatic SDO system is incorporated, using an early form of the Hima-Sella Tracklink system. Control is provided on this system while the vehicle receiver is above the loop, and depends on accuracy in the stopping position. The SDO system can disable doors in the front and rear vehicles only, and manual control by the driver is still available. This is not in everyday use because it is inherently not failsafe as there is no way of detecting a failed track loop.

A.2 Class 375 Electrostar
A.2.1 Class 375 was the first UK train to be equipped with an Automatic Selective Door Operation (ASDO) system acceptable to HMRI.

A.2.2 The ‘navigation unit’ relies solely on a GNSS receiver housed in the PIS destination indicator, although there is a back-up using the Global Positioning System (GNSS) receiver in the second cab of the leading unit. This is linked to a database to provide door opening and PIS functionality.

A.2.3 The location of every station is defined by a central point (at the centre of the station) through latitude and longitude co-ordinates. This location is programmed in the ASDO system database within the Intelligent Display Unit (IDU). The ASDO system generates a geofence of 300 m from the station centre, and the software calculates this as an approximation to a square by setting a ‘delta’ on the latitude and longitude. The delta is a value of decimal degrees latitude/longitude approximating to ±300 m. Subsequent software updates have modified this arrangement to approximate to a circle, due to difficulties in discriminating between stations on lines with NW/SE or NE/SW orientation. An
Guidance on the Application of Selective Door Operation Systems

ASDO ‘tracking system’ uses a network map of connected stations such that, working from a previous known station, a limited number of options are available for the next station. The system tracks the journey through stopping and ‘pass through’ stations. This tracking system allows the ASDO system to predict and offer possible solutions to the train driver should GNSS fail to recognise the next station, due to it having no GNSS reception. If two successive stations have no GNSS reception, drivers are required to make a manual selection. Alternatively, if GNSS can be received between the stations, then a correcting waypoint between the stations can be defined.

A.2.4 This system allows a driver to manually confirm or alter the chosen location, or manually release doors in individual vehicles when a GNSS fix is not available.

A.2.5 Class 375 is equipped with an audio/visual PIS, compliant with the Rail Vehicle Accessibility Regulations 1998 (RVAR). The PIS also deals with splitting and joining services, describing which vehicles (by number) proceed to each individual destination on splitting services.

A.3 Class 377 Electrostar

A.3.1 Class 377 is similar to Class 375, but with the addition of a Hima-Sella Tracklink 2 reader and antenna fitted to the under-frame of driving vehicles. The readers and associated antennae decode transmissions from Tracklink 2 transmitter loop installed in the 4-foot at selected stations. The routes that these units serve include some stations that have platforms of different lengths. Where Class 375 simply identifies the general area of a station (±300 m from the centre) and treats all platforms as equal, Class 377 does likewise at the majority of stations, but a small number are treated as a special case. The special cases are those stations with different platform lengths or stations where GNSS reception is not possible or reliable. The number of vehicles allowing door release is only increased following positive detection of a Tracklink 2 loop identifying that a longer platform has been approached.

A.3.2 The system uses the GNSS-based system to ascertain which station it is at, and attains a default configuration for door release based upon the shortest platform at that station. However, if the train is routed onto a longer platform, it passes over a Tracklink 2 loop, and data is received regarding the station Universal Location Identifier (ULI) number and platform length. The train then amends the door selection for the ASDO system and the audio/visual announcement accordingly. Every platform approached is equipped with a Tracklink 2 transmitter/antenna for consistency. GNSS identifies the station at a global level, and the Tracklink 2 loop identifies the platform. In some cases, a number of Tracklink 2 transmitters/antennae are installed along a particular platform. Since the system uses a hybrid of GNSS and loop, failures of loop can therefore be identified by the train; the SDO system is substantially failsafe and depends on the driver stopping at the correct point.

A.4 Class 220/221 Voyager

A.4.1 SDO system functionality is built into the train’s Train Management System (TMS) using the Class 375 principle of GNSS to identify the station; however, to ascertain which platform the train is on, the driver is required to make a manual selection.

A.4.2 Once at the station the TMS interrogates an inbuilt database that contains a list of platform lengths, platform numbers and station names. Since the system knows which station it is at, it is able to provide the driver with a list of platform options. The driver then selects the platform which he has stopped at. The system can then look up the allowable number of vehicle doors to open by cross-referencing door release codes with its internal database.
Guidance on the Application of Selective Door Operation Systems

A.4.3 While Class 220 is equipped with an RVAR compliant PIS, the train operator has chosen to provide audio announcement through the train crew. The system therefore depends on the train crew making appropriate announcements concerning SDO.

A.4.4 The system on Class 220 is not considered to be a fully ASDO system, sitting between manual SDO and ASDO systems.

A.5 Class 222 Meridian

A.5.1 The SDO system is operated on the principle of a manual system in that it relies on the driver to decide how many doors should be released at each station. This is achieved by the provision of buttons by which the driver controls the number of doors to be released. The SDO system has no awareness of train location or the number of doors that should be released. Instead, the driver selects the number of doors to be released at every station.

A.6 Class 180 Adelante

A.6.1 Class 180s have a manual SDO system. The driver operates a rotary switch within the cab to select one to five vehicles (counting from the rear) for which the doors are prevented from opening. Automatic announcements are made which can be supplemented by driver announcements. The conductor communicates a bell signal to the driver regarding platform length, in order for the driver to make the activation as a double failsafe.

A.7 Classes 444 and 450 Desiro

A.7.1 These classes are provided with a manual SDO system that works on a per unit basis. The guard is responsible for making the manual judgment and thereby operating the doors. The system does not allow the decision to be made by the driver in the leading cab. The guard positions himself in the cab in the furthest position along the train in front of which the doors can be safely opened. Once the SDO system is selected, automatic announcements are made to the passengers to move forward to the appropriate positions within the train for disembarkation. These announcements can be supplemented by the guard, as necessary. It is understood that platform marker boards have been provided at stations where SDO systems are in use, aligned with the cab where the guard undertakes the SDO system activation.

A.8 London Underground

A.8.1 Correct Side Door Enable (CSDE)

A.8.1.1 Correct Side Door Enable (CSDE) is a system that has been used on London Underground Ltd (LUL) since the early 1990s and has been installed on the Circle, Piccadilly and other lines. Its primary function is monitoring, to ensure that the drivers cannot release/open doors on the wrong side or release/open doors if the train is not positioned within an allowed tolerance of the platform stop marker. Although the primary function of the system is to protect against wrong side door release/opening, a secondary benefit of it is that it has the ability to support an SDO system.

A.8.1.2 Correct Side Door Enable (CSDE) communicates between the platform and the train by inductive coupling. If the train does not receive a valid encoded data sequence from a loop based under the platform, then the doors does not open. When a station is closed, as happens on some LUL stations at off-peak periods, the platform transmitter can be switched off to ensure that the doors cannot be inadvertently released by a driver.

A.8.1.3 If the driver selects the wrong side, the system does not release the doors.
Guidance on the Application of Selective Door Operation Systems

A.8.2 Automatic Train Operation (ATO)

A.8.2.1 One of the earliest examples of Automatic Train Operation (ATO) is on the Victoria Line, which was commissioned in 1968. ATO systems perform all the functions of the driver, except for the closing of the doors. The driver only needs to press two buttons to close the doors and, if the way is clear, then the train automatically proceeds to the next station. Many newer Metro systems are now computer-controlled, including Docklands Light Railway. In most systems a driver or train operator is still present to mitigate risks associated with failures or emergencies.
Appendix B  Lessons learnt and issues arising from existing systems

B.1 Overview

B.1.1 In the study of current SDO systems, as summarised in Appendix A, a number of issues have been identified and are listed in this appendix. During the drafting of this guidance note cognisance has been taken of these issues and incorporated, as appropriate. The list also provides useful information to those parties assessing the requirements for a specific system. The list should not be considered definitive but represents only those issues that were identified during the research carried out upon which this guidance note is based.

B.2 General

a) The balance between complexity and functionality as a consideration in the design and provision of SDO systems

b) Compatibility with regard to rolling-stock and working practices across geographical areas

c) The risk to passengers alighting where a train:
   i) Stops short at a platform
   ii) Stops incorrectly
   iii) Overruns the platform
   iv) Stops additionally or unexpectedly

d) The ability to operate manual override, or to isolate the SDO system functionality altogether without encouraging inappropriate of inadvertent use.

B.3 Geographical positioning

a) The potential for the failure of an ASDO system to reconcile the geographical location, resulting in the train being unable to locate the correct stopping position

b) The importance of accuracy and date entry in setting up the co-ordinates to be referenced by the GNSS system.

B.4 Operational principles

a) The length of time to operate door release under selective door operation, leading to impatient passengers using the emergency egress release handles

b) The possibility for doors to open under ASDO/FASDO systems at a station, where a train stops out of course. This can be desirable or undesirable, depending on the exact situation

c) Special operating scenarios are set out in section 2.4.

B.5 Rolling-stock direction and train formation

a) A change in direction of travel by a train reliant on selective door opening

b) The substitution of planned stock with a longer consist, which results in a train being routed to a platform that cannot accommodate all the vehicles

c) The disruption of the vehicle sequence where the joining order of two trains is different to that planned.
Guidance on the Application of Selective Door Operation Systems

B.6 Access for those with reduced mobility

The reversal of unit formation, potentially creating a risk of a wheelchair user being placed in a vehicle when an SDO system is in use, whereas at the time of planning/reservation this would not have been the case.

B.7 Information

a) The sequential (series) PIS addressing method proving too time consuming for the normal approach time to stations where SDO systems are in use, in order to give passengers adequate information in a timely manner

b) Inconsistency in the use of coach letters and numbers.

B.8 Infrastructure

a) The fouling of road crossings adjacent to station platforms by the leading or the rear vehicle of overlength trains operating SDO systems

b) Electro-Magnetic Compatibility (EMC) interference resulting from balises/tags positioned at the side of platforms

c) Avoiding the use of infrastructure-based equipment which is difficult to maintain or which inhibits permanent way activities.

B.9 GNSS

Issues associated with GNSS are set out in GE/GN8578: Guidance on the Use of Satellite Navigation (due for publication late 2008).
Guidance on the Application of Selective Door Operation Systems

Appendix C  Maintenance

C.1  Introduction
C.1.1  Section 2.9 of this guidance note sets out the general maintenance principles that should be adopted for SDO systems. The content of this appendix relates to specific considerations that should be addressed on establishing a maintenance regime.

C.1.2  ASDO systems should be designed for high reliability and low maintenance/overhaul requirements. ASDO systems may require specialist skills and knowledge, so self-testing should be included within the system design. The UK railway industry has experience with GNSS, and testing GNSS of PISs has been particularly troublesome, since vehicles should be moved outside covered areas to enable testing.

C.1.3  Existing applications using infrastructure balises/tags have also been problematic, as balise/tag failure is not always automatically detected. A well-designed ASDO system should be capable of detecting and potentially predicting failures of individual balises/tags.

C.2  Routine cleaning
C.2.1  Routine cleaning, as an important maintenance task, should be considered. Brake dust, for example, has the potential to affect the performance of radio antennae.

C.2.2  Consideration should be given to the GNSS/GSM antennae on the train roof being cleaned regularly by the train wash, or at least through natural rainfall.

C.2.3  Maintenance procedures should give a warning about avoiding the application of paint treatments (conductive) over the antenna domes. This has previously been a problem with some train radio systems antennae.

C.3  Routine testing (trains)
C.3.1  Overview
C.3.1.1  In common with all other train systems, depots should have a capability to test the SDO system to confirm that it is working correctly. ASDO systems, whether Global Navigation Satellite System (GNSS) or balise/tags based, require a test location to be created. The following provisions in this section should be considered:

C.3.2  GNSS testing
C.3.2.1  Special test locations may be required at depots, possibly identified by marker boards. At these locations, drivers may be required to test door release before trains are taken into service. These test locations should be entered into the on-train database, as if they are additional stations.

C.3.3  GNSS analysis
C.3.3.1  The navigation unit should have a management interface, allowing a computer to be connected and thereby perform detailed analysis. Analysis should include a method of observing satellite signal strength and average signal strength, averaged over a period of time. This analysis facilitates the performance of the antenna and cable to be checked.

C.3.4  GNSS simulation
C.3.4.1  Depot staff (and development/project engineers) should have the capability to simulate GNSS through the maintenance computer. It should be possible to take the train ‘on a journey’ from within the depot. This test facility should be used to validate databases whenever they have been changed. However, this does not
control the risk of entering the wrong latitude and longitude coordinates, as there is a strong chance that both simulator and on-train database will match, sharing the same data source. Therefore, the on-train database should be validated by RFID testing at each station along the route.

C.3.5 Balise/tag reader testing
C.3.5.1 A test facility, comprising a test RFID tag or balise, should be provided, allowing the following parameters to be varied:

a) The distance between the train reader and balise/tag, including offsets, and
b) The speed of the passing balise/tag (limited to vehicle speed on the depot, unless this can be simulated).

C.3.5.2 The on-train reader system should be capable of reporting received data packets and errors. It should be possible to identify readers that are below optimum performance, or antennae that are incorrectly fitted or aligned.

C.3.6 Daily test
C.3.6.1 Train crews should maintain familiarity with the procedure to undertake SDO system override. Depot facilities should be provided to enable testing by train crew. This should involve including different depot roads being configured for GNSS and provision of Radio Frequency Identification (RFID) tags.

C.4 Routine testing (infrastructure)
C.4.1 GNSS
C.4.1.1 The ASDO system itself can monitor system performance throughout the infrastructure. The system identifies any instances needing train crew intervention, as this is a clear indication of failings within the navigation unit. Furthermore, the systems fitted to the fleet should be used to gather data regarding the quality of GNSS navigation at individual locations within the railway network, over an extended time period. This information identifies any potential weakness in the GNSS solution and should be used to identify where GNSS solutions, in isolation, present a risk of failure.

C.4.2 Balise/tag
C.4.2.1 To supplement the facilities set out above, infrastructure installation and maintenance teams should be provided with a method of confirming the output of a balise/tag locally, if only to confirm they have installed the correct balise/tag at the correct location and that signal strength is as expected. With RFID tags installed on the platform invert, this enables the reader to be used from the platform without needing access to the track (subject to PTS limitation of working ‘on or near’ the track).

C.5 Maintenance and overhaul tasks (infrastructure)
C.5.1 A well-designed ASDO system, following this guidance note, automatically provides reports from the assistance server or, alternatively, reports available by analysis of TMS data. The reports should provide the following information for action by the infrastructure manager:

a) Balise/tag reference number
b) Platform identifier
c) Balise/tag location on platform
d) Problem
Guidance on the Application of Selective Door Operation Systems

C.5.2 Routine cleaning of infrastructure components is not currently envisaged, although a report of poor performance may be corrected by cleaning.

C.6 Maintenance and overhaul tasks (trains)

C.6.1 The ASDO system should be designed to incorporate self-testing. GNSS can be verified by regular cross-checking specific tag locations.

C.6.2 A well-designed electronic system should not require routine overhaul. However, some components may have limited life and require replacement.

C.6.3 On ASDO systems that are not fully electronic, and on manual SDO systems, overhaul of additional SDO system components should be undertaken at appropriate frequencies.

C.6.4 In the case of ASDO and FASDO systems, special attention should be paid to databases in order to ensure they are within their period of validity. Corruption should be detectable with a high degree of confidence. Updated databases should be subjected to verification to ensure that amendments are correct. Procedures should be commensurate with the level of safety determined from safety analysis, and not more demanding, as this would lead to a wastage of resources.

C.7 System self-test

C.7.1 Examples of self-test that should be considered are:

a) Testing of system memory at start-up
b) Verification that software versions are valid
c) Verification that database versions are valid
d) Verification that hardware interfaces are working. In particular, there should be a method of confirming that the train consist data is correct and the train communications are serviceable. For example, it is possible that failure of communications within a particular vehicle leads to an incorrect number of vehicles being detected, due to node bypass arrangements
e) Verification that interfaces to door control systems are working.

C.8 Reporting of failures

C.8.1 In the event of failures, the system should provide notifications as follows:

a) To the train maintenance system, and
b) To the train crew, if any action is required to enable the train to continue in service.

C.8.2 Infrastructure failure reports should provide information such as:

a) Equipment identity
b) Location
c) Fault code.
Appendix D  Further research related to this guidance note

D.1  Introduction
D.1.1  The information set out in this appendix is extracted and summarised, as appropriate, from the outline business cases for research projects T769 and T771, which are both managed by RSSB. The research projects are respectively:

a) To establish criteria for selective door operation primarily related to the identification of human factors issues, and

b) To trial RFID (Radio Frequency Identification) for SDO systems.

D.1.2  The results of both areas of research are to be considered for inclusion in a future draft of this guidance note.

D.2  Research project T769, Criteria for the Application of Selective Door Operation

D.2.1  Overall objectives of the research
D.2.1.1  The objective of the project is to understand the human factors issues associated with the introduction of SDO, through an evaluation of the costs, business benefits, safety and operations performance issues.

D.2.1.2  The deliverables from the first stage of the research should assist in the identification of the point at which the safety and performance risks outweigh the business benefits of adopting SDO when compared to other possible solutions.

D.2.1.3  This should be followed by a second stage of research to develop an assessment tool as an informal decision-making aid, which can be used to critique a station (taking into account the flow of passengers and train types using the station) as to its suitability for the application of SDO.

D.2.1.4  The research is divided into two stages, as set out in sections D.2.2 and D.2.3.

D.2.2  Specification of the external study – human factors and selective door operation work package

D.2.2.1  Work package objectives
D.2.2.1.1  The objectives of this work package are to understand the limiting factors to the implementation of SDO at stations, with regard to the behaviour of passengers and the occurrence of undesirable incidents.

D.2.2.1.2  A study is to be carried out to assess:

a)  Safety risk to passengers and staff, that is to say, would the introduction of SDO increase the occurrence of injury or death? Are there additional safety measures that could be introduced to mitigate these risks?

b)  Operational risk to the railway, that is to say, would the introduction of SDO decrease the operational effectiveness of the railway, such that SDO is not advantageous? This could be affected by location, for example at airports where passengers have luggage, and there may be a high incidence of foreign passengers who may not comprehend instructions given.

c)  The point at which the safety and performance risks outweigh the cost savings from adopting SDO, in favour of other possible solutions.
D.2.2.2 Scope

D.2.2.2.1 This work package requires the completion of:

a) A literature review, to identify parameters by which passenger behaviour is known to be influenced

b) Interviews with HM Railway Inspectorate (HMRI) and the Department for Transport (DfT) concerning current identified SDO risks and passenger behaviour. (See Note 1 below)

c) Interviews with station managers to collate further information on the types of behaviour which lead to both a safety risk to the passengers or staff, or an operational risk to the train services

d) Interviews with current users of SDO (train crew, station staff and passengers) to assess specific examples where implementation has produced specific passenger behaviours, and also where specific passenger behaviours or needs have influenced the effectiveness of SDO

e) An understanding of the business benefit of introducing SDO compared to other possible solutions, and the point at which (through the establishment of a set of criteria or factors which would be weighed against each other for any potential application scheme) these are outweighed by the human factor safety and operations performance risks. This should consider dimensions such as passenger footfall, the number of trains per day using SDO at the stations concerned (often only a fraction of the total train service) and the costs and practicability of the other possible solutions, including the lengthening of platforms

f) A specification for the generation of an assessment tool to investigate the suitability of individual/different types of stations for SDO.

Note 1: Within the current Rail Guidance Document from the HMRI, the following approach is required:

a) 'Where the provision of a “standard” platform length is not reasonably practicable, duty holders should be able to demonstrate that they have assessed the risks to passengers and staff waiting, boarding and alighting and have implemented appropriate control measures'

b) The interviews undertaken seek to address the limits of this approach, where control measures would not be able to lead to suitable management of the risk.

D.2.2.3 Deliverables and benefit delivery plans

D.2.2.3.1 This work package is required to deliver the following:

a) An SDO Human Factors Study Report

b) A specification – for the generation of an assessment tool.

D.2.2.3.2 The first deliverable is to be used to up-date this guidance note GE/GN8577: Guidance on the Application of Selective Door Operation Systems, for promulgation throughout the industry.

D.2.2.3.3 The second deliverable is to be used to support the work package for the development of an SDO assessment tool.
Guidance on the Application of Selective Door Operation Systems

D.2.2.4 Stakeholder engagement
D.2.2.4.1 The primary stakeholder groups are as follows:

a) ATOC
b) DfT
c) Infrastructure Manager (Network Rail).

These are to be engaged via regular review meetings and document deliverables review.

D.2.2.5 Critical success factors
D.2.2.5.1 The SDO Human Factors Study Report is required to provide clearly identified research results and recommendations against each of the objectives and scope statements defined within this work package. The report is required to provide an overall frame of reference to assess the point at which SDO becomes undesirable in the light of the identified human factor safety and operations performance risks, to support decision making as to whether the introduction of SDO is or is not the optimum/recommended solution to increasing passenger-carrying capacity in a particular set of circumstances. Research results and recommendations are to be presented in such a way as to readily support the amendment to GE/GN8577.

D.2.3 Specification for the development of the SDO assessment tool
D.2.3.1 Work package objectives
D.2.3.1.1 An assessment tool is to be developed which can be used to critique a station (taking into account the flow of passengers and train types using the station) as to its suitability for the application of SDO.

D.2.3.1.2 The assessment tool is to be tested against three identified stations to determine how well it helps to determine the risks, and aids the user through the determination process (recognising that passenger congestion and train frequency affect risk). It is intended that the testing should cover a variety of stations, including:

a) Terminus stations
b) Through platforms
c) Interchanges.

D.2.3.1.3 The tool is required to consider passenger management tools, which are required to ensure that passengers travel in the correct vehicles for their destination. The tool is required to identify the point at which the safety and performance risks associated with the introduction of SDO would render it unsuitable for introduction at a particular station/type of station.

D.2.3.2 Scope
D.2.3.2.1 This work package covers the development of an assessment tool which can be used to critique a station as to its suitability for the application of SDO.

D.2.3.3 Deliverables and benefit delivery plans
D.2.3.3.1 The deliverables of this work package are:

a) An SDO assessment tool, and
b) A study report – detailing the results of the testing at the individual stations.

D.2.3.3.2 The assessment tool is to be demonstrated to the RSSB and the stakeholder group at a presentation workshop. It can then be handed over to ATOC for
Guidance on the Application of Selective Door Operation Systems

possible further promulgation and used to support the up-date of this guidance note GE/GN8577: Guidance on the Application of Selective Door Operation Systems (possibly being included as an appendix).

D.2.3.4 Stakeholder engagement
D.2.3.4.1 Primary stakeholder groups are as follows:

a) ATOC
b) DfT
c) Infrastructure Manager (Network Rail).

D.2.3.4.2 These are to be engaged via regular review meetings and document deliverables review.

D.2.3.5 Critical success factors
D.2.3.5.1 The SDO assessment tool is required to be clear and simple to use by non-specialists, and to be supported by adequate documentation that defines both how it should be used and maintained, and identifies any limitations or assumptions that are associated with its design.

D.2.3.5.2 The tool is required to identify the point at which the safety and performance risks associated with the introduction of SDO would render it unsuitable for introduction at a particular station/type of station.

D.3 Research project T771, Trial of RFID (Radio Frequency Identification) for SDO (Selective Door Opening) System
D.3.1 Overall objectives of the research
D.3.1.1 The use of RFID in an SDO application is currently unproven and it is considered that the system should undergo practical trials on the railway. The research should investigate:

a) Technology issues – which technology/frequency band provides the best performance, product acceptance, multiple suppliers and opportunities for configurable tags for switchable data requirements

b) Infrastructure issues – viable options for RFID tag and reader positioning, station, train and interface considerations, common ground for the use of RFID tags to freight vehicles and the potential use of common standards and equipments

c) Environmental factors – the reliability and robustness of this technology in the railway application and other factors including EMC, snow, rain, etc.

D.3.2 Specification for the work package
D.3.2.1 Work package objectives

D.3.2.1.1 The objectives of this work package are listed below:

a) To investigate viable options for RFID tag positioning and reader positioning, including station infrastructure, train and interface considerations

b) To confirm the reliability and robustness of this technology for the SDO railway application

c) To understand the effects of the environment, for example, snow/rain and EMC, and to investigate mitigations against them

d) To understand the needs of train and infrastructure installation, including power consumption requirements
Guidance on the Application of Selective Door Operation Systems

e) To identify which technologies/frequency bands provide acceptable performance (in particular compare 2.45GHz with 860-868MHz)

f) To identify common ground with the use of RFID tags on freight vehicles, for example, potential use of common standards and equipment. In particular, investigate commonality of equipment to the existing Network Rail's AVI RFID system used for PanChex, that is to say, is a common reader/tag possible? And, more generally, to investigate the extent to which the RFID equipments supplied by various manufacturers could be interoperable within a railway environment.

g) To investigate product acceptance, approvals and support issues

h) To investigate whether it is practical to have a standard air interface and multiple suppliers

i) To investigate opportunities for configurable tags for switchable data requirements

j) Option for the provision of an outline SDO System Architecture document for a combined RFID/GNSS/SDO system, to be prepared as a separate deliverable, on the basis that this could provide a 'stepping stone' towards the proposed target architecture/currently anticipated SDO design solution.

D.3.2.2 Scope

D.3.2.2.1 The following scope statements apply to this work package:

- To investigate/identify a number of positions for readers and tags to assess whether they are capable of providing the target reliability under railway operating conditions. If the target reliability is not met, other positions or other mitigations should be investigated, as follows:

  a) To determine the range of acceptable positions of the tags in relation to the platform stop marker, taking into account the range of the expected stopping position of the train

  b) The design should consider how to accommodate complex track arrangements

  c) Where lines are bi-directionally worked, separate tags are needed for each platform working direction

  d) The preparation of the equipment/tag installation drawings and approvals needed by the train operating companies and Network Rail, including those associated with EMC approval, and obtaining the agreements necessary for the fitting of a transmitting device onto each of the trains supporting the trial. Agreeing/arranging the fitting of the equipments onto the train and station infrastructure, the maintenance of this equipment throughout the course of the trial and its removal/disposal following the completion of the trial

  e) Currently, First Capital Connect, Southern and Govia are recommended as appropriate train operating companies to be approached to support the trial, on the basis that they are able to offer dual voltage working and commonality with the work currently being carried out as part of project T510 – Obtaining data to support investigations into the dependability of GNSS-based odometry. RSSB and the DfT are available to help facilitate the making of the arrangements needed to support the trial.
Guidance on the Application of Selective Door Operation Systems

- The trials shall be undertaken on a minimum number of two routes, preferably three.
  a) The trials shall be undertaken on >10 stations per route
  b) A minimum of 2,000 passes of each reader shall be undertaken to determine error rate
  c) Currently recommended routes include those serviced by First Capital Connect (Bedford to Brighton) and Southern (Watford to Gatwick) train operating companies, as these are able to offer dual voltage working. Govia (Litchfield to Redditch) is also recommended, as this provides commonality with the GNSS research data currently being gathered by project T510 – Obtaining data to support investigations into the dependability of GNSS-based odometry.

- On-train readers must be capable of receiving a number of data packets from the tag as the train passes at a maximum of 50 mph, which is assumed to be the maximum approach speed for a train that stops at a platform. The sub-system must be capable of reading at least three identical sets of packets of data.
  a) The tests include data in the packet for two applications:
     i) Basic SDO, and
     ii) SDO incorporating Correct Side Door Checking, Correct Side Door Enabling, Correct Stop Position Checking, and 256 spare bits for other applications
  b) RFID payload data is to include a Unique Line Identifier (ULI). Each packet is to be validated to confirm ULI is as expected for direction (assuming platforms are not bi-directional). Erroneous or unexpected tag readings, including communication errors, are to be logged and used to identify failures or degradation in both train and infrastructure
  c) Investigation is to be carried out as to whether two readers are required on each driving vehicle of the train, or whether one reader suffices
  d) The RFID readers on the train have to be shown to meet the following:
     i) Capable of operating over the wide voltage range on a vehicle (0.7 x V to 1.25 x V); where V is the nominal Voltage provided by the train systems
     ii) Surge and transient tested to RIA 12
     iii) EN50155 Over-voltage and Surge Testing
     iv) EMC compliant with appropriate railway standards and testing
     v) EN61373 Random Vibration and Shock Testing (supersedes RIA13).

- As an option candidate RFID/GNSS technologies are to be reviewed in support of the SDO application and an outline System Architecture design solution prepared for the proposed SDO application. This is required to address existing on-train architecture issues (data buses, communications, power availability, multi-system applications, etc) and overall system integration issues, such that a coherent end-to-end SDO design solution can be developed as part of a further follow-on project.
Guidance on the Application of Selective Door Operation Systems

a) If during the preparation of the proposed outline SDO System Architecture Design document, or as a result of the RFID/GNSS trials, it becomes clear that the currently proposed RFID/GNSS technology solution is not the optimum design solution for an SDO application, alternative candidate architectures/technologies are to be recommended for further study/investigation. This recommendation could be on the basis of the technology issues involved or future cost considerations for the UK rail industry.

D.3.2.3 Deliverables and benefit delivery plans

D.3.2.3.1 On project completion a report is to be provided describing the evidence provided from the trials to support the following detailed conclusions, to include:

a) Viable options for RFID tag positioning and reader positioning, including station infrastructure, train and interface considerations
b) Confirmation of the reliability and robustness of this technology in the SDO railway application
c) Mitigations against the effects of the environment, for example, snow/rain, EMC
d) Details of train and infrastructure installation, including power consumption requirements
e) Identification of which technology/frequency band provides acceptable performance (compare 2.45GHz with 860-868MHz)
f) Identification of common ground with use of RFID tags on freight vehicles, potential use of common standards and equipment, recommendations on equipment interoperability and notable differences
g) Product acceptance issues and mitigations
h) Whether it is practical to have a standard air interface and multiple suppliers and, if not, what are the main obstacles
i) Opportunities for configurable tags for switchable data requirements and identification of any issues
j) Confirmation or otherwise that commonality of equipment to Network Rail’s AVI RFID system used for PanChex is possible, for example, is a common reader/tag possible?

D.3.2.4 Stakeholder engagement

a) Railway Undertakings (RUs) – for placement of tags and data logger on trains
b) Infrastructure Manager (IM) – for positioning of tags on platforms and elsewhere within the station infrastructure
c) VTC&C Systems Interface Committee and Sub Groups, that is to say, FC&PS
d) Network Rail; RFID AVI project
e) Freight Operating Companies (FOCs) – RFID is already on some wagons
f) DfT
g) ATOC.
Guidance on the Application of Selective Door Operation Systems

D.3.2.5 Critical success factors
D.3.2.5.1 Critical success factors for the work package are identified below:

a) Confidence in the RFID technology in the railway environment, for example, no change or degradation of trial equipment

b) Identification of specific technology, associated costs and suppliers

c) Error rate compatible with a target reliability; capable of operation with 99.99% reliability for train speeds from 0 mph to line-speed (for trains not stopping at platforms) and 0 mph to 50 mph (for those stopping)

d) Routes for the tag trials include AC, DC, and non-electrified lines. Candidate routes include: Litchfield to Reddich (as per project T510 currently trialling GNSS) with Govia, Watford to Gatwick with Southern Railway, and Bedford to Brighton with First Capital Connect. Support for making the necessary arrangements should be possible via the RSSB/DfT customer

e) Number of stations to be included on a trial route >10. (The number of trains/stock to be included, based on the number of passes needed, needs to be determined)

f) Error rates to be investigated for root cause and possible solutions recommended

g) Validation of data read a minimum of three times by each reader

h) Validation of bi-directional working

i) Validation that the readers can be programmed to incorporate unique line identifiers

j) The position of the tags is acceptable for maintenance and radio testing purposes

k) Validation that the tag RF radiation pattern has no interference with adjacent platform tags, other train equipment, RFID systems (for example, AVI), or EMC within the wider railway (for example, TPWS/ GSM-R, GPS, COMS, etc)

l) Recommendations for any product acceptance, approvals and support issues that may arise

m) Identification of the practical implications and associated costs of introducing a standard air interface and multiple suppliers

n) To recommend the optimum solutions for incorporating configurable tags for switchable data requirements. This should include a review of both variable and real time variable data options

o) Report on the ease of installation at each of the appropriate/recommended trial sites/positions. A critical success factor is that fitment to an acceptable standard is achievable at all of the representative sites/positions. A brief description is required of each site/position to ensure that their representativeness is transparent and to show that all of the common sites/positions have been considered

p) Confirmation or otherwise that commonality of equipment to Network Rail’s AVI RFID system used for PanChex is possible, for example, is a common reader/tag possible?
q) As an option, the preparation of an Outline SDO System Architecture Design Solution document that can support the development of a coherent end-to-end SDO design, as part of a further follow-on project

r) The SDO Study Report provides clearly identified research results and recommendations against each of the objectives and scope statements defined within this work package. Research results and recommendations should be presented in such a way as to readily support the amendment to this guidance note GE/GN8577: Guidance on the Application of Selective Door Operation Systems.
Appendix E  SIL levels: summary of provisional research results

E.1  Introduction

E.1.1 This appendix addresses the process for deriving Safety Integrity Levels (SILs) for a generic Selective Door Operation (SDO) system and is based on the main findings from the research project T686 – Production of an Industry Standard for Use of Selective Door Operation (SDO) systems in the UK. The generic SDO system considered in the Research Report is based on a hypothetical system architecture with constraints imposed by additional simplifying assumptions.

E.1.2 A SIL is intended to provide the necessary level of confidence that a safety system can deliver the required safety function with the appropriate probability. This requires a detailed analysis of the specific design architecture and the systematic and random failures that are inherent in that design. Important note: The SIL values derived in the Research Report and reproduced in this summary are therefore not suitable to be used directly as part of a design basis for an SDO system, and are only included to enhance the illustration of the process undertaken in their derivation.

E.1.3 At the time of publication of this guidance note further studies are being undertaken to investigate the SIL values applicable to SDO systems. In the interim it is considered that this summary could be of benefit to those considering installation of SDO systems.

E.1.2  Basis

E.1.2.1 The report considers both Automatic Selective Door Operation (ASDO) and Fully Automatic Selective Door Operation (FASDO) systems. In the absence of a detailed functional and system architecture design for an SDO system, the following were used as a basis for the design:

a) Only the risk arising from the failure of the SDO system is considered

b) Only random failures are considered and systematic failures have not been considered

c) Common Cause Failure (CCF) modes have been assumed to have been mitigated against, and no allowance has been included

d) Maintenance and fault diagnosis testing regimes have not been addressed

e) The tolerable individual risk of fatality to a passenger from an SDO system accident is $10^{-7}$ per annum.

E.1.2.2 Item e) above was derived on the basis that the SDO system faults should not contribute more than 10% of the risk of fatality of $10^{-6}$ per annum to an individual from railway operations. The risk tolerability criterion used as the basis for the indicative SIL analysis was therefore set at a risk of fatality to an individual of $10^{-7}$ per annum.

E.1.2.3 The time of exposure to the hazard was derived on the basis that a defect with the SDO system may occur any time in the train’s diagram, and not necessarily at a time co-incident with the use of the door. This assumption means that the exposure of the passenger to the hazard associated with the failure of the SDO system is considered to be independent of the passenger’s time using the door, and is a function of when it is used during the train’s working day. On this basis the time at risk for the passenger was estimated to be 3840 h/y (240 days/y and 16 h/day) while the time at risk for the train manager was estimated to be 5760 h/y (288 days/y and 20 h/day).
Guidance on the Application of Selective Door Operation Systems

E.1.2.4 The human error probabilities used in the analyses are presented in Table 1E.

<table>
<thead>
<tr>
<th>Human Error Description</th>
<th>Human Error Probability (HEP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When vehicle is stationary, a commuter uses the door open button when prompted, but when there is no platform outside the door</td>
<td>0.05</td>
</tr>
<tr>
<td>When vehicle is stationary, a commuter uses the door open button when prompted, but when the train is not correctly positioned (station buildings may be visible, but no platform)</td>
<td>0.1</td>
</tr>
<tr>
<td>Train crew requests door open when the vehicle is stationary outside a station when prompted by the MMI</td>
<td>0.1</td>
</tr>
<tr>
<td>Train crew requests door open when the vehicle is at the platform, but not in the correct position when prompted by the MMI</td>
<td>0.5</td>
</tr>
<tr>
<td>Train crew requests door open when SDO / non-SDO system requirement is confused and shown incorrectly on the MMI</td>
<td>0.9</td>
</tr>
<tr>
<td>Train crew requests door open when SDO / non-SDO system requirement is confused, but shown correctly on the MMI</td>
<td>1.0</td>
</tr>
<tr>
<td>Train crew requests wrong side door open when prompted by the MMI</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 1E Human Error Probability (HEP)

E.1.3 Method

E.1.3.1 The methodology used in the SIL assessment presented in the Research Report is stated to be broadly in line with that set out in BS EN 50129:2003: Railway applications. Communication, signalling and processing systems. Safety related electronic systems for signalling, and in IEC 61508-1:2002: Functional safety of electrical/electronic/programmable electronic safety-related systems. General requirements. The approach included undertaking a hazard identification process using a brainstorming technique, and developing a list of related hazardous scenarios. The five hazardous events identified from the brainstorming process are shown in Table 2E.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Hazardous events</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wrong stop position</td>
</tr>
<tr>
<td>2</td>
<td>Doors not inhibited</td>
</tr>
<tr>
<td>3</td>
<td>Wrong pattern of doors inhibited</td>
</tr>
<tr>
<td>4</td>
<td>Wrong side door opening</td>
</tr>
<tr>
<td>5</td>
<td>Doors open when stopped on the running line</td>
</tr>
</tbody>
</table>

Table 2E Hazardous events

E.1.3.2 Owing to the absence of an SDO system architecture and associated component failure analyses the causes leading to the hazards and the ensuing hazard scenarios were only identified at a high level.
E.1.3.3 The block diagram representation of the main features considered in the hazard scenarios is show in Figure 1E.

Figure 1E Block diagram representation of the features considered in the hazard scenarios for a generic SDO system.

E.1.3.4 The consequences per door open event were estimated using the Fatalities and Weighted Injury (FWI) values of 0.0106 and 0.0465 per annum extracted from the RSSB Safety Risk Profile Bulletin, issue 5, for the hazardous events HEM 7 and HEM 9A. These relate to physical harm resulting from an individual falling from a train door aperture. The corresponding FWI value per door opening for a passenger falling out of a train onto the track (HEM 7) is 0.015, and for a passenger injured while alighting a train (long train at short platform) (PTALLSP-H HEM 9A) is 0.012.

E.1.3.5 Using the risk tolerability criterion and these FWI per event, together with the time exposed to the hazard and the human error probability in relation to using the door controls and alighting from the train, the maximum failure rate for the SDO system that satisfies the criterion was then estimated. This maximum failure rate value is referred to as the ‘Tolerable Hazard Rate’ (THR) and was derived using the following formula:

$$THR = \frac{\text{Risk Criterion}}{\text{exposed to hazard (h/y) x HEP of train crew x HEP of passenger x probability of falling from train x FWI per door event}}$$

E.1.3.6 The THR was then used to determine the corresponding SIL level in accordance with the values shown in Table 3E.

<table>
<thead>
<tr>
<th>Tolerable Hazard Rate (per hour)</th>
<th>SIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{-9}$ to $10^{-8}$</td>
<td>4</td>
</tr>
<tr>
<td>$10^{-8}$ to $10^{-7}$</td>
<td>3</td>
</tr>
<tr>
<td>$10^{-7}$ to $10^{-6}$</td>
<td>2</td>
</tr>
<tr>
<td>$10^{-6}$ to $10^{-5}$</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3E Safety integrity levels

E.1.4 Results

E.1.4.1 Table 4E summarises the results of the initial analysis, which indicates using a SIL 2 value for an SDO system. However, while it is considered that the analyses is conservative, it is necessary to appreciate that a higher SIL level is likely to be...
required if the complexity of the system increases as the design develops. It is also emphasised that it is not appropriate to consider that a SIL specified for a system can be achieved by combining components or sub-systems that individually have that SIL value. It is likely that it will be necessary to apportion higher SIL values to some ‘units’ used within the system. It is for this reason that the SIL values should be appraised throughout all stages of the design process to ensure that the system meets the safety objectives and remains As Low As Reasonably Practicable (ALARP).
## Guidance on the Application of Selective Door Operation Systems

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Title</th>
<th>Description</th>
<th>Door condition</th>
<th>Consequence(^1) (FWI)(^2) per door open event</th>
<th>Tolerable Hazard Rate (Failures/h)</th>
<th>SIL equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wrong stop position</td>
<td>Any platform side doors open when vehicle is stationary, but away from correct platform location</td>
<td>Platform side doors are enabled off the platform end</td>
<td>0.012</td>
<td>(2.2 \times 10^{-7})</td>
<td>SIL 2, SIL 2</td>
</tr>
<tr>
<td>2</td>
<td>Doors not inhibited</td>
<td>Off-platform doors not inhibited by the SDO system when correctly stopped at platform</td>
<td>Doors that should be protected by the SDO system are enabled</td>
<td>0.012</td>
<td>(4.3 \times 10^{-7})</td>
<td>SIL 2, SIL 2</td>
</tr>
<tr>
<td>3</td>
<td>Wrong pattern of doors inhibited</td>
<td>Wrong pattern of doors is inhibited by the SDO system when correctly stopped at platform</td>
<td>Additional doors that should be protected by the SDO system are enabled along the rake</td>
<td>0.012</td>
<td>(4.3 \times 10^{-7})</td>
<td>SIL 2, SIL 2</td>
</tr>
<tr>
<td>4</td>
<td>Wrong side door opening</td>
<td>Any door(s) open on incorrect side of the train where there is no platform</td>
<td>Doors enabled on wrong side or both sides</td>
<td>0.015</td>
<td>(3.5 \times 10^{-7})</td>
<td>SIL 2, SIL 2</td>
</tr>
<tr>
<td>5</td>
<td>Doors open when stopped on the running line</td>
<td>Doors open when the vehicle is stopped (or moving under 5 km/h) outside a station</td>
<td>Doors enabled on any side</td>
<td>0.015</td>
<td>(3.5 \times 10^{-6}) (ASDO) (3.5 \times 10^{-7}) (FASDO)</td>
<td>SIL 1, SIL 2</td>
</tr>
</tbody>
</table>

Notes:
1. Consequence = injury as a result of falling from door aperture
2. FWI = fatalities and weighted injuries

**Table 4E** Summary of the results of the indicative safety analysis undertaken to establish SIL for a generic SDO system
Appendix F  Train crew’s MMI interface

F.1  Introduction

F.1.1  The train crew’s MMI should be similar to the arrangement as shown in Figure 1F.

F.1.2  The colour codes proposed for door status are taken from those used by Southeastern, and it is recommended that they are propagated to all ASDO systems with standardisation in mind:

- Black = door, that is to say, door disabled from being released
- Blue = normal (door closed)
- Red = door released, or open
- White = door locked or out of use
- Yellow = door fault.

F.1.2  SDO system override

F.1.2.1  Operation of the SDO system override touch-box should allow the train crew to select alternative door arrangement for release.

Figure 1F  Train crew’s MMI interface
Guidance on the Application of Selective Door Operation Systems

F.1.3 Stopping at the platform – ASDO system cannot reconcile location

F.1.3.1 There may be circumstances where the ASDO system fails to reconcile the location to the required accuracy.

F.1.3.2 The ASDO system should be designed such that the circumstances of failure are exceptional rather than routine. Where the ASDO system cannot reconcile the location, at the time of the train stopping, the screen as shown in Figure 1F is modified, as follows:

a) The SDO system information bar is made red in colour (background)

b) Text is provided relating to the systems best estimate of the location, for example, the system may have determined the macro/station location – ‘City Thameslink ?’, or ‘City Thameslink - Platform 1’

c) Beneath the SDO system information bar, the system may offer three options in red background – ‘Confirm’, ‘Change’ or ‘Emergency Release’

d) Operation of ‘Confirm’ or ‘Change’ to be logged to OTMR, as this is an indication of potential failure within the ASDO system

e) If the station (macro) location is confirmed, the system then offers the choice of platform available for that station, or the platform may already have been automatically offered at stage b)

f) If the button ‘Change’ is operated, the system initially triggers the same audio/visual announcement over PIS, as if ‘SDO System Override’ had been selected

g) When ‘Change’ has been selected, a new screen, or screen window, offers nearby stations. The ASDO system controller, independent of the GNSS Navigation Unit, estimates its whereabouts, that is to say, if the last station is known, then the current station is from a limited list, particularly if distance travelled is factored into the decision. The train crew is offered a list of stations to choose from. In case the actual station is not in the list, an alphabet selection of all stations that the train may call at is offered

h) When a member of the train crew selects a ‘Change’ station, he/she is then offered the selection of platforms

i) When the station/platform is selected, the train crew should confirm the selection

j) When finally selected, the SDO system information bar becomes blue in colour and the arrangement of doors for release is displayed

k) The train crew is now required to release the train doors.
Guidance on the Application of Selective Door Operation Systems

References

The Catalogue of Railway Group Standards and the Railway Group Standards CD-ROM give the current issue number and status of documents published by RSSB. This information is also available from www.rgsonline.co.uk.

Documents referenced in the text

**Railway Group Standards**
- RGSC 01 Railway Group Standards Code
- GE/RT8000 Rule Book
- GE/RT8064 European Train Control System: The Management of Packet 44
- GI/RT7033 Lineside Operational Safety Signs
- GM/RT2472 Data Recorders on Trains – Design Requirements
- GM/RT2473 Power Operated External Doors on Passenger Carrying Rail Vehicles
- GO/RT3437 Defective On-Train Equipment

**RSSB documents**
- GE/GN8578 Guidance on the Use of Satellite Navigation (due for publication late 2008)
- GE/GN8579 Guidance on Digital Wireless Technology for Train Operators

**Other references**
- BS EN/ISO 18000:2005 Information technology – Radio frequency identification for item management
- BS EN 14752:2005 Railway applications. Body entrance systems
- BS EN 50129:2003 Railway applications. Communication, signalling and processing systems. Safety related electronic systems for signalling
- BE EN 50155:2001 Railway applications. Electronic equipment used on rolling stock
- BE EN 61373:1999 Railway applications. Rolling stock equipment. Shock and vibration tests
- ERTMS/ETCS Class 1, Performance Requirements for Interoperability, SUBSET-041 v2.1.0

Rail Vehicle Accessibility Regulations 1998 (RVAR)