Design Manual
NR/GN/CIV/100/03

Station Capacity Planning

London Waterloo
Station Concourse
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Document Verification

Name	Role
Isabelle Milford	Head of Station Capacity Planning System Operator Network Rail
Anthony Dewar	Head of Department Buildings & Architecture, Technical Authority Network Rail
Frank Anatole	Principal Architect Buildings & Architecture, Technical Authority Network Rail

Technical Leads	Role
Shravan Patel	Station Crowding Analysis Manager System Operator, Network Rail
Kyle Adams	Station Capacity Manager System Operator, Network Rail
Hannah Finnegan	Senior Station Capacity Planner System Operator, Network Rail
Contributions by:	Charlie Parker, Daniel Chaney, Tom Pestell, Monika Zamojska and the rest of the Network Rail Station Capacity Team.

Revision Information

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About this document

Section 1
Introduction:

Introduces the basic principles of spatial planning for public areas within stations and defines the wide range of users and their needs.

Section 2
Undertaking Capacity Assessments:

Covers guidance for analysts and other parties involved in scoping and producing capacity assessments studies.

Section 3
Space Recommendations for Normal Operation:

Sets out methods to sufficiently size public areas under normal operations for each type of station element.

Recommendations are given such that an adequate level of comfort is achieved for all station users, without making elements uneconomically large.

Section 4
Planning for Abnormal Conditions:

Describes recommendations so that stations continue to function acceptably during planned and unplanned events affecting train service, passenger demand or station layout.

Section 5
Station Performance Categorisation:

Outlines performance categories for which all assessments should draw conclusions from, by rating performance against.

Section 6
Appendix:

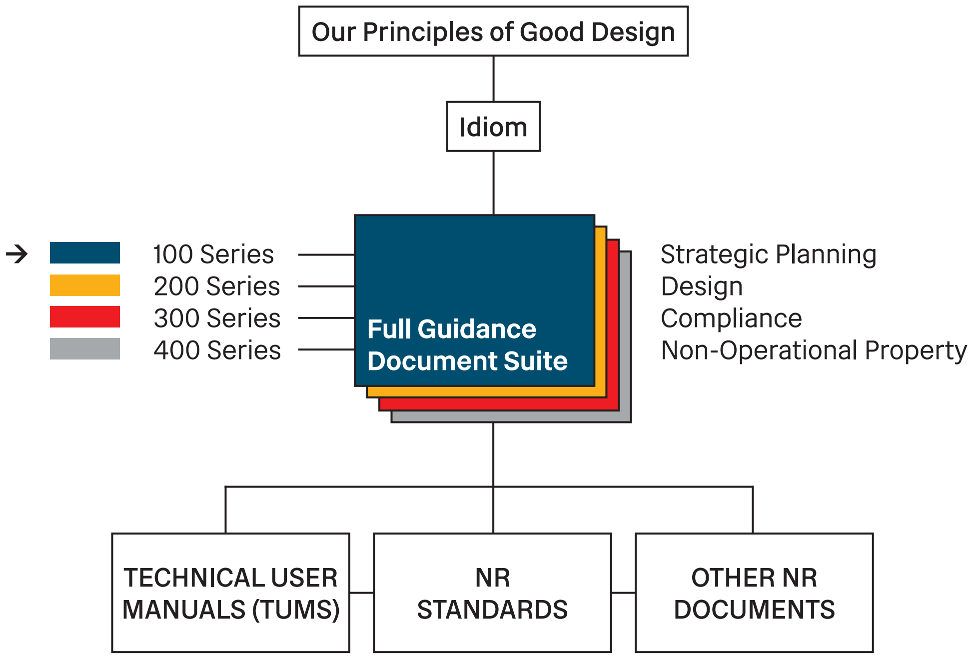
Supplementary supporting information including:

Data: Inputs and data protection
Assessments: Documentation, deliverables and outputs
Reference: Glossary, reference documents and acknowledgements.

How to use the guidance suite

The Network Rail Document Suite

You are here



References to other documents

- Code of Practice Guidance
- National Standard
- Network Rail document
- European Standard
- Supporting Information

Example:

Network Rail document

Inclusive Design manual
NR/GN/CIV/300/04

This guidance has a Network Rail standards Green status, and does not require a variation.

A full list of relevant documents, and other guidance suite documents is contained in the appendix.

Contents

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To return to the contents page you can click on the Double Arrow symbol.

London Paddington
Station Concourse

Station Capacity Planning

Introduction

1

Foreword

Stations are such a vital part of so many passenger journeys and so it is important that we make the experience of using our stations a good one. As we adjust to a new-normal in the post-pandemic world, our passengers will demand more and more from stations. Station capacity planning will be critical in delivering the best experience for passengers, now and into the future.

Andrew Haines
Chief Executive, Network Rail

The pandemic has shown us the importance of well-planned space. Whether it's enhancing existing stations or building new ones, we must continue to plan and design using the established principles set out in this guidance. It is important to have a consistent approach for sizing stations. This guidance is our baseline for minimum space provision. But we ask everyone planning and designing stations to aim for an excellent passenger experience across the network. Clearly that sometimes means going beyond the minimum.

Our updated guidance simplifies calculations and supports a design approach that puts passengers first. It increases our focus on passenger comfort and inclusive spaces and sets out methods to test a stations resilience to future change.

The importance of stations in delivering a better railway is clearer than ever. Stations should offer so much more than simply providing access to train services. This document sits within a broader suite of guidance and standards that encourage us to strive for excellence within our station environments. Through your use of this document, I'd encourage you to explore those documents as well.

Isabelle Milford
Head of Station Capacity Planning, Network Rail

Executive Summary

This document provides guidance for undertaking capacity assessments for stations across the network. It specifies the thresholds for planning and design of passenger areas with a consideration for safety, 'value for money' and passenger experience.

The guidance should be used by all parties involved in the station design process including, but not exclusive to, Network Rail staff, architects, train operating companies (TOC) and engineering and planning consultants.

The application of this guidance supports station designs that align with industry and Network Rail objectives, namely:

- Develop and maintain consistently high performing stations that support safe movement of passengers and customer satisfaction
- Deliver station improvements and designs that are fit for purpose, cost effective and sustainable
- Champion inclusive design to provide a railway that is fit for the future and puts passengers first

This guidance provides information to be used by architects and designers to produce an outline station design focussing on public areas. It includes all calculations recommended to assess whether a station meets Network Rail's aspirations regarding passenger comfort and safety.

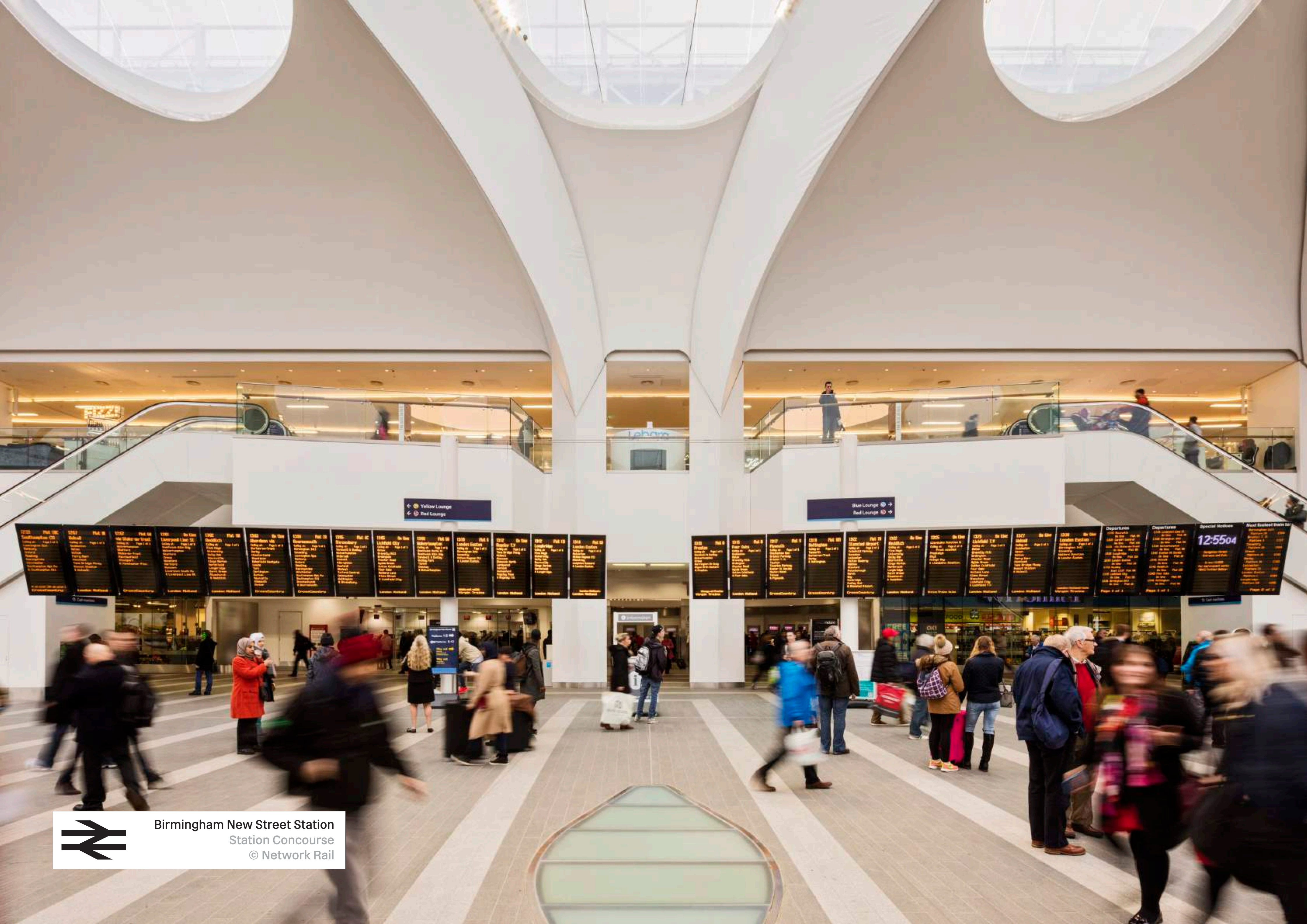
It also provides a good practice guide for undertaking capacity assessments. This information is relevant for those responsible for station capacity assessment studies and contains the Network Rail recommendations with regards to analysis and deliverables.

This document supersedes the previous version published in November 2016. The guidance is to be updated periodically, reflecting ongoing research, consultation and changes in legislation. This document should be read in conjunction with:

- Station Design Guidance – NR/GN/CIV/100/02, Network Rail
- Inclusive Design Guidance – NR/GN/CIV/300/04, Network Rail
- Design Standards for Accessible Railway Stations, Department for Transport and Transport Scotland
- Other rail industry standards and building codes referred to in Appendix C

Queries or comments regarding this document are welcomed and should be sent to:

stationcapacity@networkrail.co.uk



Birmingham New Street Station
Station Concourse
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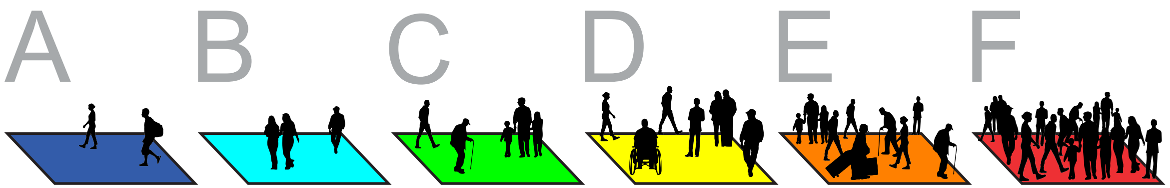
1.1 The Overview

Introduction to the basic principles of spatial planning for public areas and Network Rail's planning criteria.

This guidance applies to the spatial aspects of station planning for public areas during normal and abnormal conditions. Recommendations for staff accommodation and non-public areas are not covered in this guidance. It is important to understand that the capacity recommendations included here should be treated as a minimum. Depending on the project aspirations it may be desirable to deliberately design public areas in excess of the spatial recommendations outlined here.

The following chapters provide methods for sizing public areas so that they have sufficient space to allow unimpeded circulation of passengers, and also allow for reasonable comfort in waiting areas.

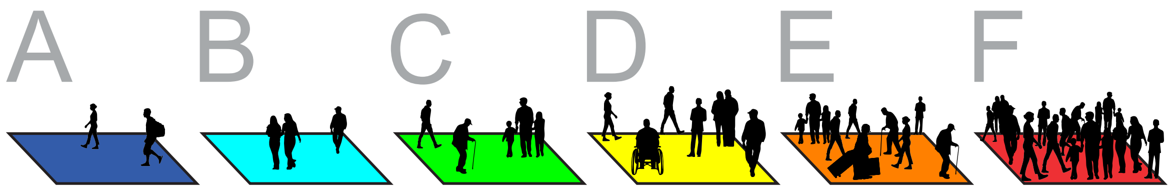
The Fruin Levels of Service (LoS) specified here relate to Network Rail's aspirations to provide adequate levels of comfort without making stations uneconomically large. These guidelines are applicable to existing and new stations. Station layouts should always be assessed in relation to peak usage based on a survey or predicted future demand.



Level of service	Definition
A	Free circulation
B	Uni-directional flows and free circulation with only minor conflicts.
C	Slightly restricted circulation, with difficulty passing others. Reverse and cross-flows with difficulty.
D	Restricted circulation for most. Reverse and cross-flows with significant difficulty.
E	Restricted circulation for all. Intermittent stoppages and serious difficulty for reverse and cross-flows.
F	Complete breakdown of flow with frequent stoppages.

Figure 1.1 Fruin level of service

1.2 Summary Table



	Normal operations				Unplanned disruption				Planned disruption				Evacuation *	
Station element	**Walk Los**	**Queue Los**	**Stair LoS**	**Value**	**Walk Los**	**Queue Los**	**Stair LoS**	**Value**	**Walk Los**	**Queue Los**	**Stair LoS**	**Value**	**LoS**	**Value**
Passageways – one-way	D			50ppmm	D/E			65ppmm	D/E			65ppmm	N/A	80ppmm
Passageways – two-way	C			40ppmm	D			50ppmm	D			50ppmm		
Stairways – one-way	C		D	35ppmm	C		D/E	43ppmm	C		D/E	43ppmm		56ppmm
Stairways – two-way	B		C	28ppmm	C		D	35ppmm	C		D	35ppmm		
Ramps**	C			36ppmm	C			45ppmm	C			45ppmm		56ppmm
Concourse circulation area	C	B		40ppmm	D	C		50ppmm	D	C		50ppmm		
Concourse waiting area	D	B		1.0m^{2}ppmm	E	D		0.45m^{2}pp	E	C		0.8m^{2}pp		
Platform circulation area	C	B		40ppmm	D/E	C/D		65ppmm	D	C		50ppmm		
Platform waiting area	D/E	C		0.93m^2 pp	***	D/E		0.28m^{2}pp	E	D		0.45m^{2}pp		
Ticket gates	E	D		25ppmg	E	D		25ppmg	E	D		25ppmg		50ppmm
Escalators	N/A			100ppmm	N/A			100ppmm	N/A			100ppmm		75ppmm*

Figure 1.2 Planning criteria during various operating conditions

* Evacuation capacities based on BS9992   ** Two-way ramp gradients >1:20   *** Densities <0.46m2 should not be assessed using walkways LoS.

The unit of measurement for passenger flow-rate is ppmm (passengers per minute per metre width) and is applicable to passageways, escalators and staircases.
The unit of measurement for passenger flow that is used for ticket gates is ppmg (passengers per minute per gate).
Ticket gate LoS refers to the queueing area. The exact capacity for escalators depends on the escalator running speed.

1.3 Consideration of Passenger Needs

1.3.1 Diversity Impact Assessments

The rail industry should strive to achieve equal access for disabled passengers. Providing accessible routes at stations plays an important part in this. Over the next 30 years the demography of those accessing rail, and their reasons for travel, are likely to change. Anyone working on station changes that exist for the next 50+ years should be mindful of this. By thinking through how changes may impact all types of station users, anyone using this guidance can have a positive impact on railway accessibility.

A Diversity Impact Assessment (DIA) should be commenced as early as possible to inform the scheme and the decision-making process. It is necessary for all station works both temporary and permanent. DIA's evidence due regard in response to Network Rail's Public Sector Equality Duty under the Equality Act.
A DIA should be completed at each project phase and reviewed by a DIA Super User.

Projects can seek advice and endorsement from the Network Rail Built Environment Accessibility Panel (BEAP). This is an independent panel of experts who can advise on the design stages of a project, particularly for complex projects, those with conflicting interests or where variations are requested.

A registered access consultant can also be engaged with to evaluate a design's compliance with accessible railway legislation. These can be found through the National Register of Access Consultants (NRAC).

See Network Rail's Guide to Diversity Impact Assessments, 2019 for more details.

Network Rail document

Guide to Diversity Impact Assessments

Supporting Information

National register of Access Consultants
www.nrac.org.uk

London Waterloo Station
Customer assistant

1.3.2 Station users

All station users have different needs, behaviours and space requirements (see Figure 1.3). In free-flow conditions most passengers travel at speeds between 0.6 to 2.0m/s on flat surfaces.

An unencumbered adult with no mobility restrictions may travel at a speed of 1.5m/s, or above, on a flat surface, but slows significantly in congestion.

Analysts should consider site specific factors that influence diversity of station users e.g. the availability of step-free access or stations serving airports or hospitals. Assumptions on the proportion of persons with reduced mobility (PRMs) and non-PRMs should be agreed with Network Rail's Station Capacity Team (NR SCT).

Passenger needs may differ depending upon their familiarity with the station and their journey purpose. For example, leisure and business travellers are more likely to arrive early to the station and dwell longer increasing the need for seating. Clear run-offs and signage are increasingly important for those unfamiliar with the station to provide a safe space to orientate themselves.

Non-PRMs
These passengers can easily navigate all routes within the station. Like PRMs their needs may differ depending on their familiarity with the station or their journey purpose.

Persons with reduced mobility (PRMs)
These passengers could be frequent (commuters) or one-off (leisure/business) travellers at the station.

PRMs encompass a wide range of passengers, such as:

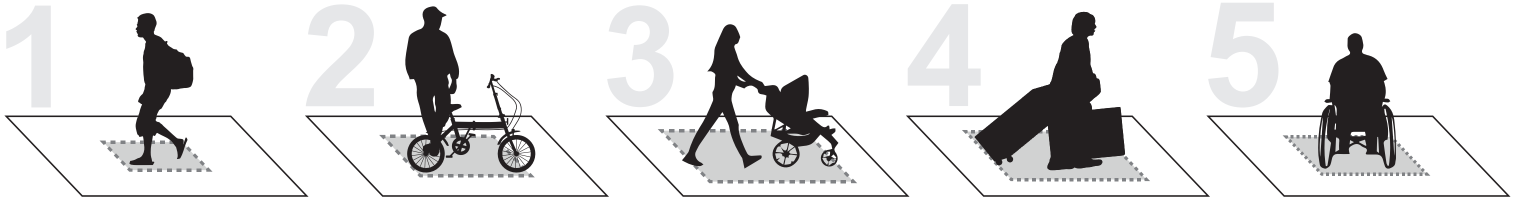
Passengers with luggage require more space depending upon the size and shape of luggage they are carrying. This includes passengers carrying small rucksacks, large shopping bags, large musical instruments, regular or fold-up bikes and large suitcases. They are more likely to require a mechanical means of changing levels in comparison to those who are unencumbered.

Wheelchair passengers require step free access and may require assistance in accessing train services or other facilities at a station. Wheelchair passengers need to pass through wide aisle gates.

Passengers with young children and infants in pushchairs may be slow-moving and prefer to remain in groups. They are more likely to require step free access.

Passengers with a **physical or cognitive condition** which affects their ability to navigate within a station environment. Such passengers could require more clear space, time or staff assistance. Not all of these passenger needs can be met with step free access. Their needs could be met by adequate space provision to alleviate crowding, additional resting points or regular breaks in stair flights.

1.3 Consideration of Passenger Needs



ID	Passenger description	Total footprint required m^2	Required space dimensions (width x depth)
1	Commuter carrying regular sized rucksack, handbag or laptop bag	$0.3m^2$	$0.7 \times 0.4\ m^2$
2	Passenger with full sized pedal cycle	$1m^2$	$1.5 \times 0.6\ m^2$
3	Passengers with young children or prams	$1.1m^2$	$1.8 \times 0.6\ m^2$
4	Passengers with medium or large luggage (suitcase, large sports bag or fold-able cycle)	$0.8m^2$	$1.4 \times 0.6\ m^2$
5	Wheelchair passengers	$0.8m^2$	$1.2 \times 0.7\ m^2$

Figure 1.3 Passenger space take and footprint

Supporting Information

Passenger travel speeds quoted here are based on anecdotal evidence gathered from various stations on the National Rail network. These are consistent with the passenger travel speeds observed by Transport for London at London Underground stations.

2

Station Capacity Planning

Undertaking Capacity Assessments

Leeds Station
Station entrance

2.1 Needs and Requirements

This section provides guidance for analysts and other parties involved in scoping and producing capacity assessment studies.

Station capacity assessments should be undertaken for the design and planning of all new railway stations, station enhancements and for schemes that may alter the usage and flow of passengers in station environments.

The objectives of a station capacity assessment may typically include:

- → Benchmarking existing station performance
- → Optimising station layouts
- → Option selection and design development
- → Evidencing a case for change or a formal appraisal / business case
- → Testing crowd management, impacts of construction and evacuation plans
- → Evaluating the impact on passengers due to network changes such as timetables, introduction of new services or rolling stock

The complexity, level of detail and methodology of a station capacity assessment should be appropriate and proportionate to the stage in the project's design and delivery life-cycle. This allows the analysis to achieve the expected level of confidence at each critical decision-making stage. For example, in some schemes it may be appropriate to begin with a spreadsheet-based analysis approach based on limited assumptions, and then transition towards more in-depth dynamic analysis as the choices and decisions become increasingly challenging and more confidence is necessary. Equally, there may be some schemes where static spreadsheet-based analysis would give a sufficient level of confidence to move all the way through these project stages. The link between project life-cycle and appropriateness of analysis is illustrated in Figure 2.1.

NR SCT can provide advice and guidance to sponsors and clients as to what approach is appropriate in terms of analysis effort and level of confidence needed for a given scheme at each stage.

Each project stage should increase the level of confidence expected from analysis.

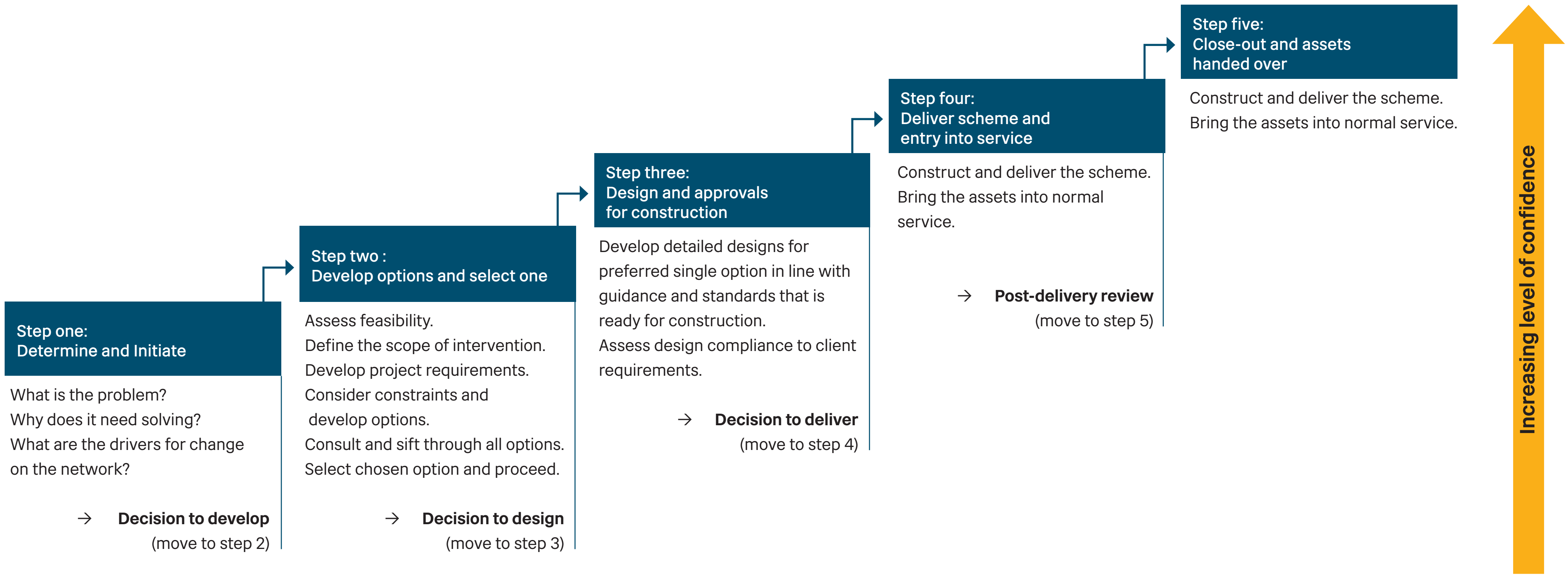


Figure 2.1 Relationship between Project Life-cycle and Analysis

2.2 Remits and Proposals

2.2.1 Remits

A remit should clearly set out the following, with respect to the assessment:

→ Context, the strategic fit and the problem statement

→ Objectives of the study, scope and interdependencies

→ Indication of any gaps in availability of passenger and train information

→ Operational and other assumptions

→ Milestones and deadlines

Remits should be developed by the Client, Sponsor or Manager in conjunction with, or reviewed by, the NR SCT.

Reading Station
Northern entrance
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2.2.2 Proposals

The NR SCT or an external consultant should respond to the remit with a project proposal. It is important that respondents understand the objectives and various stages of an assessment to develop a comprehensive proposal.

Each proposal should demonstrate:

→ Good understanding of the remit and context

→ Ability to identify key areas that should be analysed and any constraints

→ Strong capability in the discipline and selection of an appropriate method of analysis based on site complexity

→ Detailed cost and resource breakdown demonstrating value for money

→ Project plan showing alignment with wider NR delivery programme

→ Allowance for review and feedback from NR SCT throughout the project

This proposal should be sent to the Client, Sponsor or Manager and reviewed by the NR SCT. A proposal should only be approved, and the assessment initiated, once this review has been completed.

2.3 Data Input and Collection

2.3.1 Data Input

Wherever possible, surveys should be commissioned to establish a good understanding of passenger numbers in and around stations and any station specific characteristics in relation to train services, interchange and operational controls. Data inputs may vary based on the scope of the assessment and project objectives.

The checklist in Appendix A should be reviewed to identify what input data is readily available. Sources for such information include Network Rail studies, train operating companies, local authorities, Transport for London, sub-national transport bodies or other third-party developers.

Any gaps in the data should be clearly defined in the remit. In all cases, NR SCT should be consulted to determine the suitability of using existing data. Appendix A includes a brief description of the different datasets and suggested methods of data collection.

NR SCT can organise surveys if necessary. Where surveys are being commissioned by consultants the proposed methodology and scope should be approved by the NR SCT and the station manager. It is important that careful consideration is given to the planning and safe operations during any survey.

2.3.2 Legislative context for data collection

Data collection is often essential for station capacity assessments. Specialists should be aware of the regulation and legislation which applies to the collection of this data. This includes, but is not limited to, the General Data Protection Regulation (GDPR). This document provides guidance, but does not substitute legal advice or the requirement to comply with up to date legislation.

The volume, scope and type of data drives the safeguards necessary. Regulations such as the GDPR focus on the collection and use of 'personal data', which is defined as:

'Personal data' means any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person;

Common practices such as camera surveys (recognisable footage from a location) and WiFi surveys (unless aggregated and anonymised) collect these kinds of data. In the absence of certainty, it is always safest to plan for the collection of personal data.

Network Rail advocates the **PLAN** approach to data collection, that is, confirming what the project collects is:

→ **Proportionate** to the needs of the project

→ **Lawful** that is with consent or another lawful basis from subjects

→ **Accurate** and securely disposed of when this is not the case

→ **Necessary** so as to avoid collecting personal data where it is not necessary

Further guidance on key safeguards, processes and useful guidance is provided in Appendix A.

2.3.3 Passenger and train data

A survey should cover a minimum of three morning and afternoon weekday peaks (e.g. 0600 – 1000 and 1600 to 2000hrs) and any other times when passenger volumes are known to be high. Most station users are rail passengers but retail, access to other modes or through routes can result in a significant number of non-rail users. It may be necessary to include such non-rail background demand in counts.

Validation counts and observations should be made to check consistency in the data that is collected.

At some stations it may be necessary to include other times during weekdays and weekends depending on the project objectives and station usage, e.g. it may be necessary to survey off-peak periods to fully understand PRM proportions.

Video surveys are preferred, although not mandated. This is due to the richness of information they can provide compared to other survey methods, as well as the ease of validation and ability to re-count if required.

Passenger data should be collected for 1-minute intervals and should include all station users. Counts should be classified using the following categories:

→ Non-PRMs e.g. individuals carrying regular sized rucksack, handbag or laptop bags

→ Passengers with medium or large luggage e.g. suitcase, large sports bag or foldable cycle

→ Passengers with full sized pedal cycles

→ Passengers with young children or prams

→ Wheelchair passengers

Further guidance on typical passenger demand datasets is given in Appendix A.

For new stations, demand data may come from forecasting models. The suitability of such forecasts and underlying assumptions should be discussed with the NR SCT and Network Rail Economic Analysis Team.

Further detail on demand forecasts can be found in Section 2.4.

2.3.4 Station layout and operations

All assessments should use an accurate definition of the physical layout of the station being assessed. Typically, this information is in electronic CAD format, but as a minimum information would consist of a station plan including key measurements.

The configuration of existing infrastructure such as escalators, ticket barriers and station entry gates should be observed and included in the analysis. Passenger behaviour in relation to concourse dwelling, train announcements, location and format of CIS (customer information screens), wayfinding and crowd management measures such as ‘keep left / right’, one-way routes should be considered in assessments.

2.4 Demand Forecasts

Capacity assessments should, at a minimum, consider the project opening year and a future year scenario. Demand forecasts can be provided by Network Rail's Economic Analysis Team. Forecasts developed by a consultant or another organisation should be agreed with the Network Rail's Economic Analysis Team at the start of any assessment project. Any profiling of passenger demand across the peak in relation to train loadings should be agreed with NR SCT.

In the absence of demand forecasts, it is recommended that a demand uplift of at least 35% is applied. However, it is imperative that demand forecasts are attained, if available. NR SCT should review the applicability of using the 35% uplift factor on a case by case basis.

It may not be appropriate to assume a straight-line growth for PRM proportions in future year scenarios. Factors including changing demography and travel patterns and improved step-free access may lead to shifts in PRM proportions at a station.

These should be considered when undertaking future year assessments. See Section 1.3 for further information on PRMs.

Norwood Junction
Subway
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2.5 Assessment Scenarios

A Station Capacity Assessment should provide analysis on design performance during a range of scenarios. It is important to consider more than just normal operations so that our stations are resilient to fluctuations in demand and potential incidents.

Table 2.1 clarifies which scenarios should be included in an assessment.

Further information on the criteria for abnormal operating scenarios is provided in Section 4.

Scenario	Assessment	Further classification
Normal Operations	For relevant year/s for all Station Capacity Assessments	See Section 3
Unplanned Disruption – Service perturbation	For relevant year/s for all Station Capacity Assessments	Either a 15 minute delay to a group of services or the cancellation of a specific train service. See Section 4.2.
Planned Disruption – Special event	For relevant year/s only when specified in remit	Only applicable to stations with venues/events in a close vicinity. See Section 4.4.
Planned Disruption – Construction	For construction year/s for all Station Capacity Assessments if construction work is planned to occur in or around the station.	For all stages that impact on passenger capacity. This is likely to be in the later stages of the project lifecycle and could include evacuation and perturbation modelling. See Section 4.3.
Evacuation – Emergency events	For relevant year/s for all Station Capacity Assessments unless agreed otherwise.	For example, station entrance re-modelling or platform extensions to accommodate longer train formations. See Section 4.5.

Table 2.1 Scenarios to be assessed

3

Station Capacity Planning

Space Recommendations for Normal Operation

London Paddington
Ticket gates

3.1 Passenger Demand Concepts

The space recommendations specified in this section are based on specific planning criteria for each type of station element for normal operating conditions. The methods described here result in elements that are sized to provide an adequate level of comfort for all station users without making them uneconomically large.

Station capacity assessments should be based on passenger demand from the busiest time periods. At most stations the busiest times are normally the morning and afternoon peaks as passengers travel to and return from work.

A separate consideration should be made for time periods when PRM use is highest. This may be outside of the traditional commuting peak hours. These considerations are crucial for sizing station infrastructure and are not limited to gatelines and lift provision. A Diversity Impact Assessment (DIA) can help inform this.

In some cases, a separate assessment for weekends and special events may be necessary. Special events may require management controls and could involve queuing passengers in a safe environment. This can have a direct impact on the space necessary in and around stations.

Non-rail users should be included where applicable i.e. demand associated with station retail and thoroughfare. The passenger demand used in assessments should be based on survey data and relevant forecasts. Network Rail's Economic Analysis Team should be consulted regarding demand forecasts. The following concepts of demand data used in this document are displayed in Table 3.1.

Demand data concept	Description
Peak hour demand 60min	The peak hour demand is used in the calculation for run-off lengths in medium flow areas. This should include all passengers moving through the assessed area during the peak hour. Non-rail demand should be included where this is appropriate. This may be driven by retail footfall, access to other transport modes and thoroughfare.
Peak 15 minute demand 15min	The peak 15 minute demand is used to calculate the size of the dwelling area in a concourse. This should include all passengers moving through the unpaid concourse during the peak 15 minute period.
Peak 5 minute demand: 5min	The peak 5 minute demand should be used to calculate gateline recommendations. Calculations should use the entry and exit demand from the same 5 minute time period.
Entry demand	Derived using the boarding loads for the maximum possible number of trains departing during the peak 5 minute period on a typical day. The busiest train should have its departure load increased by 25% to factor in delays to the service, where appropriate. Service delays do not typically affect the arrival rate of passengers. Therefore, this uplift should only apply to station elements that would be affected by passenger accumulation. For example, elements that are downstream of a waiting area within a station.
Exit demand	Derived from the maximum cumulative alighting load from services arriving on unique platforms, within the busiest 5 minute period on a typical day. The busiest train should have its alighting load increased by 25% to factor in delays to the service.
Peak minute demand 1min	The peak minute demand is used to calculate passageway, staircase and escalator recommendations. This should be based on survey data where possible. Where data of this resolution is not available, a reasonable assumption should be made regarding the spread of passenger demand. More information is given on the next page.

Table 3.1 Demand data concept

Peak minute demand

- **Peak minute entry demand** should be estimated by applying a factor of 0.2 to the observed peak 5 minute demand (i.e. assume a uniform arrival).

- **Peak minute exit demand** should be based on a reasonable percentage applied to the peak 5 minute exit demand, as described above. In most cases the concentration of alighting passengers depends on the length of trains, stock formation and the station layout.

The ranges in Table 3.2 can be used as a guide to make an assumption about the concentration of demand within the peak minute, if passenger counts are not available. This method is useful to establish adequate sizing of station elements without unnecessarily over-designing. The calculation of peak minute demand is useful when quantifying the level of queuing realised at flow constraints (access and interchange infrastructure) as well as for the calculation of the width of terminal platforms. To confirm platform clearance elements are sized appropriately, the total clearance time should be reviewed.

Adjustments for constrained peak minute flow

At some stations, passenger flows may be constrained by the physical capacity of one or more circulation elements. For example, an escalator would regulate the flow of passengers into a connected passageway, as shown in Figure 3.1. In such situations it is important that these flow rate constraints are considered in determining the peak minute entry and exit flows to avoid unnecessary over-designing of station elements.

Train length	Approximate concentration of demand in peak minute
1-4 train cars	100% of maximum alighting demand
5-8 train cars (access point on platform)	100% – 80% of maximum alighting demand
5-8 train cars (access point at end of platform)	80% – 60% of maximum alighting demand
9-12 train cars (access point on platform)	80% – 60% of maximum alighting demand
9-12 train cars (access point at end of platform)	60% – 40% of maximum alighting demand

Note: These values differ for every station and should be derived from site observations. Platform furniture and other constraints may further limit the flow of passengers away from platforms. The effects of uneven carriage load distributions should also be considered on peak minute flow.

Table 3.2 Adjustments to peak minute flow

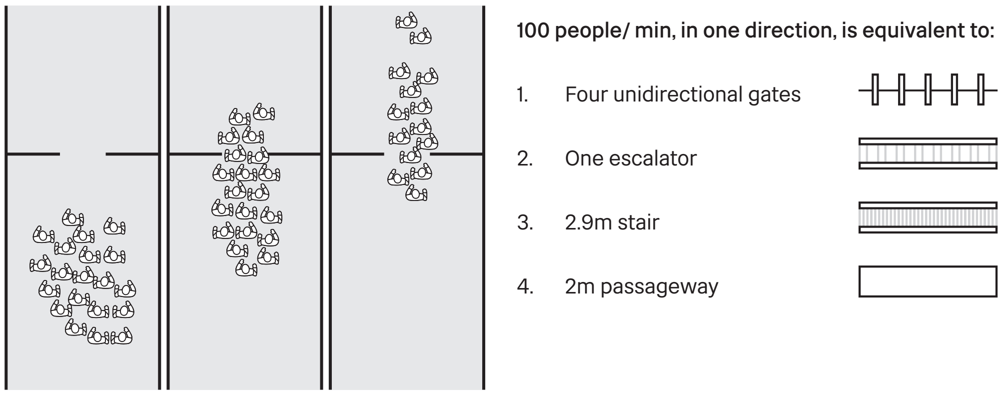


Figure 3.1 Adjustments for constrained flow

3.2.1 Calculating the number of ticket gates

Each gateline array should be capable of accommodating the forecast passenger demand. The formula provided in this section should be used to determine the number of total ticket gates that should be recommended. All gateline arrays should include wide aisle gates (WAGs) to allow passengers with luggage or reduced mobility to pass through.

Wherever possible, a Diversity Impact Assessment (DIA) should help inform the demand that would likely use WAGs. If passenger demographic information is available, then the calculation should be completed using this station specific data and an appropriate WAG throughput. Should this calculation result in a lower number of WAGs than the minimums stated in Table 3.3, the values in Table 3.3 should be used instead.

Where such usage forecasts are not available, the number of WAGs should be apportioned based on the number of standard ATGs provided in each gateline array as shown in Table 3.3.

Consideration should be given to WAG usage proportions as these may be higher outside of traditional peak periods. Recommendations for the number of WAGs may be higher at some stations depending on passenger demographics, location of gateline in relation to step-free access routes and destinations served by a station (e.g. airports and long distance rail travel).

Gate type	Minimum additional WAGs
3 gates and under	Arrays should consist of at least two WAGs
4 to 12 gates	At least two WAGs in addition to said number of ATGs
13 to 18 gates	At least three WAGs in addition to said number of ATGs
More than 18 gates	At least four WAGs in addition to said number of ATGs

Table 3.3 Minimum WAG provision in each array

Gate type	Method of operation	Recommended throughput (f value)
Standard ATG	Uni-directional	25 per minute
Wide Aisle Gate	Uni-directional	12 per minute [4]
Wide Aisle Gate	Bi-directional	7 per minute
Note: Check with NR SCT if a non-standard throughput is more appropriate based on manufacturer information or observations from an existing gateline.		

Table 3.4 Ticket gates used at stations

Different types of ticket gates are used at stations across the network, varying by manufacturer and dimensions. Table 3.4 lists the recommended throughputs by type of gate and operation for calculating the number of ticket gates.

Supporting Information

The maximum uni-directional WAG throughput may be equal to a standard ATG but it is recommended the throughput is reduced, as stated here, to reflect the reduced travel speed of PRMs. Gateline throughput data may be requested from the TOC to validate throughput. Note, at some stations, gates may be left open during off-peak times and this may skew the automatic record of throughput.

3.2 Revenue Protection

3.2.1 Calculating the number of ticket gates

The formula for calculating the recommended number of gates in a gateline is split into three parts:

1. First part calculates the recommended number of ticket gates to accommodate the entry demand
2. Second part calculates the recommended number of ticket gates to accommodate the exit demand
3. Third part of the formula adds either one or two additional gates to the combined number of entry and exit gates calculated in parts one and two.

Peak 5 minute entry demand and **Peak 5 minute exit demand** concepts are explained in Section 3.1

n-value is as per Table 3.5. This table displays a variety of acceptable n values alongside examples of when they should be used. This value is only used in static calculation to spread the total number of exiting passengers over a reasonable period of time to lessen the risk of over-specifying the number of exit gates.

f-value should be applied as per Table 3.4.

X value should be taken as X = 1 if the total (without X) is less than or equal to 10 gates, or X = 2 if the total (without X) is greater than 10 gates.
This is to take account for redundancy of gates due to fault or maintenance.

Calculating the number of ticket gates in a gateline

$$\underbrace{\text{round up}\left\{\frac{\text{Peak 5 minute entry demand}}{f \times 5}\right\}}_{1} + \underbrace{\text{round up}\left\{\frac{\text{Peak 5 minute exit demand}}{f \times n}\right\}}_{2} \underbrace{+\, x}_{3}$$

n-value	Examples of use
1	If a gateline is separated from the platforms by an intermediate flow constraint (e.g. stairs, escalators), the flow of exiting passengers will be limited by the capacity of this element of infrastructure. Therefore, total number of exiting passengers used in the above formula should be adjusted to represent the maximum number of passengers arriving at the gateline in the peak minute.
2	At a through station or platform, where a gateline is not separated from a platform by a pedestrian flow constraint such as a staircase or a passageway.
4	At a terminus station or platform, where a gateline is not separated from a platform by a pedestrian flow constraint such as a staircase or passageway.

Table 3.5 n-value

The formula should be used twice, to calculate the recommended number of gates in the AM and PM peaks. If a station has a high number of leisure travellers (i.e. tourists and shoppers) then the busiest period of gateline activity may be outside the AM and PM weekday peak times, in which case a third calculation for the number of gates should be undertaken. The highest figure from all calculations should be used as the recommended number of ticket gates.

Birmingham New Street Station
Ticket gates

3.2.2 Run-off lengths

To safely accommodate the queueing demand which could accumulate on the unpaid side of the entry gateline, sufficient run-off space should be provided such that passengers queue at acceptable levels of service.

Clear space is necessary on either side of gates to accommodate the momentary gathering of passengers at ticket gates. Where gatelines are susceptible to queueing this calculation, based on a space provision of $0.45m^2$ per person (queuing LoS D), should be undertaken. This is to allow entering and exiting passengers to queue momentarily without impeding other movements on either the paid or unpaid sides of the gateline.

At stations where it is physically not possible to provide the recommended gateline capacity, the run-off capacity may exceed the minimum value stated in Table 3.10. If the calculated run-off is less than the minimum value stated in Table 3.10, the larger value should be used.

Calculating the recommended run-off length on paid and unpaid sides

$$\text{run off length} = \left\{ \frac{\text{(Peak minute entry demand - gateline capacity) x 0.45}}{\text{(number of ATG x width of ATG) + (number of WAG x width of WAG)}} \right\} \text{m}$$

Where:
Peak minute demand is dependent upon the location of the gateline. If the gateline sits unconstrained from the platform, the approximations in Table 3.1 can be utilised. Where ticket gates are separated from the platforms by an intermediate constraint; e.g. a staircase, the peak minute gateline demand should be determined by the observed/surveyed capacity of the infrastructure.

A 25% increase should be applied to the peak minute demand, if appropriate. This uplift should only be applied to boarding passengers if the gateline is downstream of the waiting area (e.g. a station where passengers wait on the concourse until their train is announced and then proceed to the gateline).

Gateline capacity should be calculated using throughput stated in Table 3.4.

The calculation should be undertaken twice, once for the paid side and once for the unpaid side of the gateline.

London Bridge
Shard concourse
© Network Rail

3.2.3 Gateline considerations

When calculating the recommended number of ticket gates for entry flow, we should be mindful of the capacity of station elements passengers go on to use once they have passed through the gateline. By catering to total entry demand, we may overload the station elements downstream of the gateline. Therefore, we should design the gateline such that the pedestrian flow rate through subsequent station elements remains acceptable in accordance with the levels of service set out in this guidance.

Ticket gates should not be placed on platforms, wherever possible. Gatelines located on platforms may increase platform clearance times and result in queues as passengers wait to pass through the gates. In many cases this may severely impede platform circulation, forcing passengers to pass closer to the platform edge, potentially posing a safety risk. If a feasible alternative cannot be found, a risk assessment should be undertaken, including detailed quantification of any anticipated queuing.

Wide aisle gates should be clearly identified with high and low level signs.

Gatelines should be situated such that all gates are readily accessible, and entry or exit gates should be grouped in larger arrays, to minimise cross flows.

For large gatelines serving multiple terminating platforms it may be appropriate to alternate clusters of entry and exit gates along the length of the gateline. The clusters can be clearly marked with dynamic overhead signage that can change when the directional setup of the gates is reversed. This allows passengers to make an early decision on which gate to use, which reduces cross-flows and delays at the gates. Such schemes can be expensive so should only be considered where they would be beneficial.

Other pieces of gateline equipment are relevant at some stations - see examples listed below.
The installation of such equipment should be assessed on a station by station basis.

→ An equipment gate to allow mobility buggies, machinery or servicing vehicles to pass through between paid and unpaid sides.

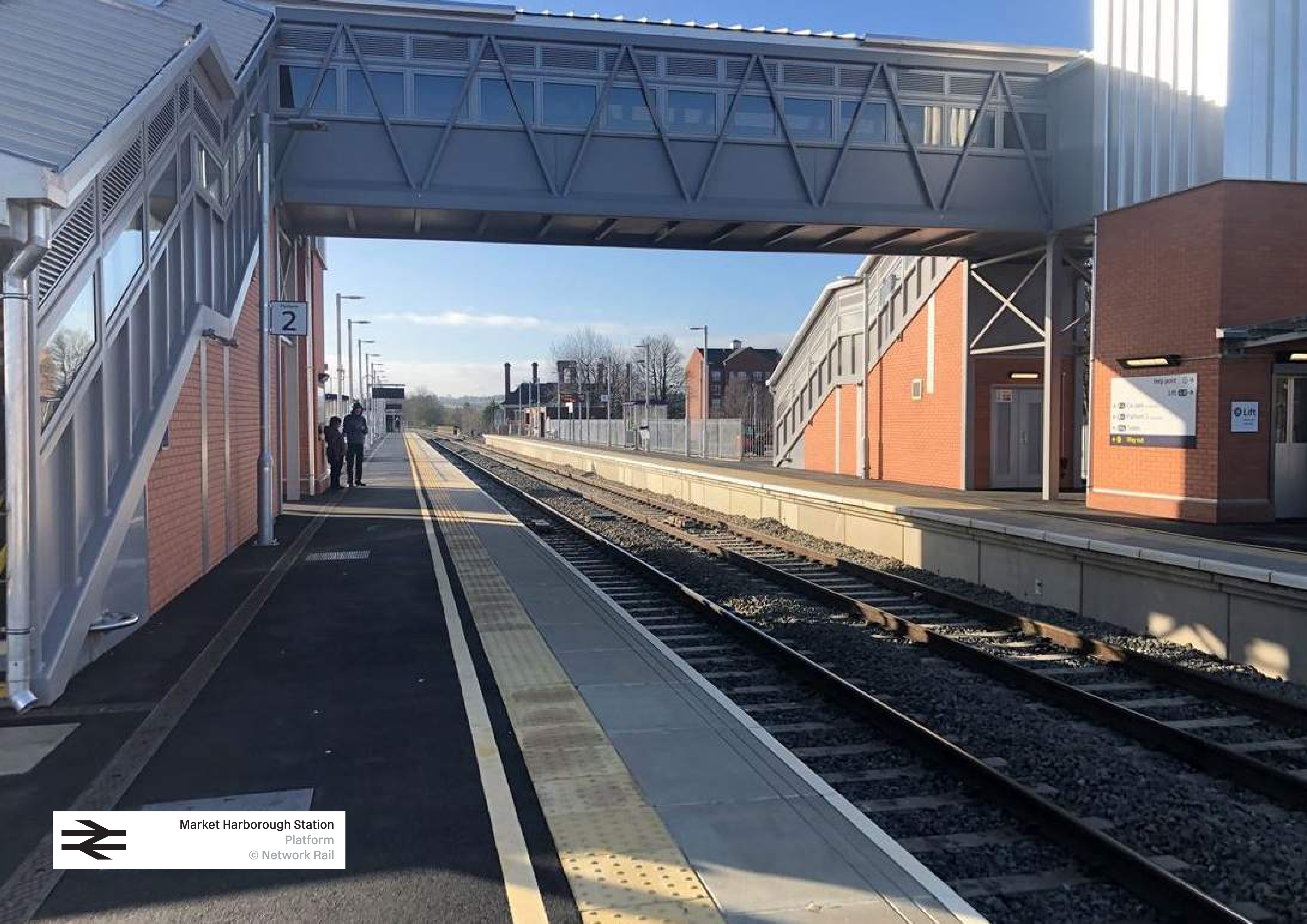
→ Gateline Attendant's Point (GLAP), or other place of safety for the gateline staff

→ A control unit to facilitate remote operation of the gateline and to allow for all gates to be opened in an emergency

→ Smart card readers

Network Rail document

Inclusive Design Guidance
NR/GN/CIV/300/04 – Section 2.2.2



Market Harborough Station
Platform
© Network Rail

3.3 Platforms

3.3.1 Overview

Platforms should accommodate passengers transferring to and from train services as well as those using the area as a route to access other parts of the station building. It is, therefore, important that they are designed to allow free circulation whilst also preserving good lines of sight.

Platforms should be long enough to accommodate the full length of trains that call at the station. Additionally, at all stations a 5.0m allowance should be added onto the minimum platform length to cater for variances in train stopping. Exceptions may be made at stations where selective door opening is in place.

The platform width along its entire length should be sufficient to accommodate, at a safe density, peak passenger volumes.

European Standard

Railway Group Standard GIRT 7020 Issue 1.1

Railway Group Standard RIS-7016-INS Issue 1.1

PRM-TSI
Technical Specification for Interoperability: Accessibility for Persons with Reduced Mobility

Element	General principles
Single face platforms	– 3000mm where line speed exceeds 160 km/h or 100 mph – 2500mm at other platforms
Island platforms	– 6000mm where line speed on both adjacent lines exceeds 160 km/h or 100 mph – 5500mm where line speed on only one line exceeds 160 km/h or 100 mph – 4000mm at other platforms
New Buildings, Structures, Furniture, Equipment and other obstructions	New buildings, structures, furniture, and other obstructions should be located such that the following minimum distances to a platform edge is achieved: – 3000mm where permissible speed exceeds 160 km/h or 100 mph – 2500mm at other platforms Isolated columns may be minimum 2000mm from a platform edge There are several examples where these minimum widths are not adequate to allow safe circulation through this space (especially alongside vertical circulation). On busy platforms, consideration should be made to allow a minimum distance to a platform edge of 3000mm or above. Where train boarding aids are used to allow wheelchair users to board or alight trains, a free space of 1500mm from the edge of the facility should be provided on the platform [8]. As a minimum this should be provided at known or expected wheelchair board/alight locations, but ideally would be provided for the full length of the train. In the case of platform boarding ramps, this can lead to a recommended free space of 3300mm (assuming a standard platform boarding ramp length of 1800mm).
"Yellow line"	A yellow line (and warning signs) should be provided at least 1500mm from the platform edge where trains pass at speeds greater than 160 km/h or 100 mph Where freight trains can pass on an adjacent line at speeds greater than 75 km/h or 45 mph steps to reduce the risk from the aerodynamic effects of passing trains should be taken. Part 10 and Appendix B of RIS-7016-INS (Issue 1.1) provide advice on this. The yellow line can be used by platform staff to manage crowding and safe dispatch of trains. Train Operating Companies (TOCs) should, therefore, be consulted whilst defining the width of this zone.

Table 3.6 General principles for platform sizing (minimums)

3.3.2 Calculating the recommended platform width

All platforms should meet the recommended minimum widths listed in Table 3.6.

These minimum platform widths only apply in cases where the calculations stipulated herein result in a width that is less than these minimum values. The same recommendations apply for tapered platform ends that are usable by passengers. In order to accommodate track access ramps or stairs, the platform structure may need to be wider than these minimum values.

To establish the correct sizing for platforms the appropriate of the two below methods should be used. The two approaches account for stations where passengers:

1. Wait on a concourse (a typical terminus station)
   or
2. Wait on platforms (a typical through station).

If it is not possible to deliver the recommended width based on this guidance, a risk assessment should be undertaken with advice from NR SCT.

For an island platform, the calculation should be repeated for both operating sides of the platform.

Supporting Information

TfL
StationPlanning Standard S1371

Method one:

Stations where passengers wait on the concourse.

For stations where passengers normally dwell in a concourse area until their train is announced. The recommended platform width should be based on the following calculation:

Stations where passengers wait on the concourse

$$\text{Platform width} = \left\{ \frac{\text{peak minute demand}}{40} \right\} + 0.3 + \text{Yellow line distance}$$

Where:
Peak minute demand is the maximum two-way demand passing along the busiest section of the platform including any circulation demand to other areas. If detailed demand data is not available, the peak minute demand should be obtained using the relevant percentages in Table 3.2 applied to the largest alighting load, combined with 20% of the boarding load for the corresponding service.

Yellow line distance should be added based on the minimums listed in Table 3.6. For stations where a yellow line zone is not necessary, based on the stated train speeds, a minimum of 0.5m should be added to the calculated width.

3.3.2 Calculating the recommended platform width

Method two:

Stations where passengers wait on platforms.

Passengers are likely to proceed directly to a platform and wait there for their train at stations with dedicated platforms for trains to different destinations or routes. For such platforms the recommended width should be determined by combining individual widths for the following zones (illustrated in Figure 3.2):

A. **Yellow line zone** is a safety requirement to mitigate the risks of aerodynamic effect from passing trains at some stations and commonly used in dispatch operations. An actual yellow line itself may not be present at all stations – but this zone safeguards the space it would occupy.

B. **Boarding and alighting zone** should accommodate maximum boarding and alighting activity at a density of 0.93m2 per person (queuing LoS B/C).

C. **Circulation zone** included to allow all circulating passengers, not associated with the maximum board & alight activity from the busiest (or 'peak', or 'determining') train, to travel through un-impeded at a flow rate of 40 passengers per minute (walkways LoS C).

D. **Activity zone** accounts for platform furniture and edge effects from vertical circulation infrastructure, station buildings and retail.

The positioning of passengers on a platform is not always uniform and is influenced by:

→ Location of platform entrances (at origin or destination)
→ Train stopping position
→ Location of CIS (customer information screen) displays
→ Preferred carriage

Zone key:
A – Yellow line zone (platform edge)
B – Boarding / Alighting zone
C – Circulation zone
D – Activity zone

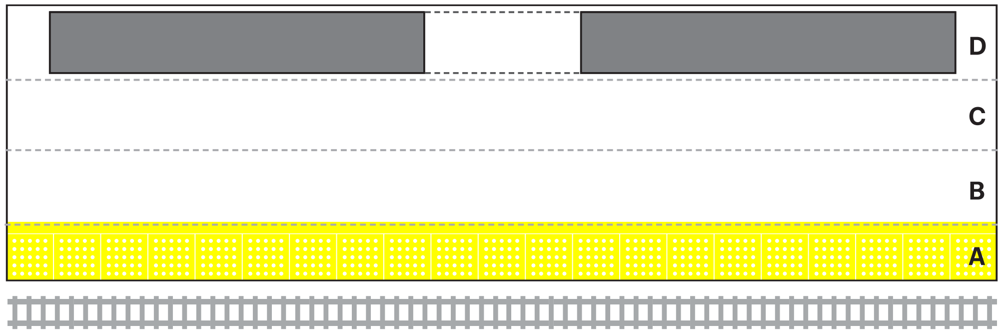


Figure 3.2 Functional areas of a typical single face platform

To account for uneven platform loadings the calculations for zones A – D should be carried out by dividing the platform length into 'carriage blocks', with each corresponding to individual train cars. The recommended width should then be calculated for each 'carriage block' separately using the formulas for Zones A – D; e.g. for an eight-car train, eight separate platform widths would be defined.

Ideally platforms should have a uniform width, with the maximum width calculated for the busiest carriage block used for the entire platform length. Where this is not the case, a risk assessment should be undertaken, with supporting calculations, to demonstrate that any risks are as low as reasonably practicable.

3.3.2 Calculating the recommended platform width

The following calculations should be carried out for each carriage block, for the busiest periods and for all different train lengths that call at the platform; e.g. some rolling stock formations may result in higher concentration of passengers within a relatively small part of the platform.

Zone A: Yellow line zone

A 'yellow line zone' should be provided based on the minimums listed in Table 3.6. For stations where a yellow line zone is not necessary based on the stated train speeds, a minimum of 0.5m should be added to the calculated width.

Zone B: Boarding / Alighting zone

This zone is used by boarders and alighters from the busiest (or 'peak', or 'determining') service, and is calculated using the following formula separately for each carriage block.

Boarding/alighting zone

$$\text{Boarding/alighting zone} = \left\{ \frac{\text{block load x 0.93}}{\text{block length}} \right\} \text{m}$$

Block length is the length of each carriage based on the appropriate rolling stock

Block load is the total number of people that board and alight the train car located within the 'carriage block' for the busiest service. Users of this document should have either an observed or inferred platform distribution by carriage for boarders and alighters. To determine this, the approach in order of preference should be:

1. Distribution of boarding and alighting passengers along the length of a platform should be based on a survey of the number of boarders and alighters for each train car, wherever possible.

2. Should this information not be available from survey data or other information, a reasonable assumption should be agreed with the NR SCT.

3. Where neither of the above are possible, users of the guidance may make use of industry-standard distribution models (such as TfL's 35%-30%-22.5%-12.5% per platform quarter from busiest to quietest), provided justification of their appropriateness accompanies the analysis undertaken.

3.3.2 Calculating the recommended platform width

Zone C: Circulation zone

This zone accounts for the space that would be used by any other person using the platform, who is not a boarder or alighter of the determining train (and, therefore, already accounted for in the Zone B calculation above). Examples of such activities include:

- → Those travelling through the platform space to access another platform
- → Those travelling through the platform space to exit the station
- → Those waiting for a subsequent service arriving after the determining train

The space recommended for other circulating passengers to pass along the platform should be based upon the following formula:

Circulation zone
$$\text{Circulating zone width} = \left\{ \frac{\text{peak 5 minute demand}}{5 \times 40} \right\} \text{m}$$

Peak 5 minute demand should be based on survey data wherever possible. The 5 minute period should correlate with the 5 minute period in which the determining train used in Part B occurs. Should peak 5 minute data not be available, a reasonable assumption should be made.

At stations where circulating movements, such as those described above, do not occur, a circulation Zone C calculation is not necessary.

Zone D: Activity zone

A minimum allowance of 0.3m should be added to the calculated platform width for an 'activity zone'. The width of this zone should be increased where appropriate, to take into account platform furniture, footprint of vertical circulation infrastructure, any station buildings and retail located within each individual 'carriage block'.

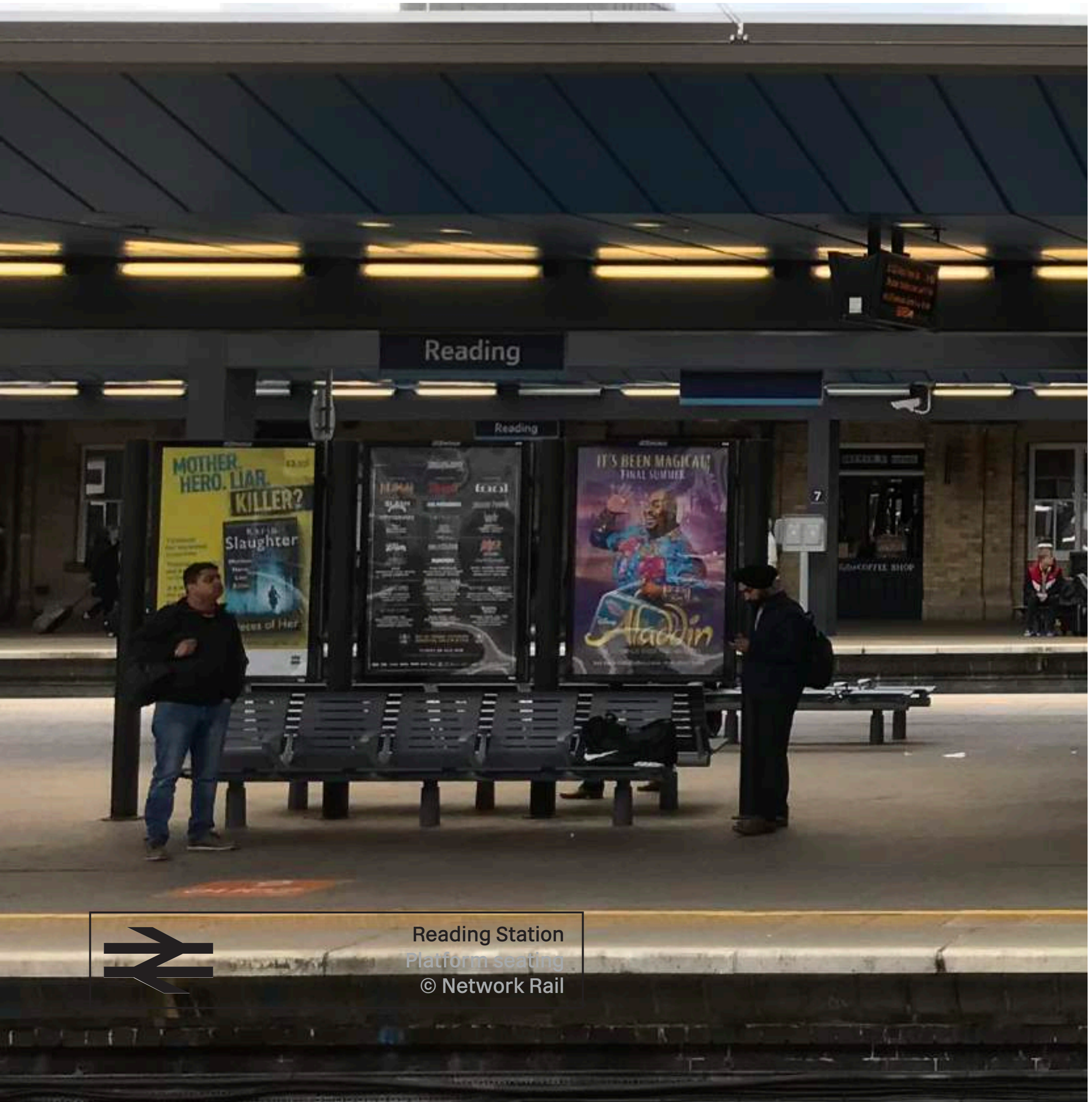
Total block (platform) width

All four calculated widths (Zones A-D) should be added together to calculate the recommended widths for each 'carriage block'. These should be adhered to when designing, or making amendments to the station.

At a more advanced design stage or where platforms have more complex movement patterns, dynamic modelling is likely to be necessary to understand platform sizing in more detail. This is discussed further in Section 2.1.

3.3 Platforms

3.3.3 Platform seating



Reading Station
Platform seating

Seating should be provided in all areas of the station where passengers wait for trains. As a minimum there should be one area fitted with seating facilities with space for a wheelchair. Seats along the platform provide resting places for passenger with limited mobility. The travel distance between seats/resting points should not be more than 50m. It is important that seating located on a platform has good weather protection, clear sightlines to CIS screens and is positioned to hear the station's PA announcements.

Locating seating near to boarding assistance points, toilets and lifts allows the platform environment to be as inclusive as possible. Where there is minimal seating, it should be clearly marked as being priority seating for passengers with limited mobility.

Care should be taken so that furniture does not encroach on run-offs and is accounted for in 'Zone D' as part of the platform width calculation.

The Diversity Impact Assessment is a valuable source of information to determine seating recommendations. For detailed guidance on sizing and specification of station seating provisions please refer to Design standards for accessible railway stations.

European Standard

PRM-TSI
Technical Specification for Interoperability: Accessibility for Persons with Reduced Mobility for high Speed and – Conventional Lines on the Trans-European Rail Network – Section 4.2.1.7.

Glasgow Central Station
Concourse

3.4 Canopies

3.4.1 Overview

Canopies should be provided over platforms and other public areas within a station to provide a weather protected route to and from train services. This is to allow safe movement of passengers and to improve passenger comfort during inclement weather. Insufficient shelter can result in congestion, with passengers congregating in covered areas. This slows boarding and alighting and has a negative impact on train dispatch and timetable performance.

It may not always be possible due to site constraints such as heritage structure to install a canopy . In such cases the possibility of installing separate sheltered waiting areas should be explored as shown in Figure 3.3.

Where a canopy is provided it is important that it gives adequate cover on platforms so that boarding and alighting operations are not compromised during inclement weather. Therefore, the canopy should cover the entire width of the platform where possible.

The position of canopy structures should be considered in accordance with minimum platform widths given in Table 3.6, namely isolated columns should be a minimum of 2000mm from a platform edge. Where possible, columns should be positioned such that they can be integrated with other services, e.g. canopy drainage or cable runs.

At some stations due to platform alignment in relation to wind direction, it may be appropriate to consider windbreaks in addition to canopy cover to protect against inclement weather. Where such windbreaks are provided, they should be designed such that they do not obstruct circulation along the platform and do not impede boarding and alighting movements that could risk compromising timetable performance.

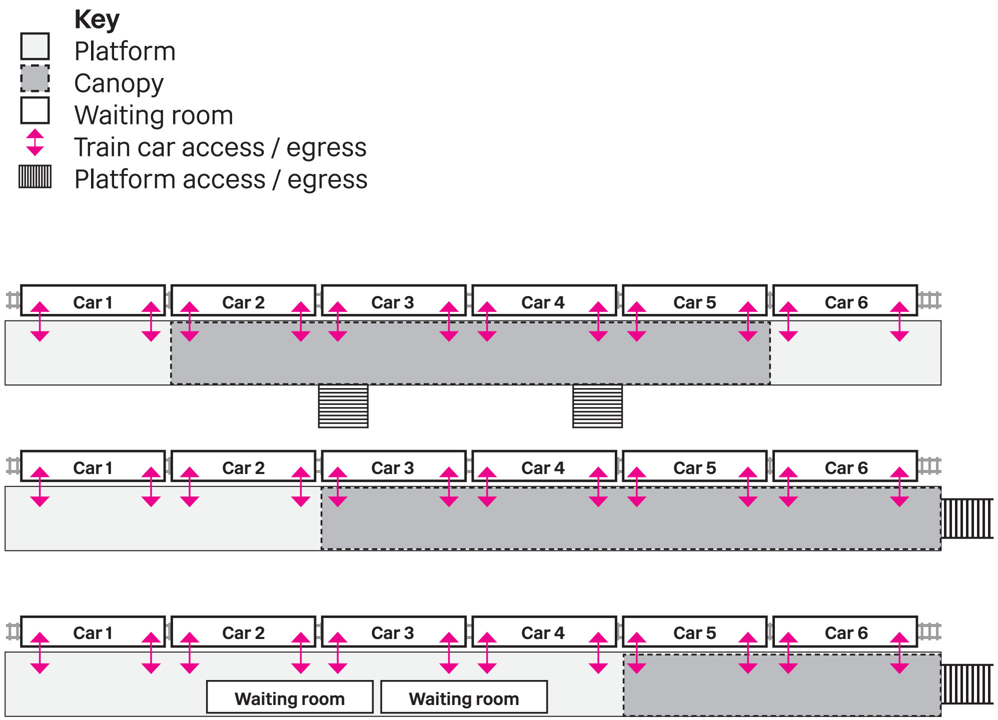


Figure 3.3 Examples of different canopy positions over platforms

3.4.2 Calculating canopy size

The recommended area covered by a canopy should be calculated by considering the area that is necessary on a platform to accommodate the maximum number boarders at Queuing LoS B/C. One should then derive the canopy length (metres) by considering the usable width along the platform.

The recommended canopy area is calculated using the following formula:

Calculating canopy size

$$\text{Area under cover} = \left\{ \text{Peak 5 minute boarding demand x 0.93} \right\} \text{m}^2$$

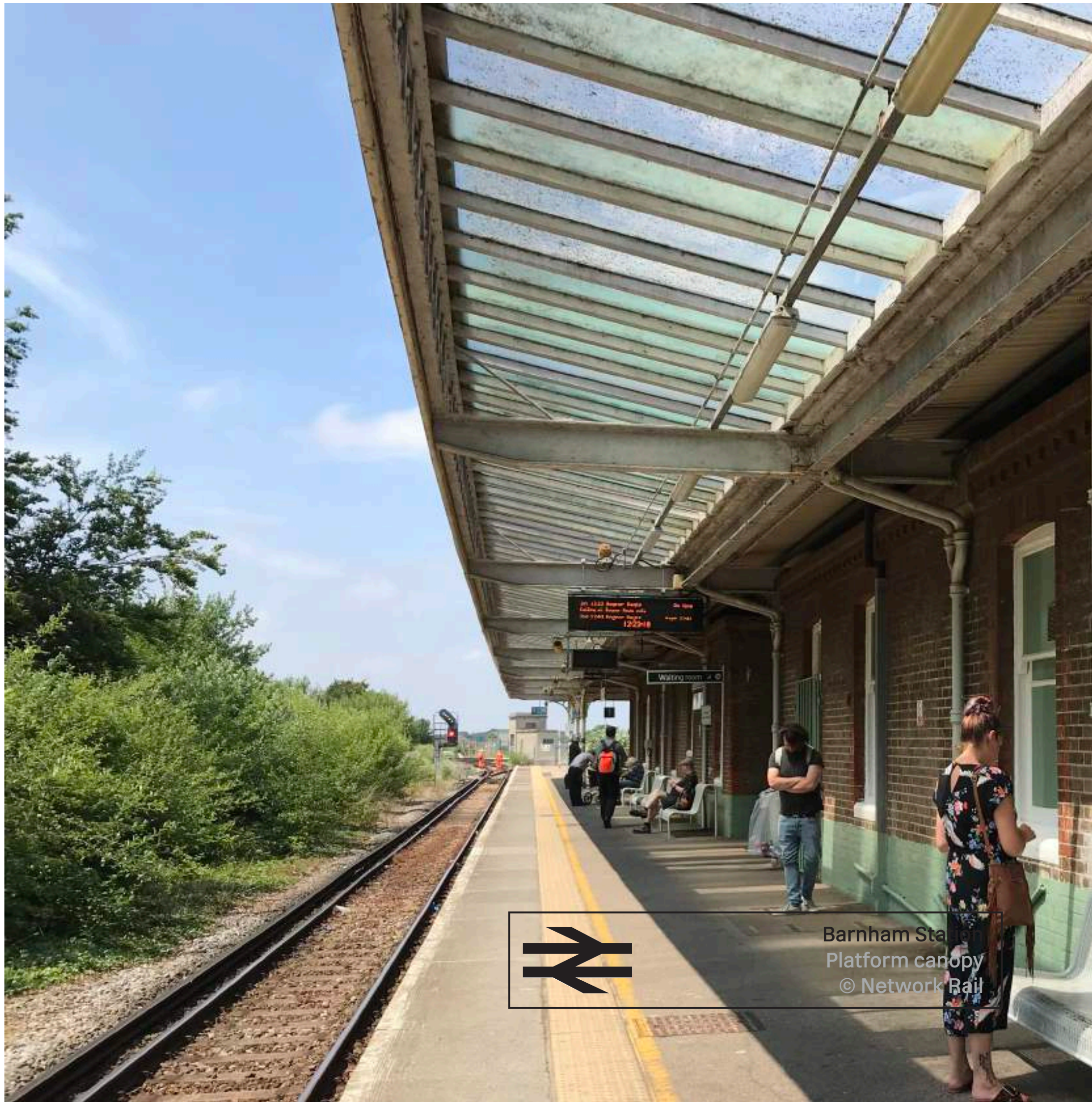
Where:

→ **Peak 5 minute boarding demand** is the maximum number of boarding passengers waiting on a platform. This should include boarders for multiple services as appropriate.

→ A passenger density of $0.93m^2$ per person (queuing LoS B/C) is used in this calculation. A lower density level can be used if deemed appropriate for a given site.

When calculating the resultant canopy length, any station buildings or areas covered by platform furniture that cannot be used by passengers waiting for trains should be excluded.

Other factors influencing the spread of passengers on platforms should be considered when designing canopies. These may include the location of platform access routes, passenger behaviour and train loadings.



Barnham Station
Platform canopy
© Network Rail

3.5.1 Concourse sizing

The main function of a station concourse is to provide sufficient space for passengers moving through and waiting within it. This section provides guidance on how to establish the appropriate concourse size, for the level of passengers utilising the area.

Calculating size of dwelling area in concourses

Concourses should be large enough for passengers to move through without experiencing excessive congestion or obstructions. Unpaid dwelling areas in concourses should be designed to a density level no greater than 1.8m^2 per person (walkways LoS C), to account for the complex movements that occur in these environments.

The below formula should be used to ascertain an appropriate concourse dwelling area. This allowance is in addition to any retail space, ticketing/information facilities, seating, gatelines and any associated run-off or queuing areas, as shown in Figure 3.4.

Calculating concourse size

$$\text{concourse dwelling area} = \left\{ \frac{\text{peak 15 minute demand} \times 1.8}{15} \right\} + \text{A or B m}^2$$

Where:

- **Peak 15 minute demand** should consist of all passengers moving through the unpaid concourse area, both entering and exiting passengers, plus non-rail users, as detailed in Section 3.1.
- **Area A –** At stations with dedicated platforms for each direction or service type, passengers are likely to wait on the platforms rather than the concourse. At these stations an allowance should still be made for passengers who stop briefly to view CIS screens in the concourse area. This area should be large enough to accommodate 10% of the peak 15 minute station entry and exit demand at a density of 1.0m^2 per person (queuing LoS B).
- **Area B** – At stations where passengers predominantly wait in the concourse area and access the platforms only after their train has been announced, a larger accumulation area is necessary for waiting passengers. This accumulation area near the CIS should be designed to be large enough to accommodate 100% of the peak 15 minute station entry demand at a density of 1.0m^2 per person (queuing LoS B).

At some stations, it may be appropriate to include both A and B areas, to account for behaviours associated with different service types at the same station.

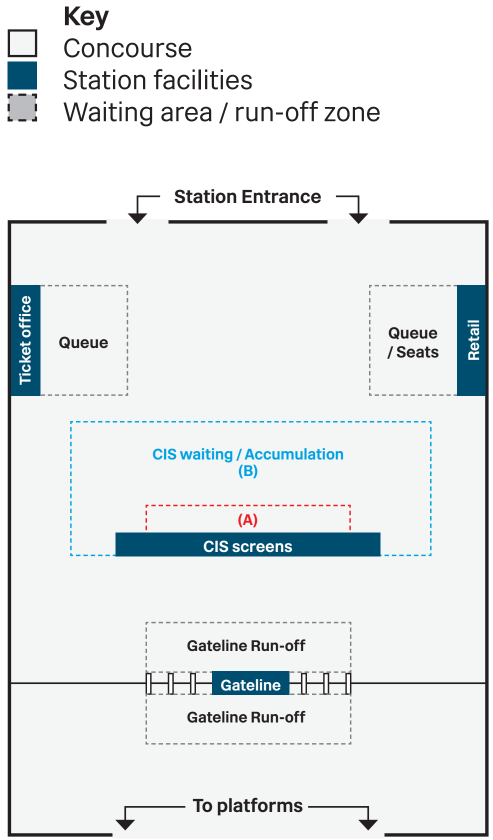


Figure 3.4 Example layout of a station concourse

3.5.1 Concourse sizing (continued)

When calculating concourse size, it is also important to consider any specific station needs that may warrant a larger concourse area.

It is also important to think about what would happen under a perturbation scenario, and if there is adequate area to hold passengers under this scenario.

Table 3.7 sets out the space recommendations for various elements that may feature in a station concourse in addition to the calculated concourse space based on formula above. Run-off lengths between other elements should be based upon Table 3.10.

3.5.2 Concourse configuration

Station concourses should aim to:
→ Provide clear sight lines
→ Be devoid of clutter and unnecessary obstacles
→ Have clear signage
→ Provide CIS areas that compliment overall wayfinding
→ Avoid convoluted routing
→ Keep passenger desire lines clear

It is important to consider these when planning the layout of concourses so that as well as having the correct amount of floor space, the space that is provided promotes ease of movement through the station.

Station facility	Space
Ticket machines **Ticket issuing windows** **ATMs**	Queuing space of 4.0m in front of each facility that is free from obstructions and circulating movements. Queuing systems may be used if necessary.
Seating	See Section 3.5.3
Retail **Food** **Refreshment outlets**	Space for such facilities should be provided in addition to the general space for passenger movement. Any queuing space or seating arrangement associated with food and refreshment outlets should be calculated separately.
Other facilities	Space recommendations for customer information points, mobility assistance, waiting rooms, left luggage, lost property, public toilets and baby changing facilities should be calculated separately if included in the design.
Note: The above areas should be strategically sited within concourse areas to cater for customer needs and avoid impeding main circulation flows.	

Table 3.7 Other functional areas to consider within station concourses

Network Rail document

Wayfinding Guidance
NR/GN/CIV/300/01

Wayfinding Standard
NR/L2/CIV/150

3.5.3 Concourse Seating

Seating should be provided in all areas of the station where passengers wait for trains. At stations where passengers dwell on the concourse seating and resting points should aim to accommodate 10% of passengers waiting during peak times.

The location of seating needs to be carefully selected, it should be convenient and logical. Seats should be close to general circulation routes at intervals of not more than 50m to provide resting places for passengers with limited mobility . Seats close to lift entrances aid those who cannot stand for long periods.

Seating near to entrances, travel information, toilets and other facilities allows the station environment to be as inclusive as possible.

Seating should complement desire lines through a station without impeding main circulation routes. It should not encroach upon minimum run-offs and its space usage and users should not reduce the access route width below the recommendations for that passenger footfall.

Where there is minimal seating, it should be clearly marked as being priority seating for passengers with limited mobility.

The Diversity Impact Assessment is a valuable source of information to determine seating recommendations. For detailed guidance on sizing and specification of station seating provisions please refer to Design Standards for Accessible Railway Stations, DfT.

Network Rail document

Inclusive Design Guidance
NR/GN/CIV/300/04

National Standard

DfT and Transport Scotland
Design Standards for Accessible Railway Stations

Brtish Standards Institution
Design of Buildings and their Approaches to meet the needs of Disabled People, BS 8300

London Liverpool Street Station
New seating
© Network Rail

3.6 Station Entrances and External areas

Station entrances and external areas should be designed to accommodate station related flows and background movement in the public realm. Station entrances are often used as meeting points and generous space provision is recommended at and around entrances. The sizing of entrances is important and should be discussed with the NR SCT on a case by case basis.

Surrounding areas external to the station are typically multifunctional spaces which can cater for rail passengers, other transport users, retail users, tourists and background activity linked to neighbouring businesses and residences . To enable efficient people movement and a valuable station user experience, a station's immediate surroundings should:

→ Provide station users with, where feasible, direct and uninterrupted paths between key origins and destinations

→ Size routes to accommodate expected peak volumes, while providing a pleasant station user experience. Where contra-flows or conflicting movements are expected, generous space provisions should be made to maintain efficient movement

→ Avoid sharp turns and broken sightlines, enabling instinctive wayfinding throughout the site

→ Deliver clutter-free paths and routes, free from advertising boards, seating, pop-up stalls, street furniture, post-racks etc

Supporting Information

TfL
Station Public Realm Design Guidance

Network Rail document

Wayfinding Guidance
NR/GN/CIV/300/01

→ Provide additional space for facilities such as shops, restaurants and cash machines where desired. Any queuing space or seating arrangement associated with outlets should not negatively affect user experience

→ Provide step-free access to all public locations. Routings should not divide PRMs and regular station users where possible

→ Provide coherent signage and wayfinding aids, easily visible and without impeding sight lines

→ Locate bicycle storage spaces such that station users can store and remove their bicycles without intruding onto dwell or circulation zones

→ Consider the location of taxi ranks, private hire dwells and car parks and the routes to access these. This is especially important as these modes are frequently relied on by PRMs

→ Consider weather protection and security

→ Provide additional space for facilities such as general seating, shops and restaurants

Consideration should also be given to how the space would be utilised outside of normal modes of operation. During service disruption, passengers often dwell, or queue, in the immediate outside spaces. Suitable waiting areas usable at times of disruption, which do not intercept paths of movement and provide space for CIS (customer information screens), should be identified.

London King’s Cross Station
Station entrance
© Network Rail

3.7 Circulation Elements

3.7.1 Overview

Circulation routes provide the means for passengers to move around the station between the external, concourse and platform zones. They consist of passageways, escalators, passenger conveyors, stairs, lifts and ramps. Circulation routes should be clear, safe, direct and compliment the station wayfinding strategy.

This section provides the recommendations for circulation infrastructure. It is recognised that at existing facilities or constrained sites it may not be possible to meet these specifications. Where this is the case, a site specific risk assessment should be undertaken.

Footbridges and subways

Both a footbridge and a subway comprise a connecting passageway plus one or more vertical circulation elements (stairs, escalators, ramps or lifts). These component parts should be considered as a whole, such that neither the width of the passageway nor the width of the vertical connections present a constraint upon each other.

The passageway and connecting vertical circulation elements should be designed in accordance with guidance in Section 3.7.2 and Section 3.7.3, respectively.

Seating for circulation elements

Long travel routes can represent a barrier for those with limited mobility. Whilst it is not intended for passengers to dwell in circulation areas seating should be provided at intervals of no more than 50m to provide resting places for passengers with limited mobility on extended footbridges, subways or passageways.

Network Rail document

Wayfinding Guidance
NR/GN/CIV/300/01

Station Footbridges and Subways
NR/GN/CIV/200/07

National Standard

DfT and Transport Scotland
Design Standards for Accessible Railway Stations

3.7.2 Passageways

It is recommended that the minimum clear width for any passageway is 2.2m. This takes into account a minimum width of 1.6m between wall finishes and an edge effect of 0.3m for each side.

Where a central handrail is provided to separate passenger flows, the minimum width either side of this should be 1.6m plus an edge effect of 0.3m for the wall on one side. No edge effect is associated with a central handrail, although the width of the rail itself should be accounted for. E.g. a passageway measuring 3.8m with a 0.2m handrail would be below the minimum recommendations.

The minimum widths stated above only apply when they exceed the recommended widths calculated in the following section of this documentation.

The passageway width formula should be used to calculate the recommended passageway widths for one-way and two-way flows. One-way flows are based on Fruin walkway LoS D and two-way flows are based on walkway LoS C.

An edge effect of 0.3m is added to each side of the passageway to account for the space passengers leave to avoid touching the walls. No edge effect is applied to central handrails.

Calculating passageway widths

$$\text{two-way passageway width} = \left\{ \frac{\text{peak minute demand}}{40} + (2\text{x}0.3) \right\} \text{m}$$

$$\text{one-way passageway width} = \left\{ \frac{\text{peak minute demand}}{50} + (2\text{x}0.3) \right\} \text{m}$$

When station routes are served by multiple passageways in different locations a simple aggregation of capacity may not be acceptable. Distribution of passageway usage might be influenced by:

→ Location along a platform combined with knowledge of train stopping position and/or boarding and alighting patterns from services

→ Connectivity e.g. whether it serves all routes or only serves a single entrance

→ Equilibrium e.g. are the routes provided similar in distance, perceived effort and journey time

The appropriate 'catchment' of each passageway, based on the above factors, should be used to correctly size individual elements.

Passenger conveyors

If it is commercially viable and beneficial to do so, passenger conveyors can be installed in a number of locations including along passageways. These should be considered when station layouts have large travel distances. It should be assumed that passenger conveyors, or travelator, have the same run-off as escalators. The manufacturer's specification should be used to determine a throughput rate for capacity calculations.

3.7 Circulation Elements

3.7.3 Vertical circulation

All new station designs should include at least one step-free route from street to concourse and from concourse to platforms. Diversity Impact Assessments will help identify the appropriate step-free access solution for each station. It is recommended to seek endorsement from BEAP for any projects involving changes to vertical circulation.

Other vertical circulation elements should be dictated by capacity and the height of level change. Guidance on the appropriate means of circulation depending on level change is given in Table 3.8 and Figure 3.5.

These principles are given as a guide. Depending on the individual station there may be capacity benefits and a business case to install escalators for a level change less than 5.0m.

To allow for routine servicing no single escalator or lift should provide the sole means of changing level. Escalators should be complemented by stair provision for operational flexibility, resilience and inclusivity.

Level change	Means
Less than 0.5m	Ramp
0.5m to 3.0m	Stairway
3.0m to 5.0m	Stairway, or escalator if the benefits are justifiable
More than 5.0m	Escalators or lifts
Note: Step-free routes should be considered separately to this.	

Table 3.8 General principles for level change on non-accessible routes

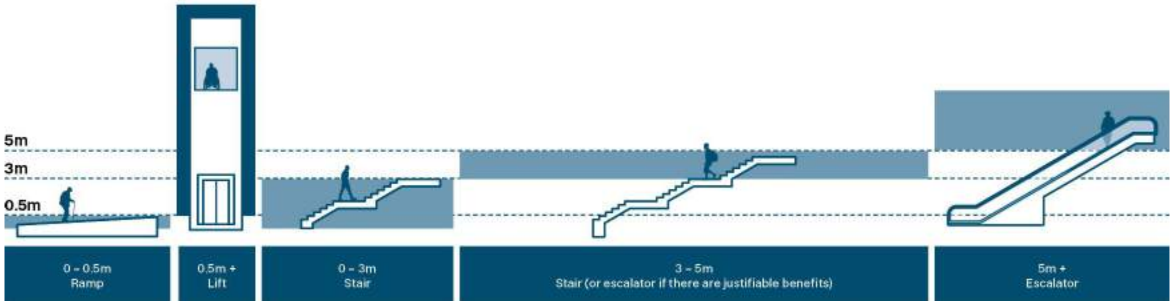


Figure 3.5 Vertical circulation general principles

Supporting Information

TfL
Station Planning Standard, S1371

National Standard

Dft and Transport Scotland
Design Standards for Accessible Railway Stations

3.7.3 Vertical circulation – Ramps

The width of a ramp should be calculated using the following steps:

- → Gradient shallower than 1 in 20, the same way as for a passageway
- → Gradient steeper than 1 in 20, the same as for a passageway but a 10% reduction in the flow rate should be assumed

Refer to Section 3.7.2 for guidance on calculating passageway widths.

The minimum recommended clear width is 1.5m, with sections of 1.8m width, to allow two wheelchairs to pass each other. Where the clear width exceeds 2.5m, ramps should be divided into two or more equal channels. It is recommended that, for stations in categories A–D, ramps have a minimum width of 2m between handrails.

Public ramps should comply with the gradients stipulated in Table 3.9.

Ramps should not be used as the only approach to a station. Where there is a change in level no greater than 0.3m a ramp is acceptable, avoiding the need for a single step on station approach.

No individual flight of a ramp should have a going of more than 10.0m or a rise of more than 0.5m. If a series of ramp fights rise more than 2 metres, an alternative means of access, such as a lift, should be provided. Ramp flights should have a consistent gradient. Landings should be provided at the top and bottom of ramps a minimum of 1500mm deep, level and clear of obstructions.

The sizing and positioning of intermediate landings and change in direction should be as per stipulated in Design Standards for Accessible Railway Stations, Department of Transport and Transport Scotland, March 2015.

Going of flight (maximum length)	Maximum gradient
10.m	1:20
9.0m	1:19
8.0m	1:18
7.0m	1:17
6.0m	1:16
5.0m	1:15
4.0m	1:14
3.0m	1:13
2.0m	1:12

Table 3.9 Maximum ramp gradient

Network Rail document

Inclusive Design Guidance
NR/GN/CIV/300/04

National Standard

Brtish Standards Institution
Design of Buildings and their Approaches to meet the needs of Disabled People, BS 8300

3.7.3 Vertical circulation – Staircases

The minimum acceptable clear width of any staircase is 1.6m between handrails.

This applies only when the width returned by a sizing calculation is less than the acceptable minimum width.

No additional width should be added to either side of stairs (an 'edge effect') – as passengers are assumed to travel up to and against side handrails.

It is recommended that a central handrail is provided on stairs wider than 4.0m . The addition of a central handrail is assumed to add 0.3m to the total width of the staircase. For example, where a capacity calculation determines a stair of 4m width, the total width of that stair would be 4.3m.

Where a central handrail is provided, no less than 1.6m width should be provided on either side.

The rise of a step should be 150-180 mm and the 'going' should be 300 mm to 450 mm.

It is preferable for a ramp to be provided instead of a stair if the stair would contain less than 3 risers in total.

No flight of stairs should contain more than 20 risers and it is preferable that the number of risers in successive flights is uniform. Between each flight a level landing should be provided that is clear of any obstructions. The length of any landing should not be less than the width of the stairs.

The formula below should be used to calculate the recommended staircase widths between handrails for one-way and two-way flows. One-way flows are based on Fruin stairways LoS D and two-way flows are based on stairways LoS C.

Vertical circulation – Staircases

$$\text{two-way staircase width} \quad \left\{ \frac{\text{peak minute demand}}{28} \right\} \text{m}$$

$$\text{one-way staircase width} \quad \left\{ \frac{\text{peak minute demand}}{35} \right\} \text{m}$$

When station routes are served by multiple staircases in different locations a simple aggregation of capacity may not be acceptable. Distribution of stair use might be influenced by:

- → Location along a platform combined with knowledge of train stopping position and/or boarding and alighting patterns from services
- → Connectivity e.g. whether it serves all routes or only serves a single entrance
- → Equilibrium e.g. are the routes provided similar in distance, perceived effort and journey time

The appropriate 'catchment' of each stair, based on the above factors, should be used to correctly size individual elements.

Network Rail document

Inclusive Design Guidance
NR/GN/CIV/300/04

National Standard

DfT and Transport Scotland
Design Standards for Accessible Railway Stations

Derby Station
Canopies and stairs

3.7.3 Vertical circulation – Escalators

Escalators are an efficient way to move large volumes of passengers, particularly across larger level changes (>5m). Due to their uni-directional nature it is important to consider whether they are appropriate for the types of flows at a station.

Stairs should be provided to complement escalators for operational flexibility, resilience and inclusivity. For example during an evacuation an escalator will continue to operate in the direction it was running prior to the start of the evacuation (BS 9992).

Where a stair is provided as part of the overall vertical circulation capacity in combination with an escalator they should conform to the minimum standards set out in Section 3.7.3 Vertical circulation – Staircases.

If a stair is provided above the recommended capacity e.g. the escalators can accommodate all of the passenger demand, then the width of the stair should conform to one of two scenarios below:

- → If directly adjacent to the bank of escalators the width can be below the minimums set out in 3.7.3 Vertical circulation – Staircases, if engineering constraints e.g. the platform width are an issue
- → If located elsewhere in the station e.g. a different location on the platform then the minimum standards set out in 3.7.3 Vertical circulation – Staircases, should be met

Escalator throughput (or capacity) is determined by variables such as:

- → The speed at which the escalator travels
- → The width of the escalator's steps
- → The occupancy rate of the steps
- → Whether users standstill or move
- → The approach to the escalator

Network Rail require an escalator to be capable of delivering 100 passengers per minute. Escalator recommendations should be calculated based on this assumed peak throughput. A lower throughput may be deemed appropriate depending on location, passenger demographics or behaviour (an airport station for example). Any change to the assumed throughput of escalators should be agreed with the NR SCT.

3.7.3 Vertical circulation – Escalators

The number of escalators recommended for any one direction should be calculated as follows:

Vertical circulation – Escalators

$$\text{Number of escalators} = \left\{ \frac{\text{peak minute one-way demand}}{100} \right\}$$

The calculated number of escalators should be rounded up to the next whole number if the first number after the decimal point is more than two and rounded down otherwise. For example, 2.3 escalators would be rounded up to three, 2.1 escalators would be rounded down to two.

NR/L2/CIV/196 sets out the following minimum for escalator design:

- → Step band width: 1000mm
- → Step band speed: 0.5 to 0.65m/s (to suit ped-flow recommendations but adjustable so can be reduced)
- → Angle of inclination: 30 degrees to the horizontal

In layouts where escalators can be approached at an angle, barriers should extend a minimum of 1.5 metres in front of the escalator. This is to aid people with visual impairments and to avoid complex crossing movements occurring in the escalator run-off area. Barrier lengths should be site specific.

Fixed luggage barriers can deter encumbered passengers from using escalators and encourage lift usage. These barriers can reduce escalator throughput, this should be considered when calculating escalator recommendations. Such barriers also remove the flexibility to change an escalator's direction.

In complex layouts it is beneficial to have overhead escalator directional signage.

Example of the use of barriers at escalators to protect run-off areas

When station routes are served by multiple escalators in different locations a simple aggregation of escalator capacity may not be acceptable. Distribution of escalator use might be influenced by:

- → Location along a platform combined with knowledge of train stopping position and/or boarding and alighting patterns from services
- → Connectivity e.g. whether it serves all routes or only serves a single entrance
- → Equilibrium e.g. are the routes provided similar in distance, perceived effort and journey time

The appropriate 'catchment' of each escalator or bank of escalators, based on the above factors, should be used to correctly size individual elements.

National standard

DfT and Transport Scotland
Design Standards for Accessible Railway Stations

3.7 Circulation Elements

3.7.3 Vertical circulation – Lifts

General principles

Lifts can be provided as either the main method of vertical circulation, or as a step-free access route. The provision and planning of lifts should be based upon the Diversity Impact Assessment (DIA).

Overall lift capacity should be driven by the volumes of passengers using them for level change. The recommended number of lift units is driven by available space and the need for resilience during redundancy. High traffic locations could justify the cost of multiple lifts.

Consideration of the following elements is key:

→ Lifts are sized for anticipated passenger needs. Sizing for wheelchairs and passengers with luggage, trolleys, prams or bicycles rather than plated capacity

→ Lifts offer attractive journey times. Passengers should not wait more than two lift cycles to encourage lift use and reduce the risks of accidents on stairs or escalators

→ Lifts have minimum internal dimensions of 1600mm (wide), 1600 mm (deep) and 2300mm (high)

BEAP can provide guidance where there are differing options for lift provision or where the optimum provision is not achievable.

Key
- Available space
- Wheelchair passenger
- Standing passenger
- Passenger personal space
- Wheelchair user
- Standing passenger

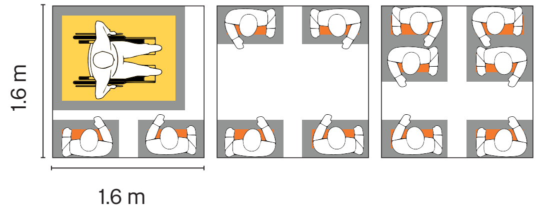


Figure 3.6 Space provision in lifts

Network Rail document

Inclusive Design Guidance
NR/GN/CIV/300/04

Standard Specification for New and Upgraded Lifts
NR/L2/CIV/193

3.7.3 Vertical circulation – Lifts

Where detailed demand information is available

The DIA should specify demand assumptions to use for lift sizing. Where a station is not fully accessible, or a survey has only been carried out during part of the day, PRM observations may be under-reported. Approaches such as benchmarking with similar stations and using demographic data from the catchment can strengthen any assumptions made.

Lift provision should consider the spatial requirements by user:

→ 0.45m² per unencumbered passenger is recommended in the lift cab

→ Up to 0.85m² per passenger for passengers with reduced mobility, including those with luggage is recommended

→ 1.4m² for a wheelchair user, allowing for the appliance plus personal space

This is visualised in Figure 3.6.

Where detailed demand information is unavailable

Where detailed user information cannot be obtained or inferred, the space available to passengers should be calculated to facilitate LoS Queuing C. This means, for example, a 1600mm x 1600mm lift with a plated capacity of six, has an effective passenger capacity of three. This allows for one of these passengers to be a wheelchair user, without compromising the calculation.

Other considerations

It may be necessary to make alterations to the above in specific scenarios, for example, in areas where lifts are a primary (or sole) access route to a platform.

In such cases a reasonable provision should be allowed considering passenger experience and safe platform clearance.

Visibility and signage are important to promote lift usage, as is the use of through lifts to ease passenger movement, where care should be taken to consider the safety of the point of discharge of the lifts and its implications for passenger flow.

Calculating waiting area recommendations

There should be a minimum clear space of at least 1.5m x 1.5m outside the lifts. This may be insufficient at stations with higher passenger volumes.

The lift waiting area should be one from:

→ 1 x internal floor space (if all demand can be serviced by one lift cycle)

→ 2 x internal floor space (where lift provision meets recommendations in this guidance)

→ Greater than 2 x internal floor space (where the lift provision is below the recommendations in this guidance)

National Standard

DfT and Transport Scotland
Design Standards for Accessible Railway Stations

3.8 Minimum Run-off Distances

It is important to provide run-off (and run-on) space in front of escalators, gatelines and staircases to encourage passengers to move on and provide a clear landing area for following passengers. These areas provide the following:

1. Orientation time to allow passengers to move clear and decide where to go next.

2. Decision/action time to decide which gate/escalator to use or to get tickets out/put them away.

3. Queuing time where passengers can accumulate safely

Table 3.10 provides a list of recommended minimum run-off/run-on distances. Where a range is given the run-off/run-on is dependent on the level of passenger demand as follows:

→ **Light flow**: where the maximum peak hour flow through the relevant area of the station is less than 1000 passengers, the lowest minimum dimension should be adhered to

→ **Heavy flow**: where the maximum peak hour flow through the relevant area of the station is greater than 3000 passengers, the highest minimum dimension should be adhered to

→ **Medium flow**: where the maximum peak hour flow through the relevant area of the station is between 1000 and 3000 passengers the run off length should be calculated using the below formula:

Minimum recommended run-off for medium flow

$$\text{run-off length} = \left\{ \text{minimum run-off} + \frac{\text{peak hour demand - 1000}}{500} \right\} \text{m}$$

Run-off width should be consistent along its entire length.

Run-offs should be provided before any change in direction or reduction in width occur. The entire length of a run-off should be protected from movements that cut across the provision. Where protection from cross-movements is not possible due to, for example, a stair landing onto a busy concourse the minimum dimensions in Table 3.10 may not suffice and further space allowance is recommended. The placement of items such as retail, furniture (e.g. seating) or ticket machines should not result in movements encroaching into the run-off area. If there is a risk of this happening additional run-off should be provided.

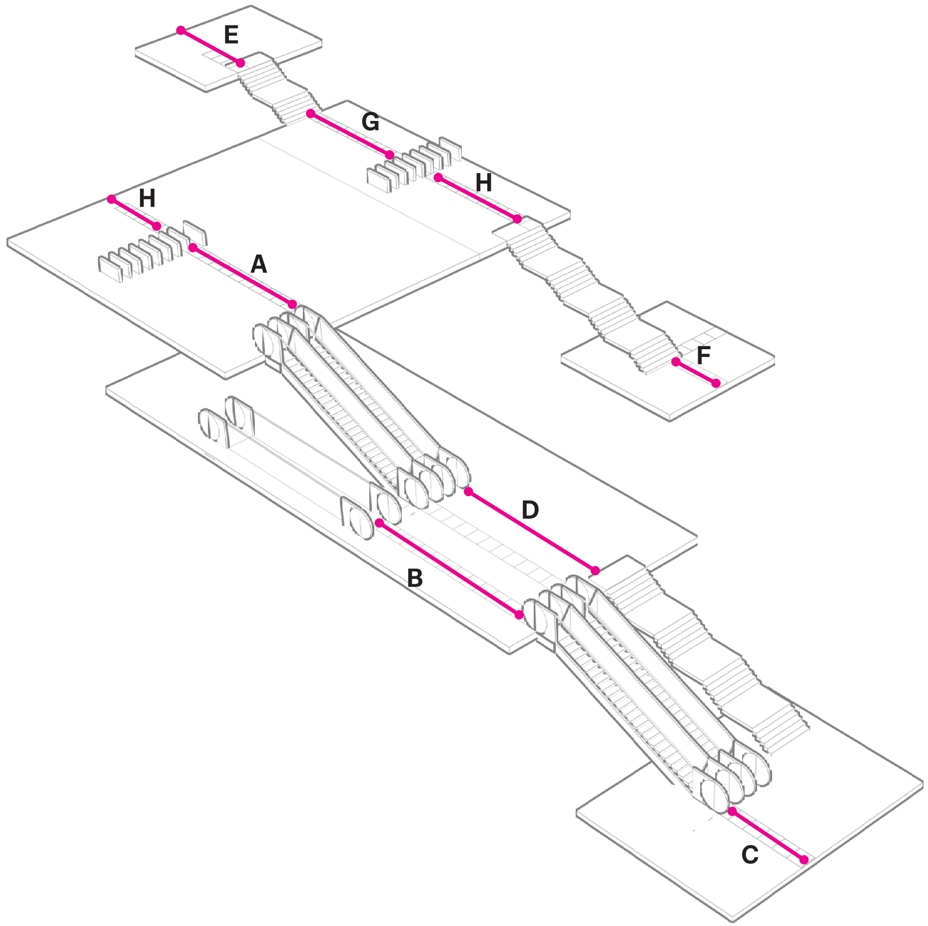
In cases where run-off distances cannot be achieved a site-specific risk assessment should be undertaken so that the appropriate mitigation measures are in place.

Queuing areas at gatelines and their relationship with run-off distances are discussed in more detail in Section 3.2.2.

3.8 Minimum Run-off Distances

	Between elements		Minimum lengths (see Section 3.8 for variable lengths)
A	Escalator / Travelator	Gateline	8 – 12m
B	Escalator / Travelator	Escalator / Travelator	8 – 12m
C	Escalator / Travelator	Passageway / Street / Concourse / Platform	6m
D	Escalator / Travelator	Stairway	6 – 10m
E	Stairway	Passageway / Street	4 – 6m
F	Stairway	Concourse / Platform	4 – 6m
G	Stairway	Gateline	6 – 10m
H	Gateline	Passageway / Street / Concourse / Platform	6m

Table 3.10 Recommended minimum run-off or run-on distances



4

Station Capacity Planning

Planning for Abnormal Conditions

London Bridge
Concourse
© Network Rail

Station Support Staff
Network Rail managed stations

4.1 Overview

It is important to certify that stations continue to function acceptably during planned and unplanned events affecting train service, passenger demand or station layout.

The minimum space recommendations outlined in Section 3 relate to station performance during normal operations. However, it is important that a station can continue to function acceptably during various abnormal scenarios. The temporary nature of these scenarios increases the thresholds in terms of acceptable density conditions and at the same time allows passenger safety to be maintained (see Figure 1.1).

Unless otherwise prescribed, a Station Capacity Assessment should include a perturbation scenario and emergency evacuation analysis.
Special events and construction scenarios should only be analysed when appropriate; for example, when construction work is planned to occur in or around the station, or when stations experience or are planned to experience significant event day demand.

The scope of abnormal conditions analysis should be agreed with the NR SCT, the project and station management teams.

4.2 Perturbation

Service perturbation is defined as a significant delay to trains, leading to increased waiting in the station environment, either on the platforms or the concourses. The impact of service perturbation is different for each station.

For termini and larger interchange stations, perturbation represents a 15 minute delay to one group of services (e.g. Main Line or Relief Line), or in one direction (e.g. Up or Down Line). For smaller stations perturbation represents the cancellation of a train service. For assessment purposes the busiest 15 minute period and the busiest train service, respectively, should be used.

During perturbation station management follow the procedures outlined in the station crowd management plan, which detail a number of controls in response to the level of disruption. These could include introducing queueing systems, closing entrances, opening automatic ticket gates, removing retail seating areas, stopping or reversing escalators and using police assistance.

Consideration should also be given to how the space outside a station could be utilised under perturbation. During service disruption, passengers often dwell, or queue, in the immediate outside spaces. Suitable waiting areas usable at times of disruption, which do not intercept paths of movement and provide space for CIS (customer information screens), should be identified.

Following any period of perturbation, the train services enter into a recovery period before the running timetable is fully restored. The recovery period depends on a number of factors including the network performance and the displacement of trains. This recovery period may put pressure on the station infrastructure and should form part of any perturbation analysis.

Points to consider include:

→ Backlog of trains and the frequency with which they arrive at the station following perturbation

→ Capacity of the trains and the number of boarders and alighters, taking into account the impact of cancellations and perturbation at preceding stations

4.2 Perturbation

Example Levels of Service observed at stations

Figure 4.1 and Figure 4.2 are images from London Waterloo station concourse. The images show levels of service observed during normal operations and an example of high density observed during a train service perturbation, respectively.

Figure 4.1 (LoS A)

This density level may be observed during less busy times on station concourses. It allows sufficient space for standing and free circulation through the waiting area without disturbing dwelling passengers.

Figure 4.1 (LoS B)

This density is used as the planning criteria for sizing of waiting areas in front of CIS screens. Such density levels allow restricted circulation through the waiting area without disturbing the dwelling passengers.

Figure 4.2 (disruption)

Service disruption should be included as a sensitivity test during design development. Passenger density in open concourses should meet the criteria of 0.45m2 per passenger for perturbation assessments.

Average density of ~1.8m per pax² (LoS A queueing)	Average density of ~1.0m² per pax (LoS B queueing)

Figure 4.1 Levels of service normally observed on station concourse, London Waterloo station

Figure 4.2 Concourse crowding at Waterloo station during train service disruptions

4.3 Construction

Careful planning of construction phasing is recommended to complete project works on time, whilst maintaining safety and minimising disruption to passengers.

A Diversity Impact Assessments should be completed and approved for temporary works, temporary conditions, permanent works and any staging works.

As a rule, the period of time where degraded Levels of Service associated with planned disruption are deemed acceptable (Figure 1.1) should not exceed one month for all works at a given station. For construction works exceeding one month (entire duration of all stages combined) the Levels of Service should be the same as normal operations.

The provision of high-quality and effective passenger information during construction (and any other planned and unplanned disruptions) is vitally important. Information should be provided with enough notice and detail to enable passengers to plan for changes in their journey (e.g. extended travel distances within the station, change of access to platforms, bus replacement services) or allow them to make alternative travel arrangements. Any changes to routing within the station dictated by the construction should be clearly communicated and kept to minimum.

Of particular importance during temporary construction works is the safety of passengers during service perturbation and emergency evacuation. During each assessment the busiest time period for the particular area in question should be used.

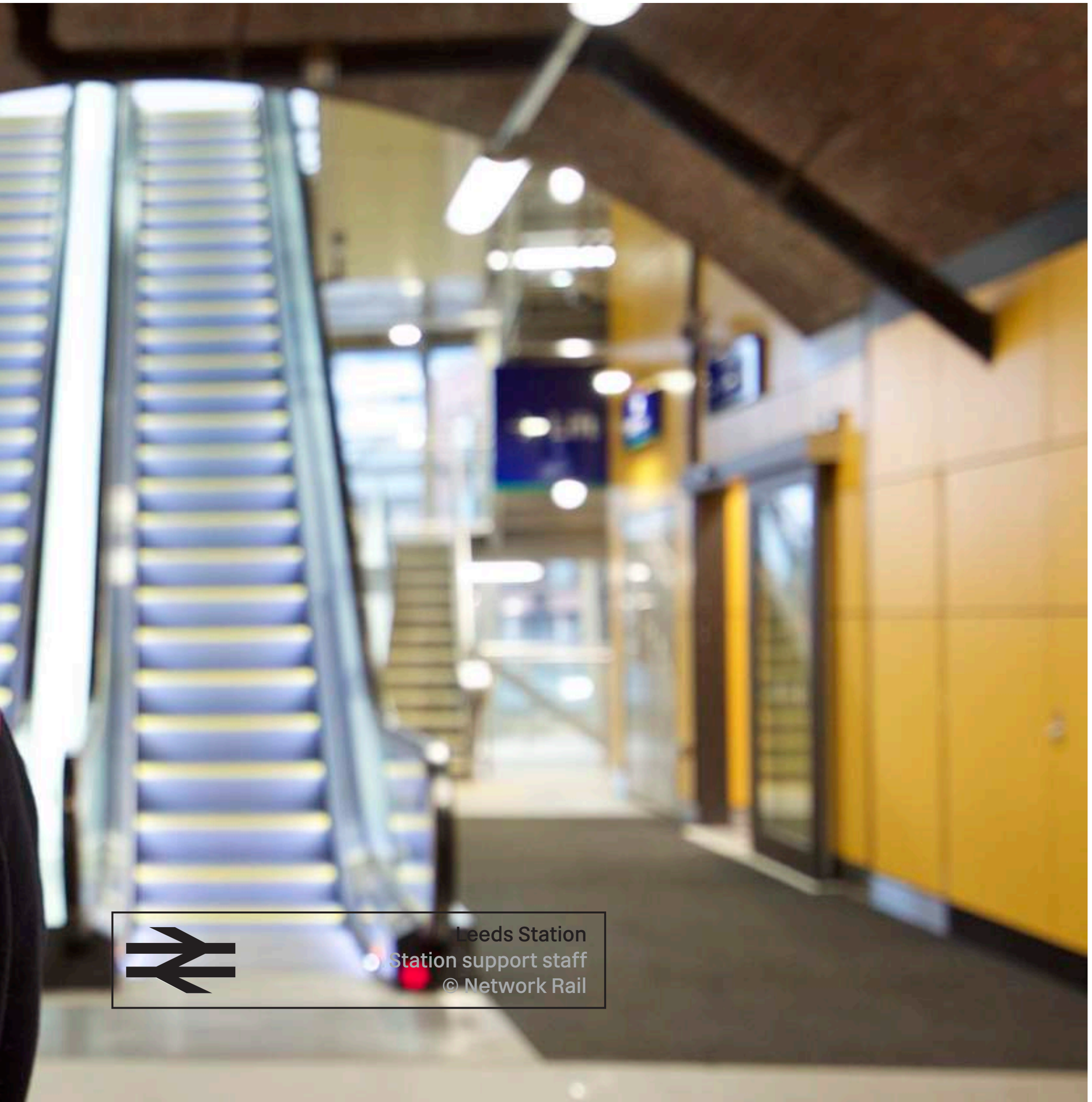
4.4 Special Events

Events taking place at, or in the vicinity of, stations can lead to a temporary change in passenger flows at stations and their external areas. A passenger count may be necessary to determine this change in flow.

Events that may impact a station's capacity and operation include, but are not limited to: sporting, musical or cultural events (at adjacent or nearby stadia, arena and venues); annual festivals (New Year fireworks etc) or events of national significance (royal weddings, monarch's jubilee).

During special events station management follow the procedures outlined in the station's crowd management plan. This specifies a number of controls so that passengers can pass through the station safely and efficiently – this may include alternative (likely longer) routes to dilute flows, one-way routing to separate flows or 'stop and hold' measures to ease pressure on key pinch points (to name just a few).

4.5 Emergency Evacuation



Leeds Station
Station support staff
© Network Rail

An emergency event could lead to a partial or full evacuation of a station asset. Such evacuations can occur in a managed, partially managed or un-managed state. A station evacuation can be triggered by fire or other events, such as security threats or overcrowding. To represent a design's ability to evacuate, analysis should be undertaken for station evacuation scenarios caused by fire.

BS 9992:2020 in conjunction with BS 9999:2017 sets out the principles to undertake a fire evacuation assessment. These documents provide assumptions for calculating egress capacities and give maximum evacuations times. Designs of evacuation routes should incorporate inclusive principles.

The interpretation of modelling outputs in relation to the acceptance criteria set within BS 9992:2020 should be agreed with Network Rail Fire Engineers.

National Standard

Brtish Standards Institution
Fire safety in the design, management and use of rail infrastructure — Code of practice, BS 9992

Brtish Standards Institution
Code of practice for fire safety in the design, management and use of buildings, BS 9999

5

Station Capacity Planning

Station Performance Categorisation

5.1 Station Performance Categorisation

If the recommendations set out in this document are not correctly met it can impact on safety, performance and passenger experience. The scale of these risks should be clearly articulated by the analyst.

All assessments should draw conclusions by rating the performance of the station using the following categories. A rating is requested for every scenario analysed and should be based on the categories to the right.

Once the assessment is complete an overall category for the station should be provided. This should take into account the core remit of the project if, for example, some scenarios are 'acceptable' and some are 'unacceptable'.

The category should be reviewed with the Station Capacity Team.

Acceptable – The station is expected to operate with minimal management interventions and no residual risks have been identified to passenger safety or train performance.

Acceptable with Management Intervention – The sizing of individual station elements is such that parts of the station may regularly require planned management interventions to reduce the risks to passenger safety and train performance. If it is not possible to improve the situation through design, then a risk assessment should be undertaken to verify that the residual risks are mitigated with the implementation of appropriate measures.

Unacceptable – The sizing of station infrastructure is such that regular management interventions fail to reduce the safety and train performance risks. Here, further disruptive measures are necessary. These may include: changes to the train timetable, altering train lengths, diverting passengers to other stations or partial station closures. In such cases immediate mitigation measures are required to temporarily reduce the identified risks, until effective design and operational interventions can be made to move the station into 'acceptable or 'acceptable with management intervention' categories.

6

Station Capacity Planning

Appendices

Station Capacity Planning

Appendix A – Data

A

Appendix A – Data
Data inputs for assessments

The following checklist should be used in remits to clearly identify gaps in data.

Table A.1: Data inputs for assessments – Passenger Data			
Data element	**Static assessments**	**Modelling**	**Source –** Primary source[s] listed, but not limited to
Station usage, or entry/exit flows	√	√	Observed: count survey Measured: footfall sensors (if present)
Origin-destination matrix	–	√	Survey (typically requiring some derivation by analyst)
Localised two-way counts (i.e. at a specific entry, gateline, stair etc.)	√	√	Observed: count survey Measured: footfall sensors (if present)
Board, alight and loading counts (especially where platform sizing is being considered)	o	o	Observed: count survey Estimated: mobile phone data (if feasible and economic to do so)
Gateline data (rail)	o	o	Operator
Gateline or ticket-validation data (LU / other)	o	o	TfL; Operator
Forecast station entry/exit flows	√	√	Simple uplift forecast, no further information. Detailed forecast provided by NR's Economic Analysis team
Forecast origin-destination matrix	–	√	Analyst derived
In station passenger journey times	o	o	Survey
Observed or video evidence showing passenger movement and behaviours	o	√	Survey or site visit

√ Mandatory minimum input for assessments
o Non-mandatory, but useful information for assessment and/or demonstrating validity of output
– Not usually required

Appendix A – Data
Data inputs for assessments

The following checklist should be used in remits to clearly identify gaps in data.

Table A.2: Drawings

Data element	Static assessments	Modelling	Source – Primary source[s] listed, but not limited to
Station plan including key station layout (CAD)	√	o	Site visit and/or NR or Operator
Scalable drawings of existing station layout (CAD)	o	√	NR or operator
Proposed station layout in scalable format (CAD)	√	√	Design lead (NR or third party)
Rolling stock layout (CAD)	–	o	Operator

Table A.3: Train and station data

Data element	Static assessments	Modelling	Source – Primary source[s] listed, but not limited to
Train timetables	√	√	NR or Operator
Operational configuration of gates and escalators	√	√	Site visit
Station control or crowd management	o	o	Sensitive. Disruption at SFO's behest
Evacuation plan	o	o	Sensitive. Disruption at SFO's behest
Station signage and wayfinding	o	√	Observed in station or sourced from design lead (NR or third party)
Ticket purchase activity	-	o	Survey or Operator
Life capacities (actual not plated) and cycle times	√	√	Observed during survey
Usage of secondary revenue facilities (i.e. retail)	-	o	Observed: count survey Measured: Footfall sensor (if present)

√ Mandatory minimum input for assessments
o Non-mandatory, but useful information for assessment and/or demonstrating validity of output
– Not usually required

Data inputs for assessments

Further details
Passenger datasets may be mandatory or useful (or impractical) for use, depending on their nature, the modelling or analysis approach undertaken, or the complexity of the station layout and its operation.

The source of any data sets used in an assessment should be clearly stated.

The following provides further context information on some of the items in the data inputs table above, in alphabetical order:

- **Automatic ticket barrier usage**
  Ticket barrier activation data may be made available by the train operator and could be used as a proxy for station usage counts or to help understand the throughput of individual gates (where individual plinth data is available) or to understand the range of ticket types used. However, limitations of ticket barrier data should be considered: gates might be left open out of peak hours or opened to ease crowding during peak times; and the granularity of data recorded varies from operator to operator.

- **Board and alight counts**
  The number of people getting on (boarding) or getting off (alighting) each carriage of each train within a data-collection period. This should be seen as a vital component of platform sizing analysis. Data can be collected through low or high technology approaches (counted or monitored) – or inferred from train loading data where available.

- **Journey time**
  These measurements should be made during free flow conditions in order to benchmark unimpeded journey times experienced by passengers. This can be used to calculate the delay caused by congestion and support business case development.

- **Localised counts at other key locations**
  These should be recorded for 5 minute intervals during peak times and can be used to validate routing of passengers within stations; e.g. counts at stairs, passageways, escalators and ticket gates.

- **Origin and destination matrix or pairs**
  This data can be gathered by various methods including: 'colour card' survey, interviews, 'people following', video analytics or by using more advanced methods that rely on technology to track devices that passengers carry with them i.e. mobile phones and tablet devices.

- **Passenger behaviour**
  Video footage recorded at different locations can be very useful to understand passenger behaviour that may be specific to the station environment.

- **Peak one-minute flow**
  This should be used to understand the concentration of flow in different areas of station; e.g. flow on stairs, passageways and through ticket barriers.

- **Platform occupancy**
  At many stations, platforms can be used by trains serving different routes. At such stations, passengers dwell on the platform for the first, second or subsequent services departing from the same platform. For these stations, platform occupancy should be recorded to include in capacity calculations for platform width and canopy sizing. This data can be collected by video analysis with a count at set intervals or before and after every train departure. Alternatively, passenger tracking can be used if deemed appropriate.

Data inputs for assessments

→ **Station usage**
This data should be collected for 1-minute intervals during the peak periods and should include all station users. So that any counts, surveys and subsequent analysis considers all station users, the counts should be classified into the PRM categories described below:

- → Non-PRMs, including passengers who are carrying regular sized backpacks, handbags, laptop bags or similar
- → Passengers with medium or large luggage such as a suitcase, large sports bag or foldable cycle
- → Passengers with full sized pedal cycles
- → Passengers with young children or infants in pushchairs
- → Wheelchair users

Any deviation from the standard classified counts should be discussed with a member of the NR SCT.

→ **Train operations**
The actual train arrival, departure and dwell times should be recorded. In case of stations where passengers wait in a concourse area away from the platforms, the boarding announcement time should also be observed. It is preferable this data is recorded on site. Where this is not the case, free-to-use websites are available that provide scheduled and actual train times (for a limited period after the date of survey).

→ **Train rolling stock**
At some stations, train services using different rolling stock may call at the same platform and this may vary by time of day (i.e. peak and off-peak services using different rolling stock). Train stopping locations should be observed for different services and type of rolling stock. Note that the number of doors per carriage, width of each door, number of seats and standing capacity may vary depending on the type of rolling stock.

→ **Train usage**
Some platforms may be served by multiple train services with different loadings. Furthermore, there may be a bias towards the use of certain train carriages (e.g. car 5 could be more attractive due to the position of stairs at the station).

This may vary by train service and time of day. Boarding and alighting data can be collected using manual survey or advanced methods such as video analytics or use of mobile phone date (if feasible or affordable) - and is especially informative when undertaking platform related analysis or sizing.

Data protection guidance

Where personal data is collected, the following key principles should be considered:

- **Organisational roles and responsibilities**
  The GDPR prescribes roles such as controller and processor of the data, and it is important to understand who holds which of these responsibilities. As an example, in undertaking a capacity assessment, a specialist is likely to retain the controller role, with a survey provider (who collects and/or counts footage) acting as a processor. Controllers have obligations to check consent from those whose personal data is collected and that their processors follow their requirements. Processors have an obligation to follow the requirements set out by the controller, as far as is reasonably possible.

- **Lawfulness, fairness and transparency**
  Why is the data being collected, is it appropriate to the needs of the project? Is it an activity that the public would expect the project to be undertaking? How can they be made aware of what is being collected and obtain unambiguous consent or is there another legitimate basis that is intended for use in lieu of consent?

- **Purpose limitation**
  How can it be ensured that the data collected is only used for the intended project goals? What safeguards or requirements could be in place so that ‘scope creep’ or uses outside of those intended for the legitimate basis do not occur.

- **Data minimisation**
  How can the amount of data collected be minimised, and personal data in particular be reduced? Do other datasets exist which are anonymised?

- **Accuracy**
  How can you be sure that the data remains accurate? Data which is not accurate should be disposed of or corrected. For example, is entrance data accurate if the station is rebuilt?

- **Storage limitation**
  Who in the organisation should hold a copy of the data? How should you decide when the data is no longer accurate and should be disposed of? A retention schedule is necessary to address this. What other organisations (outlined in the consent) should hold copies of the data, and for how long? Plan how you intend to circulate the data before collecting it.

- **Integrity and confidentiality (security)**
  What safeguards should be applied in the storage of data and how should the risk of unauthorised access, loss or damage be mitigated? Consider how access to the data can be controlled to certain individuals in an organisation only and how the need for transfers of data should be removed or securely managed.

- **Accountability**
  Data may need to be shared as part of a legal obligation, such as when a subject included in the collection activity raises a “Subject Access Request” (SAR). In this case, controllers should have a plan to enable them to share this data with the subject, as is required in current legislation. This generally requires an accountable person and process to facilitate.

A Data Protection Impact Assessment (DPIA) can help identify some of these challenges and suggest the level of response necessary. The Information Commissioners Office (ICO) can assist with supporting information and often provides templates for such documents.

An organisation may wish to consider logical trade-offs, such as reducing or removing the personal data collected during a study, to reduce the regulatory requirements. The following practical approaches could be considered:

→ Using lower-definition video recording which does not allow the identification of individuals

→ Automatic facial recognition and anonymisation software (face blurring and similar)

→ Irreversible data pseudonymisation and/or 'salting' for security

→ Using changeable identifiers for digital tracking and collection (advertising IDs, instead of MAC addresses, for example)

→ Collecting less data or using existing non-personal data

B

Station Capacity Planning

Appendix B – Assessments

Documentation and deliverables

It is important that all assumptions, demand data, analysis, outputs and recommendations are reported in a clear and succinct manner.

The following should be included in any station capacity assessment, where relevant:

- Baseline section including site visit notes and survey observations
- Model validation, in the case of microsimulation analysis
- Capacity assessment
- Audit summary

Baseline

All observations and information gathered from the initial site visit and survey should be summarised. The findings of this study may have an impact on the type and scope of the assessment. It is recommended that for major station redevelopment schemes, a standalone baseline study is undertaken.

Model validation

Validation is a process of confirming that a microsimulation model accurately reflects reality and involves comparing simulated outputs from the current situation or Base Year with real life observations and other survey data. Model validation is a default necessity when undertaking microsimulation analyses for Network Rail.

A base year model should always be validated when the microsimulation is being undertaken for an existing station. The microsimulation model is considered validated if the variations between simulated outputs and on-site observations (or survey) are less than 10%. If necessary, the base model should be revised to achieve the best validation that is practically possible.

It is noted that different simulation methodologies lend themselves to different methods of validation and hence not all of the below may be appropriate. The specialist should, therefore, choose appropriate methods to demonstrate that the model is representative. A validation study should cover some or all of the following:

1. **Visual validation**
   This is the initial step where the animated videos from a microsimulation model are compared with real life video footage or photographs. The animation of simulated passenger movements is run to check for any obvious inconsistencies in routing, behaviour and passenger volumes.

   Passenger densities observed in real life could be compared against the simulated congestion levels e.g. cumulative mean density and corresponding Fruin LoS.

2. **Origin-Destination and cordon count checks**
   The surveyed counts and input demand matrices may be compared against the output origin-destination matrix and cordon counts at specific locations. This is to confirm that the passenger volumes and route choice have been accurately simulated in the model.

3. **Journey time comparison**
   The simulated journey times on key routes could be compared against the observed journey times in free-flow and crowded conditions. This is to provide confidence in the simulated passenger behaviour in the model. As the software is by definition a model, journey times may not be exact, however they should be justifiably valid. Some sensible uses for a journey time comparison include identifying excessive concourse dwells, checking passengers board the next (appropriate) train and validating free-flow conditions are replicable across simulation runs.

Capacity assessment findings
This is the main deliverable for a station capacity assessment. This should clearly explain the key assumptions, level of confidence and source for all inputs, passenger demand used, station layout and operations being assessed.
A good station capacity assessment write-up should include the relevant analysis outputs (see Appendix B – Presentation of outputs) and recommendations for the design and/or operations team to pursue.

Station designs should be categorised based on Section 5 in relation to the different passenger demand and train timetable scenarios considered in the analysis.

Any areas of non-compliances with industry standards and planning criteria stipulated here should be clearly highlighted, with suitable design solutions implemented or recommended.

Other operational mitigation measures should only be recommended where there is no feasible design solution. In such cases longevity of operational controls and residual risks should be clearly stated.

Quality assurance process
A Quality Assurance (QA) statement should accompany all station capacity assessments and be covered in the supporting audit documentation. The adopted analytical assurance framework used by analysts in Network Rail and its suppliers should adhere to the principles set out in the DfT's "Strength in Numbers" document . The principles set out here suggest an appropriate and proportionate audit process is applied. A senior accountable person within the analysis team (internal or external) should identify the level of risk rating applied to the analysis project and undertake appropriate assurance process.

The level of checking necessary, and authorisation at each stage, should vary depending on the scale and size of the project, categorising the project into low, medium, or high risk. A process for identification should involve an assessment that includes, but is not limited to:

- → Reputational and legal consequences of an error or inappropriate use of modelling or analysis
- → Role of modelling in reporting and on final decision
- → Number of times the model is to be used
- → Safety consequence of an error or inappropriate use of the modelling
- → Size of the financial decision to which the model relates
- → ORR annual passengers

By adding a weighting to each category, a low, medium or high rating can be assigned to the project. This determines what the appropriate level of checking is necessary. This is illustrated in Figure B.1.

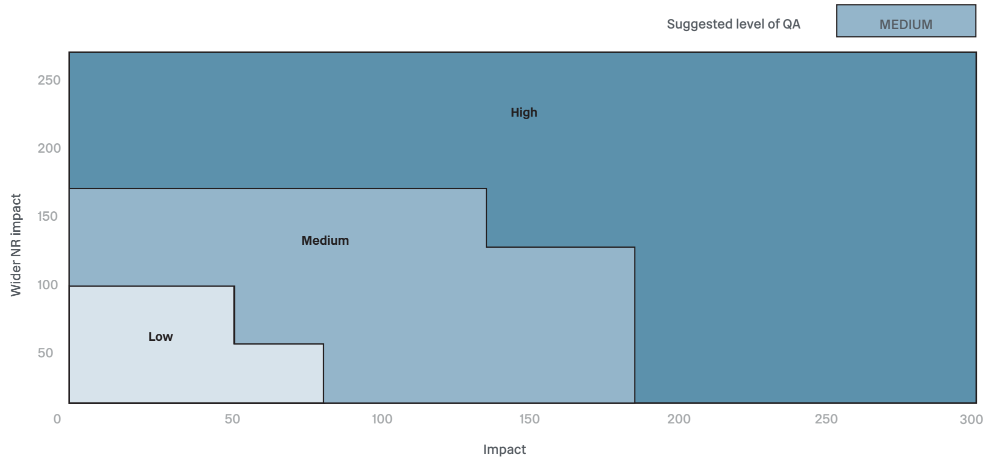


Figure B.1 – Appropriate level of QA

Model audit
A model can be anything from a static spreadsheet through to a dynamic microsimulation. A structured audit checklist should be used to confirm the chosen method for capacity analysis follows due process and is replicable. For each project this should be signed off by a member of the team with relevant seniority and overseen by the senior accountable person.

A model audit should at the minimum cover the:

- → Suitability of demand data and other operational assumptions
- → Accuracy of passenger and train data, and other modelling assumptions
- → Compliance with general industry best practice methods for model development
- → Relevance of scenarios assessed

Presentation of outputs

The analysis requirements should be defined clearly in the remit. The following outputs are generally useful depending upon the type of analysis undertaken.

Static analysis outputs

The outputs that can be derived from a spreadsheet based static analysis include:

→ **Gatelines**
Number of gates in a gateline, configuration of gates for various scenarios (entry / exit), time to process peak demand and minimum run-off.

→ **Concourse**
Sizing of concourse space and CIS accumulation areas, density at peak times.

→ **Stairs and passageways**
Clear width recommended for peak passenger demand, density and flow rate at peak times, journey time along stair or passageway for free-flow and crowded conditions.

→ **Queue modelling**
Length of the queue and period of time for which queue remains when the demand on station elements exceeds its capacity.

→ **Escalators**
Number of escalators, minimum run-on and run-offs, operational configuration for various scenarios (up / down) based on passenger demand, peak flow rate.

→ **Platforms**
Width of platforms and platform extensions, density at peak times, location of platform furniture, canopy length, and platform clearance time after peak train arrival.

Microsimulation analysis outputs

Typically, the following outputs can be derived from a microsimulation model of passenger movement. Outputs that are most relevant to a project or study should be presented in a capacity assessment report.

→ **Gatelines**
Peak 5 minute maps showing mean density based on Fruin queuing LoS scale. Flow rates during peak periods to show the maximum and average throughput that is simulated in the models. In most cases, the throughput of individual gates should be capped at 25ppm per gate (see Section 3.2.1 for different types of gates used on the network). This can be used to validate the model against surveyed and observed flow rates and throughputs. Simulated gateline clearance times can be presented as a histogram or similar output which demonstrates both the clearance time, and the severity of any breaches of the target.

→ **Concourse**
Peak 15 minute maps showing mean density based on Fruin walkways LoS scale. A smaller time interval may be used at some stations to assess performance in greater detail. It may be appropriate to include cumulative high density maps to demonstrate the duration of any breaches of NR targets, to identify momentary modelling incidents from significant concerns.
Space utilisation maps can highlight the heavily used areas and paths, and under-utilised areas.

Presentation of outputs

→ **Journey times**
Average and maximum journey times between all different locations during the peak periods are useful for business cases. Comparing journey times to times under free flow can be useful for establishing potential benefits. Journey times can be presented as histograms between each origin and destination pair. It is recommended these are included where multiple simulation runs are undertaken, to confirm replicability and model stability.

→ **Stairs and passageways**
Peak 5 minute maps showing mean density based on Fruin stairway and walkway LoS, as applicable on the stairs and along passageways. Peak 5 minute mean density maps showing Fruin queuing LoS at the top and bottom of stairs. Maximum and average flow rate simulated on stairs and along passageways. Average and maximum journey times on stairs and along passageways during the peak periods. Comparing journey times to times under free flow can be useful for establishing potential benefits. Journey times may be presented as histograms.

→ **Lifts**
Peak 5 minute mean density maps showing Fruin queuing LoS in the waiting area in front of the lift doors. Maximum and average number of passenger queuing for the lifts in a simulation. Maximum and average transfer time between different levels including waiting time.

→ **Escalators**
Maximum and average flow rate simulated on escalators.

→ **Platforms**
Peak 5 minute mean density maps showing Fruin walkway LoS over platforms and peak 15 minute mean density maps showing queuing LoS. Cumulative high density maps, with a threshold of the appropriate LoS target for the conditions, should be included where the layout produces densities close to or exceeding the NR target in mean density map outputs. This allows identification of consistently uncomfortable areas and/or lack of contingency capacity in the layout. Maximum and average waiting times for passenger on platforms in a simulation. Time spent at each LoS density band. These may be as a histogram for each train service. Maximum and average platform clearance time for alighting passengers in the simulation. This should be measured from the train doors to the platform exit.

→ **Emergency egress analysis**
Evacuation maps showing the length of time taken by the last person to clear different areas of a station. These should consider the appropriate “place of relative safety” as determined by a fire engineer and demonstrate egress to both this point, and, where logical, an appropriate location outside of the station building.

Example outputs

The presentation of outputs varies on a case by case basis, dependent upon the results or conclusions the analyst is wishing to demonstrate. Network Rail's Station Capacity Team encourages and welcomes innovative methods of data presentation. Below are examples of some of the most frequently used data presentation techniques.

Journey times can be recorded from a microsimulation model and presented either in tabular form or in histogram form as shown in the examples below (Figure B.2 and Table B.1). This format can be adopted for presenting gateline or platform clearance times, journey times on different routes, and evacuation times through different exits.

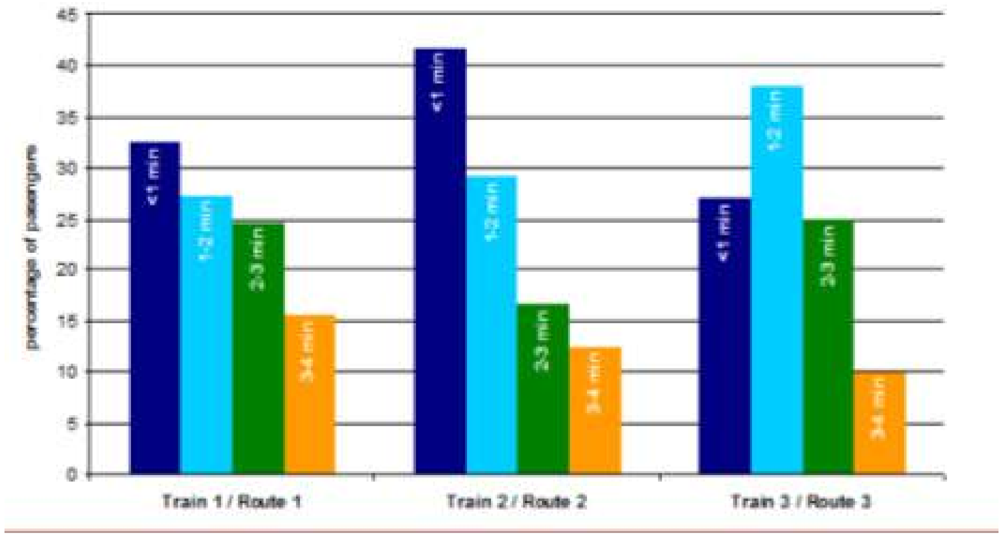


Figure B.2 – Example of a histogram showing platform egress time by train service group

In some cases, it may be useful to present journey times separately for different types of station users i.e. non-PRMs and PRMs. Furthermore, journey times for select routes across the station can be particularly useful to home in on the benefit of a small-scale station infrastructure enhancement, removing the noise of other A more simplified and holistic way of presenting and utilising journey time outputs is to calculate and compare the average journey time of passengers making a particular journey through the station. For example, Table B.1.

Cumulative journey times on a route by route basis, as well as the total number of passengers making a journey across a specific route, can be extracted directly from a dynamic pedestrian model.

Table B.1 – Example of tabular journey time analysis

Route	Cumulative Journey Time (sec)	Number of Passengers on Route	Average Journey Time per Passenger (sec)
Main entrance to Platform 1	A	D	A/D
Side entrance to Platform 1	B	E	B/E
Platform 2 to Platform 1	C	F	C/E

Table B.1 – Example of tabular journey time analysis

Simulated flow rates through stairs, escalators and passageways in different areas of a station can be recorded from a microsimulation model and compared against the planning criteria promoted by this guidance. Simulated flow rates can also be extracted and compared against surveyed flow rates in order to validate the dynamic pedestrian model.

Flow rates can be visually displayed on LoS banded line charts, this allows for quick inference of the three key factors; LoS band, time frame for which a station element is at a particular level of service, and flow rate. Figure B.3 gives an example of a LoS banded line chart.

Figure B.3 – Level of Service banded line chart

However, LoS banded line charts are limited to a single piece of infrastructure, which has been simplified to a single key characterising measurement.

Therefore, graphical outputs such as Cumulative Mean Density (CMD) or Cumulative High Density (CHD) metrics should be also included. Such features can be exported from microsimulation models.

The best practise guidance for density metrics and space utilisation modelling outputs is as follows:

- → Remove all on-train areas from any density plots
- → Include a timestamp on all plots
- → Use a consistent camera viewpoint when comparing scenarios
- → Cumulative High and Cumulative Mean Density maps should be plotted on a white background
- → No entities or model objects should be visible on the density plots
- → Include the appropriate LoS scale alongside all density plots
- → Maps produced are of sufficient image quality, we recommend a PNG file with a resolution of 1920 x 1080

Figure B.4 provides examples of cumulative mean density plots adhering to the best practise principles outlined above.

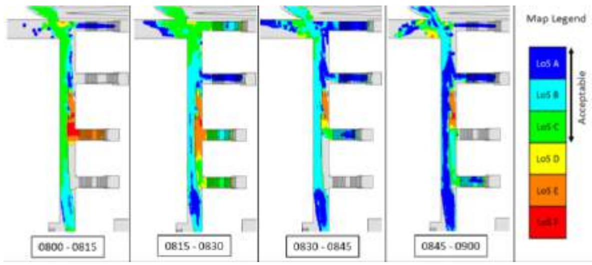


Figure B.4 – Example of 15-minute CMD maps in relation to Fruin's Level of Service Walkways

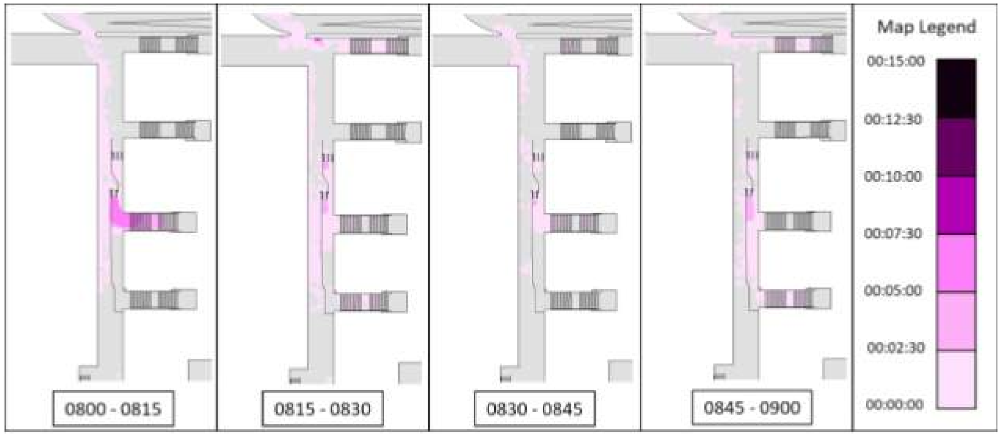


Figure B.5 – Example of 15-minute CHD map with a threshold of 1.08 pax. per m^2

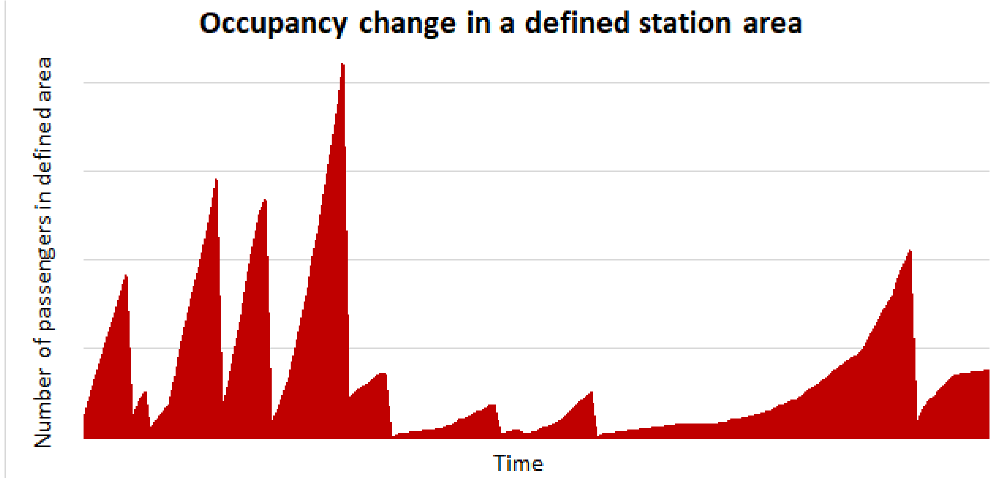


Figure B.6 – Example of an area chart

Cumulative High Density maps display how long an area remains above a specified level of service threshold. If an area cannot meet guidance levels they are a good way of quantifying the impact on passengers.

Time above specific level of service thresholds should be set in accordance with Figure B.5, illustrating how long an area operates above an acceptable level of congestion.

Care should be taken so that the colour scheme for the CMD and CHD maps do not clash, Network Rail's Station Capacity Team strongly recommends the default CHD setting used in Bentley LEGION, also endorsed by TfL.

CHD maps should be read alongside CMD maps, confirming both outputs are created for the same period and length of time.

Area charts can be a useful way of visualising clearance times or platform/ concourse occupancy. A plot of occupancy versus time, combined with key infrastructure measurements, can be a useful way of approximating Level of Service metrics in the absence of detailed dynamic pedestrian modelling. An example for platform occupancy is provided in Figure B.6.

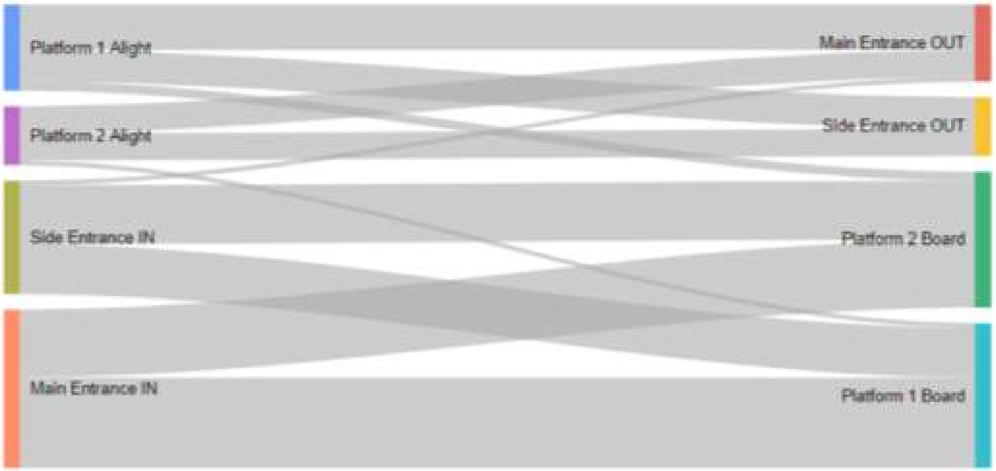


Figure B.7 – Example of an Origin-Destination matrix presented as a Sankey Diagram

Origin and Destination matrices can be succinctly presented as a Sankey Diagram, a diagram on which the direction and width of the arrows is correspondent and proportionate of the flow rate. An example is given in Figure B.7.

Sankey diagrams neatly visualise the relative scale of flow from demand origins on the left-hand side to final destinations on the right. They provide an overarching view of interchange demand, that is much easier to interpret than the standard tabular method of presentation.

Interpretation of microsimulation analysis outputs

The tables provided in this section give an overview of the typical outputs that could be extracted from a microsimulation model, together with an interpretation based upon the relevant planning criteria from this document.

It should be noted that different planning criteria apply to normal and abnormal conditions.

Outputs from a modelling assessment do not have to be limited to those as described.

Gatelines that are separated from platforms	
Station element	**Modelling**
Exit Gates	– The gateline should not cause any queuing, instead it should match the capacity of the intermediate constraint. – The outputs from dynamic modelling simulation analysis should be presented in the form of a histogram showing clearance times and percentage of alighting passengers from individual or concurrent train arrivals. – Peak 5 minute average density maps showing the queuing LoS should demonstrate that the accumulation of passengers on the paid side remain within acceptable density levels i.e. not exceeding LoS D (queuing), and does not impede circulation of other passengers.
Entry Gates	– Gatelines should allow the peak 5 minute entry demand to pass through the gates in 5 minutes with no prolonged build-up of congestion. –Peak 5 minute average density maps showing queuing LoS should demonstrate that the simulated accumulation of passengers on the unpaid side remains within acceptable density levels i.e. not exceeding LoS D (queuing). This density level is generally acceptable as long as other circulation routes through the station are not affected.

Gatelines that are adjacent to platforms	
Station element	**Modelling**
Exit Gates	– For the peak train arrivals, the time between the first person passing through the gateline and the last, should not exceed the targets set out in Table 3.4. This clearance time threshold is station specific based on the risks posed by queuing, and the space available. The paid side accumulation of passengers near the gateline should not impede other circulating movements. – The outputs from dynamic simulation analysis should be presented in the form of a histogram showing clearance times and percentage of alighting passengers from individual or concurrent train arrivals. – Peak 5 minute average density maps showing queuing LoS should demonstrate that the simulated passenger accumulation on the paid side remains within acceptable density levels i.e. not exceeding LoS D (queuing).
Entry Gates	– Gatelines should allow the peak 5 minute entry demand to pass through the gates in 5 minutes with no prolonged build-up of congestion. – Peak 5 min average density maps showing queuing LoS to demonstrate that the simulated queues on the un-paid side remain within acceptable density levels i.e. not exceeding LoS D (queuing). – Queuing at this density is generally acceptable as long as other circulation routes through the station are not affected.

Passageway	
Station element	**Modelling**
One-way	– Simulated average flow rate during the peak 5 minutes should not exceed the planning criteria of 50ppmm. It may be acceptable for flow rates to exceed the planning threshold for a short duration of time if other circulating movements are not impeded and passenger safety is not compromised. – Flow-rate analysis similar to the example in Figure B.3 should show that high flow rates occur for no more than 2 minutes of the 5 minute peak (during peak periods). – Peak 5 minute average density maps should show density levels not exceeding LoS D (walkways).
Two-way	– Simulated average flow-rate during the peak 5 minutes should not exceed the planning criteria of 40ppmm. It may be acceptable for flow-rates to exceed the planning threshold for a short duration of time if other circulating movements are not impeded and passenger safety is not compromised. – Flow-rate analysis similar to the example in Figure B.3 should show that high flow-rates occur for no more than 2 minutes of the 5 minute peak (during peak periods). – Peak 5 minute average density maps should show density levels not exceeding LoS C (walkways).

Stairway	
Station element	**Modelling**
One-way	– Simulated average flow-rate during the peak 5 minutes should not exceed the planning criteria of 35ppmm. It may be acceptable for flow-rates to exceed the planning threshold for a short duration of time if other circulating movements are not impeded and passenger safety is not compromised. – Flow-rate analysis similar to the example in Figure B.3 should show that high flow-rates occur for no more than 2 minutes of the 5 minute peak (during peak periods). – Peak 5 minute average density maps should show density levels not exceeding LoS D (stairways).
Two-way	– Simulated average flow-rate during the peak 5 minutes should not exceed the planning criteria of 28ppmm. It may be acceptable for flow-rates to exceed the planning threshold for a short duration of time if passenger safety on stairs is not compromised and there is no perceptible queuing at the top or bottom of the stairs. – Flow-rate analysis similar to the example in Figure B.3 should show that high flow-rates occur for no more than 2 minutes of the 5 minute peak (during peak periods). – Peak 5 minute average density maps should show density levels not exceeding LoS C (stairways).

Escalators	
Station element	**Modelling**
Any direction	– Simulated average flow-rate during the peak 5 minutes should not exceed the planning criteria of 100ppmm. At some stations a lower planning criteria may be more appropriate as discussed in Section 3.7.3. It may be acceptable for flow-rates to exceed the relevant planning threshold for a short duration of time if passenger safety on escalators is not compromised and there is no perceptible queuing at the top or bottom of an escalator. – Flow-rate analysis similar to the example in Figure B.3 should show that high-flow rates occur for no more than 2 minutes of the 5 minute peak (during peak periods).

Concourse	
Station element	**Modelling**
Circulation areas	– Peak 15 minute average density maps should show density levels not exceeding LoS C (walkway) i.e. 1.8sqm per person. – Space utilisation maps may help optimise concourse layouts by highlighting busier routes and areas that are under-utilised.
Dwelling areas near CIS	– Peak 15 minute average density maps should show that density levels do not exceed LoS B (queuing) i.e. 1.0sqm per person. Apart from localised hot-spots with higher density, the average density should not exceed this threshold.

Ramps, Stairways, Escalators and Travelators	
Station element	**Modelling**
On approach	There should be no perceptible queuing on approach to ramps, escalators, travelators and stairs. Peak 5 minute average density maps at either ends of such circulation elements should show that density levels do not exceed LoS C (queuing) in these areas.

Platforms	
Station element	**Modelling**
Waiting areas	– It is acknowledged that there should be localised areas of higher densities in certain areas of platforms (particularly around train carriage doors). The average 5 minute density within waiting areas in front of all carriages for the peak period should not exceed LoS B/C (queuing) i.e. 0.93 sqm per person. – Waiting areas and areas of localised queuing (e.g. in front of popular carriages) should not exceed LoS C (queuing) for more than 5 minute during the peak 15 minute period. – Platform clearance time e.g. time taken for all alighters to have egressed the platform following the train arrival. The threshold for this varies on a case by case basis.
Circulation areas	– The average 5 minute density in circulation areas on platforms should not exceed LoS C (walkways) during peak times. – Localised queuing should not impede movement of passengers along the platform. This should be based on the review of average densities (for circulation and waiting areas) and video animations for the peak periods.

Interpretation of microsimulation analysis outputs

Free flow

Reasonably free flow
Speeds maintained

Circulation Areas
Stable flow – Design target
Contra flows slightly restricted

Dwelling Areas
Stable in one-way flow
Difficulty in cross or contraflow

Need Controls
One-way flow seen in busy areas
Serious difficulty in cross
or contraflow

Above thresholds
Shuffling, one-way flow

The images in this appendix are given to provide a visual representation of Fruin's Levels of Service which can help when displaying outputs to an inexperienced audience.

Example calculations

Four example calculations are included below for a variety of station elements. These calculations are indicative of the station capacity assessment process. They do not represent a definitive methodology and should, therefore, not be followed indiscriminately without consideration for assumptions, station user behaviours, and station user characteristics.

Calculating the recommended number of ticket gates
Section 3.2.1 should be referred to when calculating the recommended number of ticket gates.

Example: Gateline on platform
The busiest 5 minute period has been identified for a gated terminating platform from a survey. It contains a single service with 50 boarders and 250 alighters. Passengers at the station wait on the platform for the train to arrive.

$$\text{No. gates} = \text{round up}\left\{\frac{\text{Peak 5 min entry demand}}{f \times 5}\right\} + \text{round up}\left\{\frac{\text{Peak 5 min exit demand}}{f \times 5}\right\} + x$$

$$= \text{round up}\left\{\frac{50}{25 \times 5}\right\} + \text{round up}\left\{\frac{250 \times 1.25}{25 \times 4}\right\} + x$$

- → The value for n should be taken as 4, given that the gateline is not separated by a flow constraint, and the platform serves terminating trains.
- → A 25% uplift is applied to the peak 5 minute exit demand only, as per Section 3.1. No uplift is assumed for the boarding passengers as they wait on platform and as such are not affected by service perturbation.
- → The recommended combined number of gates is less than 10. Therefore, we should state X = 1.
- → We should consider the recommended number of WAGs. For a gateline with fewer than 12 gates, we should include 2 WAGs.
- → We should also consider whether the gateline we have designed is below the minimum recommendations.
- → We now have a fully designed gateline, comprising of 6 ATGs and 2 WAGs.

Example calculations

Example: Gateline separated from platform

The busiest 5 minute period has been identified for a gated terminating platform from a survey. It contains an ingress demand of 350 passengers, and a 180 passenger station egress demand originating from a bank of escalators in a peak single minute. Passengers at the station wait on the concourse until the train is announced.

$$\text{No. gates} = \text{round up}\left\{\frac{\text{Peak 5 min entry demand}}{f \times 5}\right\} + \text{round up}\left\{\frac{\text{Peak 5 min exit demand}}{f \times n}\right\} + x$$

$$= \text{round up}\left\{\frac{350 \times 1.25}{25 \times 5}\right\} + \text{round up}\left\{\frac{180 \times 1.25}{25 \times 1}\right\} + x$$

→ The value for n should be taken as 1, given that the gateline is separated by an intermediate flow constraint.

→ A 25% uplift is applied to the peak 5 minute entry and exit demand as per Section 3.1.

→ The recommended combined number of ingress and egress gates is greater than 10. Therefore, we should state X = 2.

→ Now we should consider the recommended number of WAGs. For a gateline with more than 12 gates, we should include 3 WAGs.

→ We should also consider whether the gateline we have designed is below the minimum recommendations.

→ We now have a fully designed gateline, comprising of 15 ATGs and 3 WAGs.

Calculating the recommended platform width
Section 3.3.2 should be referred to when calculating the recommended platform width.

Example: Passengers wait on the concourse

The train service with the highest combined boarding and alighting load calling on the platform has been identified from a survey, and was found to be a 10-car service with a boarding load of 35 passengers and an alighting load of 210 passengers. The platform access is central on the platform.

$$\text{Platform width} = \left\{ \frac{\text{peak minute demand}}{40} \right\} + 0.3 + \text{Yellow line distance}$$

$$\text{Platform width} = \left\{ \frac{(35 \times 0.2) + (210 \times 0.55)}{40} \right\} + 0.3 + 0.5$$

- → An approximation for the peak minute alighting demand has been obtained by applying the appropriate value in Table 3-1 for a 10-car train, with access on the platform to the alighting load This has been combined with 20% of the boarding load to obtain the peak minute demand.
- → In the absence of a yellow line requirement, a minimum value of 0.5m has been applied
- → A platform width of 3.9m is recommended.

Example: Passengers wait on platforms

This example considers a through platform which provides access to a bay platform. During the peak 5 minutes, a 10-car service calls on the through platform with 350 boarders and 40 alighters. Concurrently, a 4-car service terminates on the other platform, with 150 boarders and 30 alighters. The rolling stock calling at this station has carriages of 22m in length.

Zone A: the yellow line width should be determined from Table 3.5.

Zone B:

$$\text{Zone B} = \left\{ \frac{\text{Block Load} \times 0.93}{\text{Block Length}} \right\} \left\{ \frac{(350 \times 0.35 \times 1.25 \times 0.5) \times 0.93}{22} \right\} = 3.3\text{m}$$

In the absence boarding and alighting counts, TfL's approximation has been used, which states 35% of the demand can be found within the busiest 25% of the train. A 25% uplift has been applied to accommodate any potential perturbation.

Zone C:

$$\text{Zone C} = \left\{ \frac{\text{Peak 5 minute demand}}{5 \times 40} \right\} = \left\{ \frac{150 + 30}{5 \times 40} \right\} = 1.5\text{m}$$

Zone C accounts for the circulation of passengers along the through platform to the terminating platform. An approximation for the peak minute flow has been obtained by applying the values in Table 3-1 to the alighting load, and combining this with 20% of the boarding load.

Zone D: 0.3m
The total recommended platform width is the sum of Zones A through D;
(0.5 + 3.3 + 1.5 + 0.3) = 5.6

C

Station Capacity Planning

Appendix C – Reference

Glossary

ATGs	Automatic Ticket Gates (standard width)
ATM	Automated Teller Machine (cash machine)
BEAP	Built Environment Accessibility Panel
CAD	Computer Aided Design Software
CHD	Cumulative High Density
CIS	Customer Information Screens
CMD	Cumulative Mean Density
DfT	Department for Transport (HM Government department)
DIA	Diversity Impact Assessment
DPIA	Data Protection Impact Assessment
GDPR	General Data Protection Regulation
GLAP	Gateline Assistance Point
ICO	Information Commissioners Office
ID	Identifier(s)
LoS	(Fruin's) Level of Service
LU	London Underground
MAC	Media Access Control Address (unique identifier for network connected devices)
mph	Miles per hour
m/s	Metres per second
NR	Network Rail
NRAC	National Register of Access Consultants
ppmm	Persons per minute per metre width
PNG	Portable Network Graphics (digital image file format)
PRM	Person(s) of Reduced Mobility
QA	Quality Assurance (process)
RIS	Rail Industry Standard
SAR	Subject Access Request (for personal data)
SCT	Station Capacity Team
SFO	Station Facility Owner
TfL	Transport for London
TOC	Train Operating Company
TSI	Technical Specification for Interoperability
WAG	Wide Aisle Gates (automatic ticket gates)
WiFi	Wireless Network Connectivity

Reference Documents

A wide range of Network Rail and industry-wide documents and guidance notes were used in compiling this Guide.

Below is a list of the most relevant standards and guidance documents referenced within this Guide. These documents are drawn from a range of sources and have been used in the development of this Guide. The list is not intended to be exhaustive but provide the user of this Guide with a sound basis upon which to develop any station scheme.

Relevant Network Rail Standards and Guidance documents:

- Station Design Guidance, Network Rail
- Guide to Diversity Impact Assessments, Network Rail
- National register of Access Consultants (NRAC)www.nrac.org.uk
- NR/L3/CIV/162 Issue 2, Platform Extensions, Network Rail
- NR/GN/CIV/300/04 Inclusive Design Guidance, Network Rail
- NR/L2/CIV/193, Standard Specification for New and Upgraded Lifts, Network Rail
- NR/L2/CIV/196, Standard Specification for New and Upgraded Escalators, Network Rail
- NR/CIV/SD/TUM/4000 Technical User Manual for Railway Footbridges in Stations, Network Rail
- BS 9999, Fire safety in the Design, Management and Use of Buildings — Code of Practice, Brtish Standards Institution
- 1BS 9992, Fire Safety in the Design, Management and Use of Rail Infrastructure — Code of Practice, Brtish Standards Institution
- BS 8300 Design of Buildings and their Approaches to Meet the Needs of Disabled People, Brtish Standards Institution
- NR/L1/FIR/100 Issue 6, Fire Safety Handbook Network Rail
- Equalities Act, Government Equalities Office
- Strength in numbers: the DfT analytical assurance framework, Department for Transport
- RIS-7700-INS Issue 2 Voluntary Rail Industry Standard for Station Infrastructure, Railway Safety and Standards Board
- RIS-7701-INS , Voluntary Rail Industry Standard for Automatic Ticket Gates at Stations, Railway Safety and Standards Board Limited
- GI/RT7016 Issue 1.1, Interface between Station Platforms, Track and Trains, Mandatory Requirements, Railway Safety and Standards Board
- Goal-setting Principles for Railway Health and Safety, Office of Rail and Road
- Design Standards for Accessible Railway Stations: Code of Practice Version 04, Department for Transport and Transport Scotland
- Technical Specification for Interoperability: Accessibility for Persons with Reduced Mobility for high Speed and – Conventional Lines on the Trans-European Rail Network, PRM-TSI
- Railways for All the Accessibility Strategy for Great Britain's Railway, Department for Transport,
- Station Planning Standards and Guidelines G371A, TfL, London Underground
- Station Planning Standard S1371 Revision A7, TfL, London Underground
- Station Public Realm Guidance, TfL
- Premises – Stairways and Ramps Standard S1133, London Underground
- Architectural Design Criteria for Road and Rail Transit Systems, Land Transport Authority, Singapore
- Better Rail Stations, Department for Transport
- Planning and design for safer escalator use at stations, Network Rail
- Inclusive design guidance for ticket-sales, Network Rail
- Our Principles of Good Design, Network Rail
- Tomorrows Living Station, Network Rail
- Signage and Wayfinding, RSSB
- Inclusive Design Requirements Note 17 Station Seating and Rest Points, Network Rail

Acknowledgements

Photo credits

Network Rail

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- Page 7 – London Paddington, Station Concourse
- Page 11 – Birmingham New Street Station, Station Concourse
- Page 15 – London Waterloo Station, Customer assistant
- Page 19 – Leeds Station, Station entrance
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- Page 26 – Norwood Junction, Subway
- Page 29 – London Paddington, Ticket gates
- Page 34 – Birmingham New Street Station, Ticket gates
- Page 36 – London Bridge, Shard concourse
- Page 38 – Market Harborough Station, Platform
- Page 44 – Reading Station, Platform seating
- Page 45 – Glasgow Central Station, Concourse
- Page 47 – Barnham Station, Platformy canopy
- Page 51 – London Liverpool Street Station, New seating
- Page 53 – London King's Cross Station, Station entrance
- Page 59 – Derby Station, Canopies and stairs
- Page 61 – Birmingham New Street Station, Example of the use of barriers at escalators to protect run-off areas
- Page 67 – London Bridge, Concourse
- Page 68 – Station Support Staff, Network Rail managed stations
- Page 72/73 – Meridian Water Station, Construction work
- Page 74/75 – Leeds Station, Station support staff

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