



Gatwick Airport Northern Runway Project

Transport Assessment Annex D – Station and Shuttle Legion Modelling Report

Book 7

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Executive summary

Improvements to Gatwick Station are the subject of a separate consenting process, with a planning application submitted by Network Rail to Crawley Borough Council in April 2018. Consent has been granted and these improvements are currently under construction and will be complete by the time the Project is operational. Construction works are currently scheduled to finish in 2023.

Analysis and modelling with the Project to 2047 shows that no major improvements will be required to the railway station concourse or platforms beyond these works.

Assessment criteria

The analysis has been undertaken against Network Rail's Station Capacity Planning Design Manual (December 2021). The assessment of crowding is based on Fruin Level of Service criteria.

Level of Service (LoS) is used to describe pedestrian movement, relating density of pedestrians and flow rates for walkways and circulation areas, stairs and in waiting environments (eg platforms) or queues.

Criteria used in the assessment have been taken from the Network Rail guidance and include:

- concourse circulation areas – LoS C Walkways or better;
- concourse waiting areas – LoS B Queuing or better;
- gateline queues – LoS D Queuing or better; and
- platforms – LoS B/C Queuing or better.

Station performance, AM peak

In the AM peak, modelling shows station performance at concourse level being predominantly LoS C or better for Walkways (85% to 93% of passenger time at LoS C or better depending on scenario) and LoS A for Queuing (86% to 95% of passengers at LoS A depending on scenario), meaning acceptable conditions. One location where congestion does occur is the gateline in the North Bridge of the Station Entry concourse and this is the main cause of passenger time spent at LoS D Queuing by 2047 with the Project (up to 4% of passenger time in the AM peak as compared to 2% in 2047 in the future baseline). This level of queuing at LoS D is acceptable as it is only for short periods, with flows being one-way and other circulation routes being unaffected.

The modelling shows station performance at platform level being predominantly LoS B or better in terms of Fruin Queuing (93% to 98% of passengers depending on scenario), also meaning acceptable conditions.

Small areas of localised congestion do occur, with a low proportion of passenger time spent at LoS D (2% or lower depending on scenario).

Station performance, PM peak

In the PM peak, modelling shows station performance at concourse level being predominantly LoS C or better for Walkways (81% to 91% of passengers experience LoS C or better depending on scenario) and LoS A for Queuing (84% to 92% of passengers at LoS A depending on scenario). As in the AM peak, congestion does occur at the gateline in the North Bridge of the Station Entry Concourse and this is the main cause of passenger time spent at LoS D Queuing by 2047 with the Project (up to 5% of passenger time in the PM peak as compared to 3% in 2047 in the future baseline). This level of queuing at LoS D is acceptable as it is only for short periods, with flows being one-way and other circulation routes being unaffected.

The modelling shows station performance at platform level being predominantly LoS B or better in terms of Fruin Queuing (85% to 95% of passengers depending on scenario). Small areas of localised congestion do occur, with a low proportion of passenger time spent at LoS D (6% or lower depending on scenario).

Inter-terminal shuttle

Modelling to 2047 with the Project shows that the boarding platform of the shuttle stations, particularly at the South Terminal, can become congested at peak times and that congestion blocks the platform and prevents full use of shuttle capacity. Analysis indicates that reducing the headway of the system from 6 minutes down to 5 minutes has the greatest benefit. Adding a fourth car to the system does not provide an additional 33% capacity as the boarding platform remains congested unless the shuttle headway is reduced. GAL therefore proposes to reduce the shuttle headway to achieve appropriate additional capacity in peak periods by 2047.

Stakeholder engagement

Model files and outputs have been shared with Network Rail as part of the DCO process. At a meeting held to discuss the modelling on 1 December 2022, Network Rail indicated that the modelling approach was logical and that results were expected and proportionate.

1 Introduction

1.1 General

1.1.1 This document, the Station and Shuttle - Legion Modelling Report forms Annex D of the Transport Assessment (TA) for the Development Consent Order (DCO) application prepared on behalf of Gatwick Airport Limited (GAL). The DCO application presents the findings of the Environmental Impact Assessment (EIA) process for GAL's proposal to make best use of its existing runways (referred to within this report as 'the Project'). The Project proposes alterations to the existing northern runway which would enable dual runway operations resulting in increased airport passenger and aircraft movements. Further details regarding the components of the Project can be found in Chapter 2 of the **Transport Assessment** (Doc Ref: 7.4).

1.2 Purpose of this report

1.2.1 Gatwick Airport Limited (GAL) has developed a suite of transport models to inform development of a sustainable surface access strategy for the future of the airport. The models enable different travel policies at the airport to be assessed to help reduce the impact of increased passenger demand on the surface transport network.

1.2.2 The models have been developed and refined to support GAL's northern runway proposals and enable the assessment of environmental effects in line with national guidance.

1.2.3 This Station and Shuttle Legion Modelling Report describes work undertaken to demonstrate the performance of the railway station and the inter-terminal shuttle at different assessment years, using a base model provided to GAL by Network Rail.

1.2.4 The Legion model takes rail demand from Gatwick's multi-modal strategic transport model to inform usage of the station.

1.3 Northern Runway proposals

1.3.1 Gatwick Airport is served by a single runway. The airport also has a further runway, which is located north of the main runway and is only available for use when the main runway is closed. This runway is known as the 'northern runway' or the 'standby runway'.

1.3.2 The Project proposes to make alterations to the northern runway which would enable dual runway operations in accordance with international standards.

1.3.3 It is assumed that by 2047 these improvements could increase airport capacity up to 80.2 million passengers per annum (mppa), compared to a maximum potential capacity based on existing facilities of 67.2 mppa within the same timescale. This represents an increase of approximately 13 mppa. Further details of the proposals are presented in the TA Chapter 2.

1.4 Scenarios for assessment

1.4.1 The modelling considers the following assessment years to test and analyse the operation of the Airport without and with the Project:

- 2029 being the first full year of operation of the Project;
- 2032 being an interim assessment year representing the point at which slots on the northern runway are filled; and
- 2047 being 15 years after opening of the highway works in line with guidance for the assessment of highway projects (see Section 3.2.4).

1.5 Stakeholder engagement

1.5.1 Model files and outputs have been shared with Network Rail as part of the engagement process. Further details on how the model was used for this Project can be found in Section 3. At a meeting held to discuss the modelling on 1 December 2022, Network Rail indicated that the modelling approach was logical and that results were expected and proportionate.

1.6 Structure of report

1.6.1 This report is set out as follows:

- Section 2 provides an overview of the railway station and inter-terminal shuttle;
- Section 3 describes the Legion model provided to GAL by Network Rail;
- Section 3.2.4 sets out the demand data used in the modelling;
- Section 5 describes other inputs and assumptions to the station model;
- Section 6 describes the inter-terminal shuttle modelling;
- Section 7 provides the assessment criteria used as the basis for evaluating the results;
- Section 8 provides model findings; and
- Section 9 summarises the conclusions from the modelling.

2 Railway station and inter-terminal shuttle system

2.1 Gatwick Airport railway station

2.1.1 Opened in 1958, the current station is located adjacent to South Terminal with direct access from the terminal to the station concourse.

2.1.2 In 2014, the station underwent a £53 million improvement programme, with the opening of an additional platform (Platform 7) and improved circulation for passengers.

2.1.3 However, despite this improvement, the current station is constrained with a shortfall of capacity on the concourse at peak times, including crowding at ticket barriers and information screens; queuing at ticket windows; congestion at ticket gates on the overbridge to access South Terminal; insufficient safeguarded space, also known as run-on and run-off, at the top and bottom of escalator and stair elements; narrow stairs; and inefficient use of platforms and therefore capacity issues for passengers when boarding and alighting trains.

2.1.4 Gatwick has been working with the Department for Transport, Network Rail and other stakeholders over several years to develop an appropriate design to improve passenger experience in the station, which is being delivered as part of the Gatwick Station Project.

2.1.5 In July 2019, the Department for Transport announced a £150 million investment in the Gatwick Station Project, which includes doubling the size of the station overbridge, adding five new lifts and eight escalators to improve passenger flow, and widening two platforms to reduce crowding.

2.1.6 The Gatwick Station Project is currently under construction and should be complete by 2023. It is therefore the reference design for all future assessment work and modelling of the station.

2.2 Inter-terminal shuttle

2.2.1 Located in close proximity to the railway station is the inter-terminal shuttle which takes passengers arriving by rail to or from the North Terminal. The shuttle operates as two trains of three Innovia APM 100 cars as manufactured by Bombardier. These two trains each operate on their own track, with a peak headway of 6 minutes, which means that passengers typically wait no more than 3 minutes for a train at peak times.

2.2.2 There is a shuttle station at each end of the system, with a single central boarding platform between the two tracks and two alighting platforms, on the outside of each track. This means that boarding and alighting flows can be kept separate which reduces congestion and dwell times.

2.2.3 The system was upgraded in 2010 and has an average design life of 25 years, meaning another upgrade is likely to be required prior to the end of the assessment period. Modelling reported here has assumed the current shuttle configuration and service frequency, though future improvements have been identified (see Section 8.4).

3 Legion model

3.1 Model history

3.1.1 Network Rail's Governance for Railway Investment Projects (GRIP) defines different design stages for rail projects in the UK, with GRIP3 being the option selection phase, GRIP4 being further development of that single design option and GRIP5 representing Detailed Design stage of a preferred option to be taken forward for construction.

3.1.2 For Gatwick's Northern Runway proposals, Network Rail provided GAL with the 2036 GRIP5 Legion model developed as part of the Gatwick Station Project.

3.1.3 The GRIP5 model was developed by a third party on behalf of Network Rail. It is understood that this model has been calibrated and validated to observed survey data prior to being used for future year testing. The model was used to demonstrate the performance of the station under 2036 AM and PM peak demand conditions assuming incremental growth without the Project.

3.1.4 The latest version of the model was provided to GAL by Network Rail on 18 August 2022 and has been modified to reflect the requirements of the assessment for the DCO application, namely demand adjustments to reflect the DCO assessment years as well as addition of the inter-terminal shuttle operation.

3.2 Model extents

3.2.1 The model of the station as provided by Network Rail includes the existing concourse, the new concourse and all seven platforms, as shown in Diagram 3-1.

3.2.2 The GRIP5 model provided by Network Rail has been built on the following assumptions:

- a gated station solution (ie including for ticket gates). This is different to the modelling undertaken for the Preliminary Environmental Information Report (PEIR) which was based on the GRIP3 design for the redevelopment of the station. This GRIP3 design assumed that the station would be an 'open' station (ie there would be no gatelines within the station);
- the existing concourse is primarily the Station Entry Concourse (ie, for those departing Gatwick on trains), with the main customer information screens and ticket retail accommodated in the reconfigured concourse;
- the Airport Entry concourse provides the main exit route from all platforms to the Airport, being an expansion of the existing station overbridge. This concourse also provides a new entry route to the station from the South Terminal forecourt and Passenger Terminal Interchange (PTI), which will benefit commuters who park at Gatwick Airport and use the station for journeys into London and elsewhere on the rail network. Customer information screens will also be provided on this concourse;
- the station will continue to operate broadly as per current passenger flows, with boarding passengers encouraged to wait on the platforms as far as possible (to safeguard train dwell times); and
- the passenger composition (the number of passengers with luggage and restricted mobility) passing through the station is based on Network Rail's passenger survey carried out at the station.

3.2.3 Arup has taken Network Rail's validated and calibrated Legion model and extended it to include the inter-terminal shuttle operation. Diagram 3-2 shows the South Terminal station but the model now also includes the North Terminal station which is configured in the same way, with a central boarding platform and alighting platforms on the outside. The as-built CAD files used for to add the shuttle station elements are:

- Southern Terminal Shuttle: 20702-10-A-200-M2-000001.DWG, TTS South Station Concourse Floor Plan (Level 10), Revision RD, 30/09/2013;
- Northern Terminal Shuttle Upper Level: 20701-10-A-200-M2-000001.DWG, TTS North Station First Floor Plan (Level 10), Revision RD, 30/09/2013; and
- North Terminal Shuttle Lower Level: 20701-00-A-200-M2-000001-Lower.DWG, TTS North Station Ground Floor Plan (Level 00), Revision 02, 30/09/2013.

Diagram 3-1: Legion Model of Gatwick Airport Rail Station

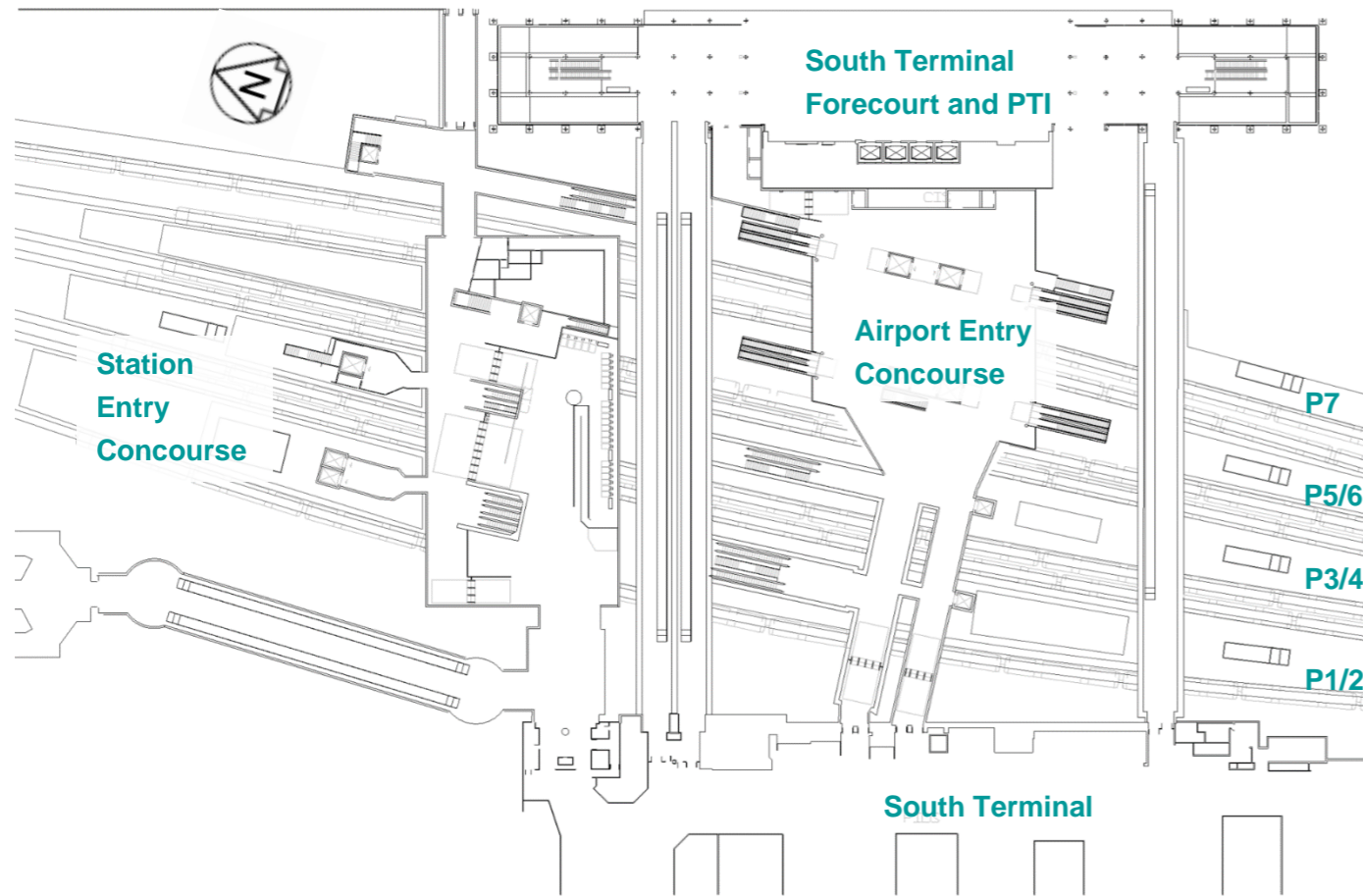
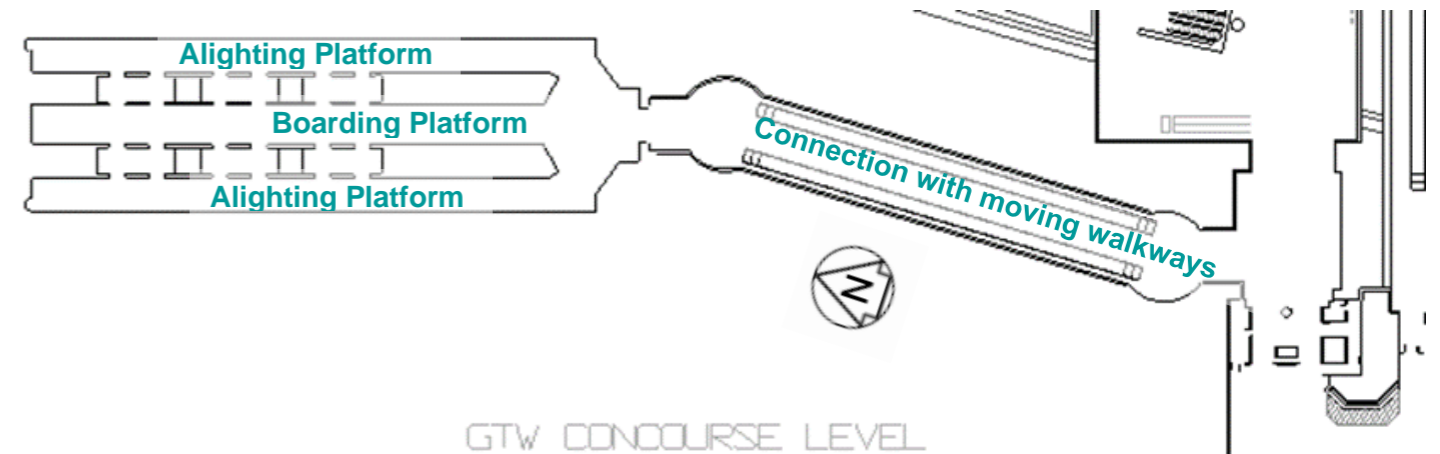


Diagram 3-2: Legion Model of Inter-Terminal Shuttle Extension (South Terminal)



3.2.4 The shuttle operation has been calibrated to video and CCTV footage, in particular for loading of boarding platforms and maximum loading of the shuttle itself.

4 Demand

4.1.1 Testing of Gatwick Airport station and the shuttle has been undertaken for six future demand scenarios; the future baseline in 2029, 2032 and 2047, and the same years with the Project, as further described in 4.1.2 to 4.1.4. Both the AM and PM 2-hour peak have been modelled.

2029 first full year of operation

4.1.2 The first year of operation after opening of the new runway is assumed to be 2029; accordingly this is the first operational year modelled and tested.

2032 interim assessment year

4.1.3 2032 is an interim assessment year, by which time it is expected that all slots on the northern runway are likely to have been filled and the highway works which form part of the Project are expected to be in place. This horizon year has been tested both without and with the Project.

2047 ultimate year

4.1.4 2047 reflects a requirement under the Design Manual for Road and Bridges¹ to assess the effects of a highway project (the highway works associated with the Project in this context) 15 years after it has been completed. This assessment year has been tested both without and with the Project.

4.2 Legion entity groups

4.2.1 To prepare the Legion Data Template that provides demand into the models, the 2036 template was used to identify different "entity groups" (rail users, forecourts users, staff, visitors etc) and their origins/destinations. As appropriate, passenger proportions from the 2036 Network Rail model were then updated to reflect demand associated with the future baseline and with Project from

¹DMRB Vol. 5, Sec. 1 (TD37/93)

GAL's multi-modal strategic transport model to inform usage of the station.

4.2.2 Entity groups in the Legion model include passengers arriving to Gatwick by train or car, passengers landing at North and South Terminal, and commuters interchanging at Gatwick Station. In total, the 2036 Network Rail model has 17 passenger profiles as follows:

1. South Terminal via Southern Entrance bridge including London commuters;
2. Passengers landing at South Terminal;
3. South Terminal via Northern Entrance bridge;
4. Passengers arriving by train using the shuttle to go to North Terminal ;
5. Passengers arriving at South Terminal via the shuttle;
6. Passengers arriving by train going to South Terminal including London commuters;
7. Passengers landing at South Terminal going to the train station;
8. Passengers leaving South Terminal via the Northern Entrance bridge;
9. Escorts² crossing from South Terminal via the link bridge;
10. Staff milling across South Terminal check-in coming from shuttle;
11. Staff milling across South Terminal check-in going to shuttle;
12. Staff from southbound A23 bus-stop via shuttle station;
13. Staff from destinations via shuttle station to A23 bus stop;
14. Staff on shuttle from destinations to North Terminal;
15. Staff on shuttle from North Terminal to Destinations;
16. North terminal to South Terminal landside transfers; and
17. South terminal to North Terminal landside transfers.

4.2.3 A comparison of total demand across all 17 entity groups for each of the assessment years across a 2-hour AM and PM peak as well as the 2036 model received from Network Rail is provided in Table 4.3.2.

4.2.4 A number of these entity groups cannot be derived with confidence from the strategic transport model which assesses passengers, staff, commuters and other users and their journeys to and from the Airport. For example, the behaviour of staff already at the Airport and moving between various functions (as per profiles 10 to 15) or transfer passengers between different airlines (as per profiles 16 to 17) are not included in the strategic

transport model as they do not affect landside demand outside of the immediate terminal and shuttle environment. The mix of users in profiles 1, 3, 8 and 9 is also not directly output from the strategic model which provides zonal output only (ie not demand-specific to link bridge usage).

4.3 Future year station demand

4.3.1 The Legion entity groups directly related to the rail operation and station, profiles 4 to 7, have been taken from the strategic transport model, reflecting airport passengers, staff, meeter-greeters and well-wishers (called escorts in the Network Rail Legion model), as well as other users such as commuters, to ensure the core demand of station users in the Legion model is directly translated across from GAL's strategic transport model.

4.3.2 The strategic transport model has been run for a year (2019) to allow comparison, calibration and validation with observed data, including observed 2019 gateline data for the station. Table 4.3.1 shows AM and PM entry and exit factors reflecting the intensity of gateline usage in the station over a 2-hour period as compared to rail demand for that same time period. These factors have been applied to the relevant strategic modelling demand profiles to generate appropriate levels of station demand.

Table 4.3.1: Gateline calibration factors

Calibration factors	Entries	Exits
AM	0.97	1.18
PM	1.02	1.12

4.3.3 Raw data from the strategic model for rail demand is provided in Table 4.3.3 with the station usage in terms of entries and exits calibrated to gateline data provided in Table 4.3.4.

4.3.4 All the other demand profiles or entity groups in the Legion model have then been factored proportionally to station demand. This generates a more conservative amount of "background" demand in the model when compared to the 2036 Network Rail model. The Network Rail 2036 model was built assuming a former

Airport Surface Access Strategy (ASAS) rail mode share target of 46.2% by 2036 as compared to current ASAS targets of 50%.

4.3.5 By using profile 2 "Passengers landing at South terminal" (eg South Terminal arrivals) as a control, it is estimated that this factoring method generates background demand (ie non-station users) which is between 0% and 20% higher than would occur if using demand output from the strategic model. This level of difference is both more conservative and reflects variation which might occur on any given day.

4.3.6 The station entry and exit demand, calibrated to gateline counts and as shown in Table 4.3.4 was therefore considered a robust basis on which to move forward with modelling the station and shuttle and estimating congestion effects.

4.3.7 Interchange movements have been calculated as 7.3% of the total station entry and exit journeys, based on the 2019/20 Office of Road and Rail (ORR) Station Footfall figures.

Passengers and luggage

4.3.8 The passenger composition is based on Network Rail's passenger survey carried out in May 2014, and divides passengers across three types: no luggage, medium luggage and large luggage, as shown in Table 4.3.5.

Table 4.3.2: Total demand modelled across 2-hour AM and PM peak

Total Demand	Future baseline 2029	With Project 2029	Future baseline 2032	With Project 2032	Future baseline 2047	With Project 2047
AM 2 hours (0700-0900)	20,371	21,710	21,717	25,105	22,100	28,494
PM 2 hours(1600-1800)	19,707	20,965	20,512	25,265	23,920	28,557

Table 4.3.3: Raw rail entry and exit demand modelled across each AM and PM peak hour for each horizon (strategic transport model)

Station Demand	Future baseline 2029	With Project 2029	Future baseline 2032	With Project 2032	Future baseline 2047	With Project 2047
AM Boarders (0700-0800)	1,487	1,599	1,632	1,881	1,885	2,254
AM Alighters (0700-0800)	2,226	2,639	2,364	3,001	2,678	3,562
AM Boarders (0800-0900)	3,232	3,448	3,449	4,166	3,980	4,830
AM Alighters (0800-0900)	2,549	2,977	2,695	3,356	2,998	3,944
PM Boarders (1600-1700)	2,199	2,323	2,278	2,791	2,862	3,282
PM Alighters (1600-1700)	2,882	2,992	3,030	3,597	3,556	4,153
PM Boarders (1700-1800)	2,667	2,898	2,768	3,447	3,381	3,962
PM Alighters (1700-1800)	2,951	3,114	3,117	3,761	3,630	4,365

Table 4.3.4: Station entry and exit demand modelled across each AM and PM peak hour for each horizon (calibrated to 2019 gateline counts)

Station Demand	Future baseline 2029	Project 2029	Future baseline 2032	Project 2032	Future baseline 2047	Project 2047
AM Entries (0700-0800)	1,446	1,555	1,587	1,829	1,833	2,192
AM Exits (0700-0800)	2,637	3,127	2,800	3,555	3,172	4,220
AM Entries (0800-0900)	3,143	3,353	3,402	4,051	3,871	4,679
AM Exits (0800-0900)	3,020	3,526	3,193	3,975	3,552	4,672
PM Entries (1600-1700)	2,237	2,363	2,318	2,839	2,912	3,339
PM Exits (1600-1700)	3,218	3,341	3,384	4,016	3,971	4,637
PM Entries (1700-1800)	2,713	2,948	2,816	3,507	3,440	4,031
PM Exits (1700-1800)	3,295	3,477	3,480	4,199	4,053	4,874

Table 4.3.5: Passenger types used in model

Type	No Luggage	Medium Luggage	Large Luggage
Alighters	54%	36%	10%
Boarders	51%	36%	13%
Meeters	100%	0%	0%
Interchange	90%	10%	0%
Staff	100%	0%	0%

5 Station operation

5.1 Train timetable

5.1.1 Diagram 5-1 and Diagram 5-2 show the frequency of train services per platform in the AM and PM peak period for all assessment years³. Platforms 4 and 7 have most train arrivals and departures.

5.2 Vertical circulation

5.2.1 Vertical circulation in Gatwick Airport railway station and replicated in the 2036 Legion model provided by Network Rail is shown in Diagram 5-3. There are nine up and eight down escalators, eight bi-directional stairs and one one-way stair to/from the platforms.

Diagram 5-1: AM train departures per platform

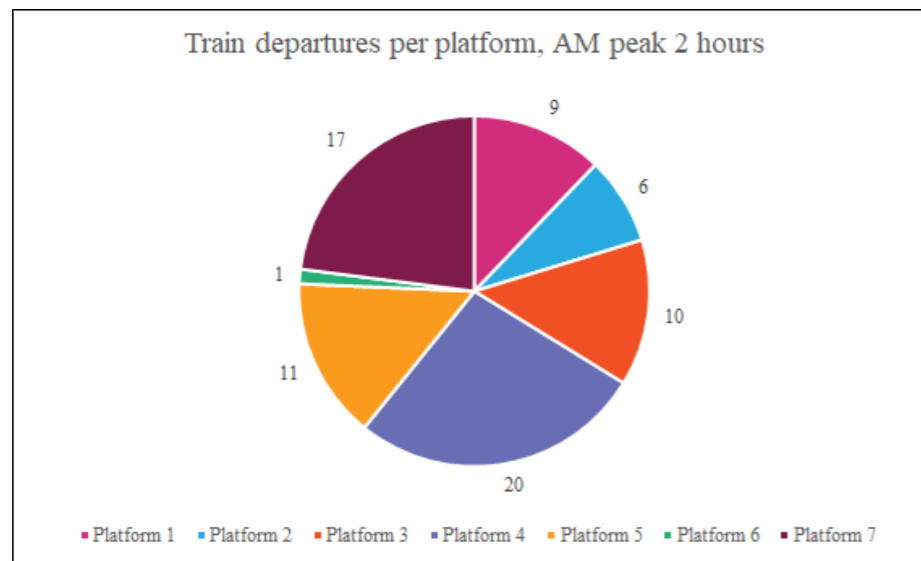


Diagram 5-2: PM train departures per platform

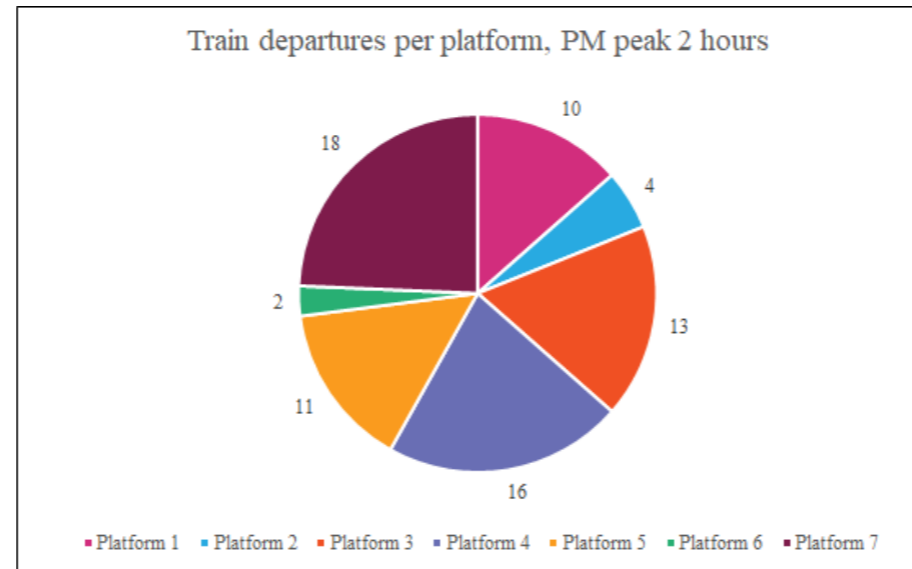


Diagram 5-3: Platform vertical circulation



5.2.2 Assumptions related to vertical circulation elements include the following:

- escalator average peak capacity flow rate of ~60 passengers per minute;
- lift capacity at 35% of the plated capacity; and

- lift cycle times of 110 seconds per cycle.

5.2.3 The above flow rates were confirmed by Arup during a site survey on 31 July 2019. Train arrivals on all platforms between 16:00 and 17:30 were observed and escalator flow rates recorded. For escalators with a continuous demand over 1 minute, flow rates observed were between 52 and 57 people per minute.

5.2.4 The following maximum flow rates for stairs have been used from Network Rail's Station Capacity Planning Guidance (Network Rail, 2016):

- stairs (one-way): 35 passengers/minute/metre; and
- stairway (two-way): 28 passengers/minute/metre.

5.3 Gateline operation

5.3.1 The gateline operation at concourse level comprises:

- Station Entry concourse, consisting of 3 gatelines:
 - West: 3 Wide Aisle Gates (WAGs) - all Exit;
 - Middle: 8 WAGs - all Entry; and
 - East: 4 WAGs - all Entry
- The Airport Entry concourse and overbridge, consisting of 2 gatelines:
 - North Bridge: 4 WAGs – all Exit; and
 - South Bridge: 3 WAGs + 1 standard width Automatic Ticket Gate (ATG) - all Exit.
- PTI Gateline, consisting of 3 WAGs:
 - Both AM and PM Peaks = 1 Entry, 1 Exit and 1 Reversible.

5.3.2 The following gateline flow rate assumptions have been taken from the Network Rail model and as confirmed with Network Rail via email on 21 September 2022:

- passengers with large luggage/reduced mobility/in wheelchairs: flow rate of 12 ppl/min/gate;
- passengers with medium luggage: flow rate of 12 ppl/min/gate; and
- passengers with small/no luggage: flow rate of 25 ppl/min/gate.

5.3.3 This approach is in line with Network Rail's standards which states that the "maximum uni-directional WAG throughput may be equal to a standard ATG but it is recommended the throughput is

³ The train service used is as provided in the NR Legion model for all assessment years. Comparison of train services with Gatwick strategic model generated a difference of only two

trains in the 2 hour peak period. As the Legion model has fewer trains and is therefore marginally more onerous, the modelled train service was left as per the GRIP5 Legion model.

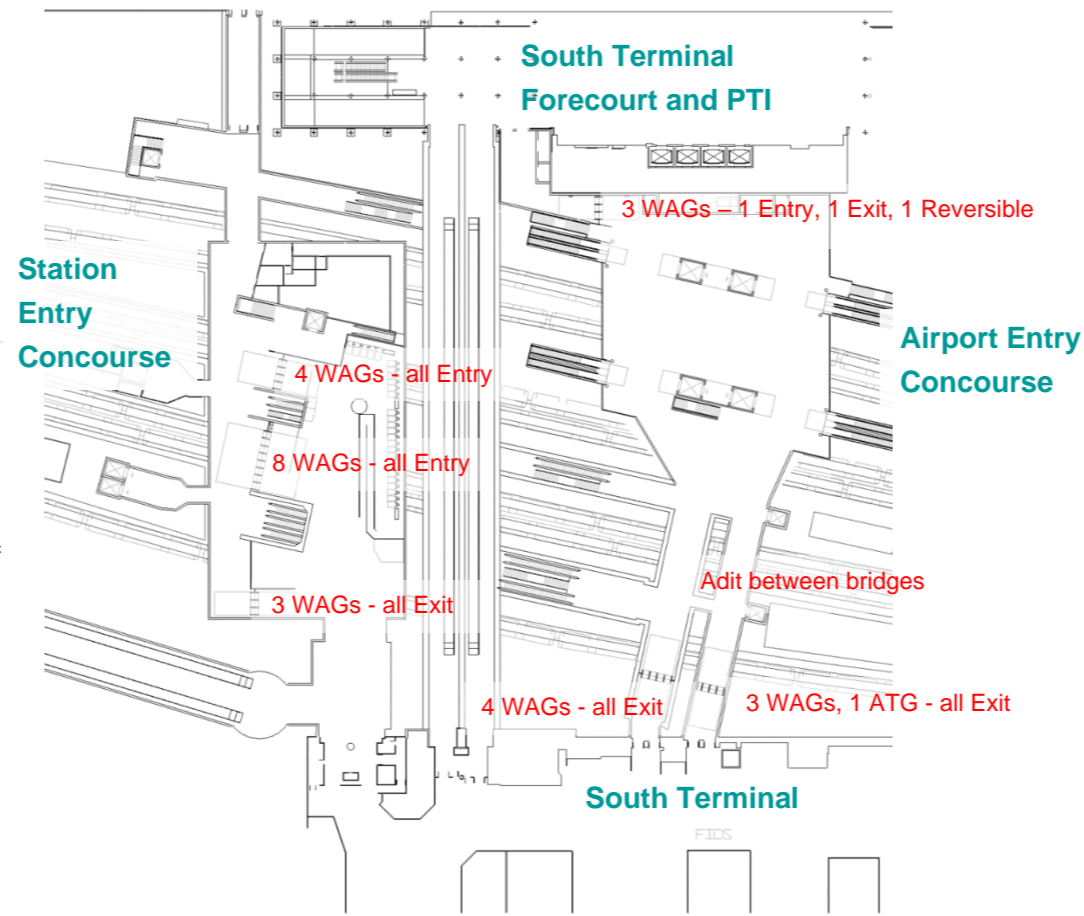
reduced, to reflect the reduced travel speed of PRMs [Persons with Reduced Mobility].

5.3.4 Based on discussions in the meeting between GAL and Network Rail on 1 December 2022, a level of signage and potential operational intervention has been assumed to improve the balance of demand between the two gatelines from the Airport Entry concourse into South Terminal.

5.3.5 As agreed at the meeting, up to 25% of passengers arriving from the northern side of Platforms 5/6 and 7 are directed by signage to the southern gateline. In addition, it is assumed that signage or operational staffing will be provided in peak periods in the North Bridge directing up to 25% passengers through the **adit** connecting to the South Bridge when passenger queuing builds back across the access corridor from P1/2.

5.3.6 25% of rail passengers is equivalent to 50% of staff and 12.5% of air passengers from P5/6 and 7 being directed to use the South Bridge in the PM peak. The majority of staff who use rail to come to the Airport are aware of the southern gateline and therefore 50% using the southern gateline at busy times is considered realistic and appropriate.

Diagram 5-4: Gateline locations, Gatwick Airport Rail Station

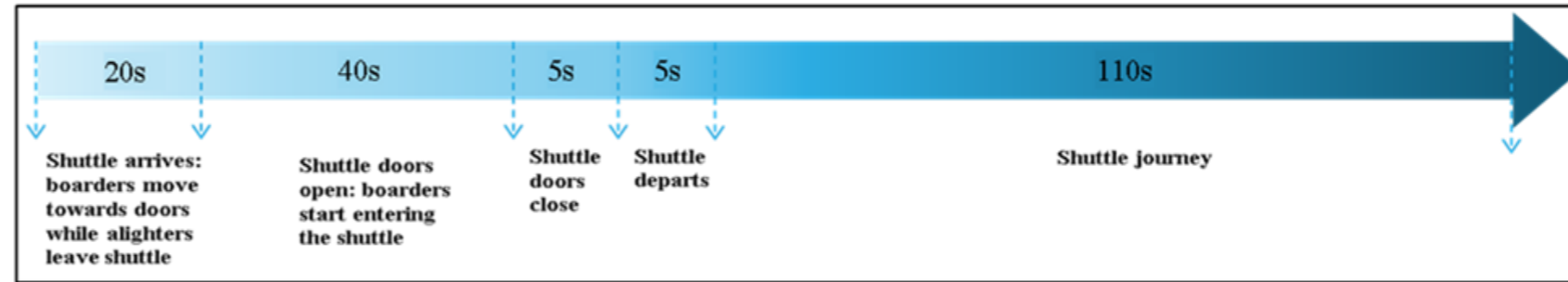


6 Shuttle operation

6.1.1 The shuttle connections between the North and South Terminals have been added to the Network Rail model. Diagram 6-1 shows the pattern of service to achieve a 6-minute shuttle headway. Timings are based on data received from GAL and a site survey undertaken by Arup in 2019.

Diagram 6-1: 6-minute shuttle operation times

6 minute Shuttle Operation – 3 minutes from South Terminal to North Terminal



7 Assessment criteria

7.1 Levels of Service

- 7.1.1 The analysis has been undertaken against Network Rail’s Station Capacity Planning Design Manual (December 2021). The assessment of crowding is based on Fruin Level of Service (LoS) criteria.
- 7.1.2 In the 1970s and 1980s, John Fruin pioneered pedestrian planning analysis and the development of LoS criteria for pedestrians – previously Level of Service metrics had only been used to describe vehicular traffic flow by highways agencies (Fruin, 1987).
- 7.1.3 LoS is used to describe pedestrian movement, relating density of pedestrians and flow rates for walkways and circulation areas,

stairs and in queues, with LoS A representing free flow and LoS F a complete breakdown in circulation.

- 7.1.4 LoS C is typically used for designing transport interchanges as it provides a balance between peak congestion, efficient design and operations. Network Rail therefore typically recommends LoS C or better for the design of new stations and station enhancements.
- 7.1.5 It is important to note that Fruin differentiates between LoS for walkways – areas where a pedestrian would expect free movement – and queues/waiting areas – where pedestrians tolerate higher densities and still consider their environment comfortable. The difference between flow rates and area requirements for walkways and queues at each LoS range are very different, as shown in Table 7.1.1.

- 7.1.6 Platforms are considered as a queuing/waiting environment and Network Rail guidance states that these should perform at LoS B/C or 0.93m² per person. Similarly, concourse waiting areas should perform at LoS B for queuing/waiting behaviour at 1.0 m² per person.
- 7.1.7 This is an important consideration when reviewing any Legion outputs shown in this report. The typical approach is to show a Fruin walkways map such that the overall station performance can be considered. This mapping is likely showing areas of queuing as LoS D or E for walkways – ie less than 1.0m² per person. However, if these locations are where a queue is expected to occur, such as at the top or bottom of an escalator, at gatelines or for boarding on a platform, it should be assessed in terms of acceptable queuing density.

Diagram 7-1: Levels of Service ranges



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.

Table 7.1.1: Fruin Level of Service criteria for Walkways and Queues

Level of Service	Fruin Walkways		Fruin Queues
	Flow (people per m of circulation width)	Area per Person (m ²)	Area per Person (m ²)
A	23 or less	3.3 or more	1.2 or more
B	23 to 33	2.3 to 3.3	0.9 to 1.2
C	33 to 49	1.4 to 2.3	0.7 to 0.9
D	49 to 66	0.9 to 1.4	0.3 to 0.7
E	66 to 82	0.5 to 0.9	0.2 to 0.3
F	82 and over	0.5 or less	0.2 or less

7.1.8 Given that the concourse level is a mix of circulation and waiting/queuing behaviours, LoS mapping for this level of the station is shown using both Fruin Level of Service criteria for Walkways and Queues. Platforms have been shown using Level of Service criteria for Walkways and for Queuing, in order to show both higher density “hotspots” (using the Walkways output) and the actual Level of Service experienced on the platform (using the Queuing output).

7.1.9 A summary of the assessment criteria in the Network Rail guidance to be used when assessing normal station operations is as follows:

- concourse circulation areas – LoS C Walkways or better;
- concourse waiting areas – LoS B Queuing or better;
- gateline queues – LoS D Queuing or better; and
- platforms – LoS B/C Queuing or better.

8 Model findings

8.1 AM peak comparison of future baseline and with Project scenarios

Concourse level, future baseline

8.1.1 Diagram 8-1 to Diagram 8-3 show LoS on the concourse level for the AM peak 15 minutes for 2029 through to the 2047 future baseline scenarios.

8.1.2 In general, the station concourse level performs at a comparable Level of Service out to 2047 in the future baseline, with predominantly LoS A to LoS C (Walkways) shown by modelling.

8.1.3 Higher densities are shown at the gatelines with LoS D/E (Walkways) shown by the model. This reflects that gatelines are queuing environments and accordingly people expect to slow down at these points of the journey and are prepared to tolerate higher densities. LoS D/E for Walkways is equivalent to LoS B/C for Queues which is acceptable performance, as per Diagram 8-4 to Diagram 8-6.

8.1.4 Higher densities are also shown on escalator elements which reflects people bunching on escalator treads which is typical and expected.

Concourse level, with Project

8.1.5 Diagram 8-7 to Diagram 8-9 show LoS on the concourse level for the AM peak 15 minutes for 2029 through to the 2047 with Project scenarios.

8.1.6 In general, the station concourse level performs at a comparable Level of Service out to 2047 with the Project, with predominantly LoS A to LoS C shown by modelling.

8.1.7 Higher densities are shown at the gatelines with LoS E (Walkways) shown by the model on the North Bridge into South Terminal. This reflects that gatelines are queuing environments and accordingly people expect to slow down at these points of the journey and are prepared to tolerate higher densities.

8.1.8 LoS E for Walkways is equivalent to LoS C/D for Queues, as shown in Diagram 8-10 to Diagram 8-12 for 2029 to 2047

respectively. LoS C is expected and LoS D can be tolerated for queuing at gatelines for short periods at the height of the peak⁴, noting that flows at this gateline are one-way and other circulation routes are unaffected.

8.1.9 Higher densities are shown on escalator elements which reflects people bunching on escalator treads which is typical and expected.

Platform level, future baseline

8.1.10 Diagram 8-13 to Diagram 8-15 show LoS Walkways on the platform level for the AM peak 15 minutes for 2029 through to the 2047 future baseline scenarios.

8.1.11 It can be seen that platforms perform at an appropriate Level of Service in the 2029 future baseline, with predominantly LoS C or better (Walkways) shown by the modelling.

8.1.12 Diagram 8-16 to Diagram 8-18 show LoS Queuing on the platform level for the AM peak 15 minutes for 2029 through to the 2047 future baseline scenarios.

8.1.13 The model shows primarily LoS A for queuing environments, ie more than 1.2m² per person, with pockets of higher density at LoS B/C, indicating acceptable conditions.

Platform level, with Project

8.1.14 Diagram 8-19 to Diagram 8-21 show LoS Walkways on the platform level for the AM peak 15 minutes for 2029 through to the 2047 with Project scenarios.

8.1.15 It can be seen that platforms perform at an appropriate Level of Service, with predominantly LoS C or better shown by the modelling. Higher densities are shown on some narrower sections of platform.

8.1.16 Diagram 8-22 to Diagram 8-24 show LoS Queues on the platform level for the AM peak 15 minutes for 2029 through to the 2047 with Project scenarios.

8.1.17 The model shows primarily LoS A for queuing environments, ie more than 1.2m² per person, with pockets of higher density at LoS B/C, indicating acceptable conditions.

⁴ Modelling shows that LoS D is only shown for the peak 5 minutes within the peak 15 minutes.

Diagram 8-1: Concourse LoS, Fruin Walkways – 2029 future baseline AM peak (07:30 – 07:45)

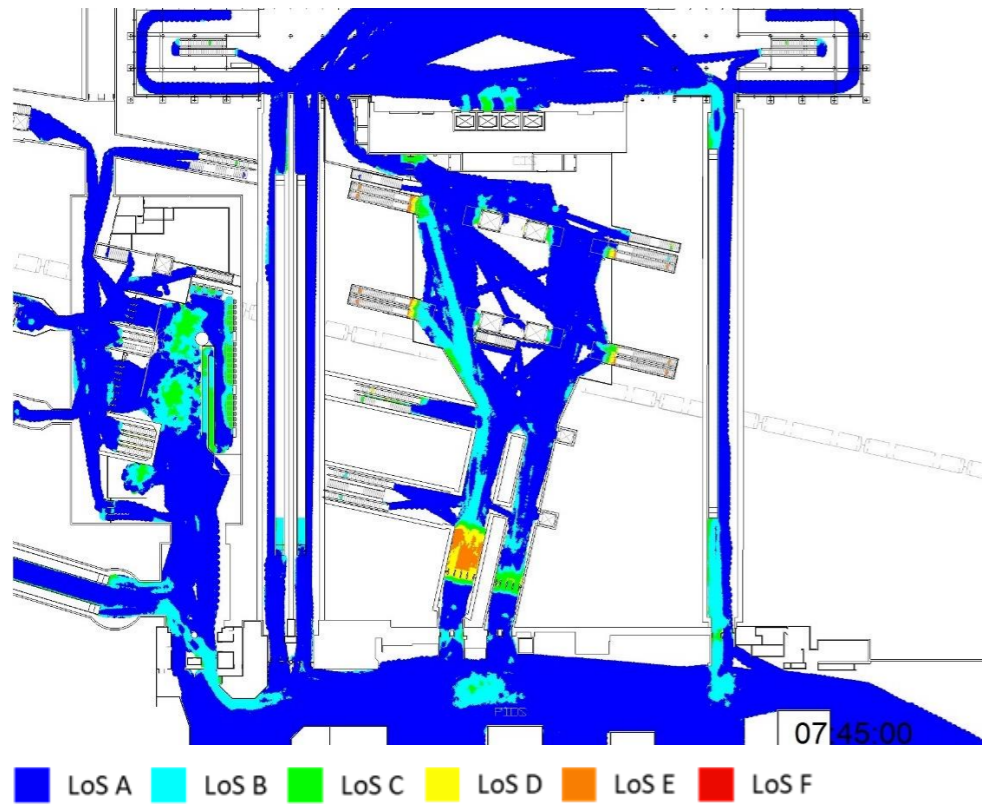


Diagram 8-2: Concourse LoS, Fruin Walkways – 2032 future baseline AM peak (07:30 – 07:45)

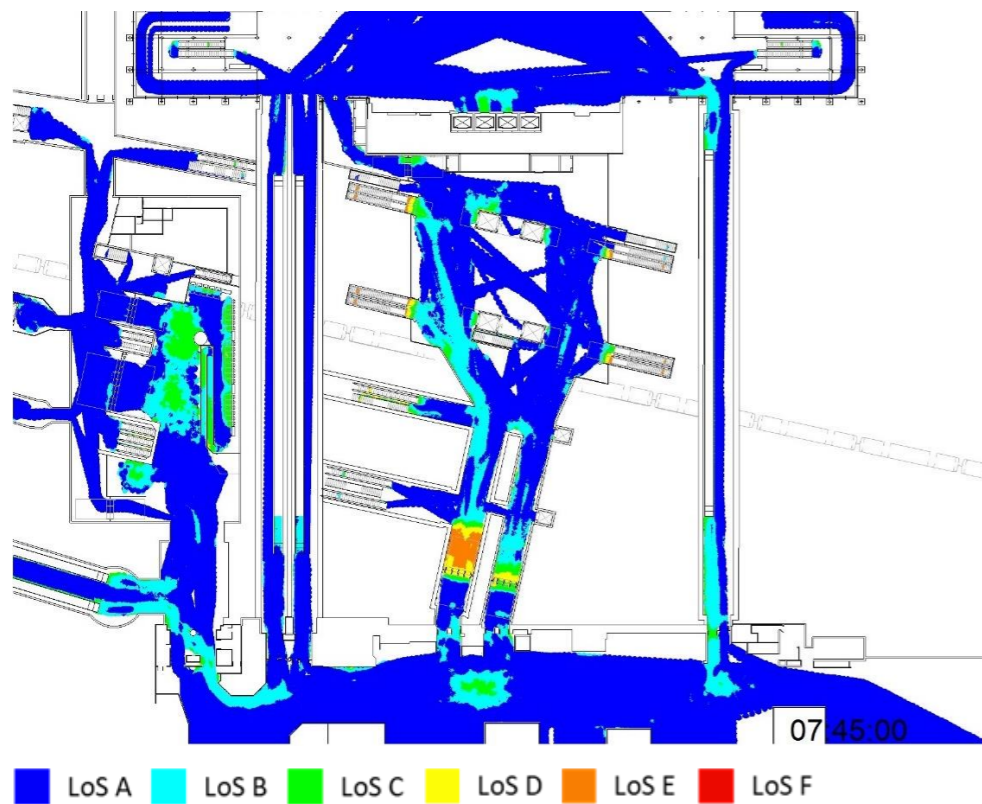


Diagram 8-3: Concourse LoS, Fruin Walkways – 2047 future baseline AM peak (07:30 – 07:45)

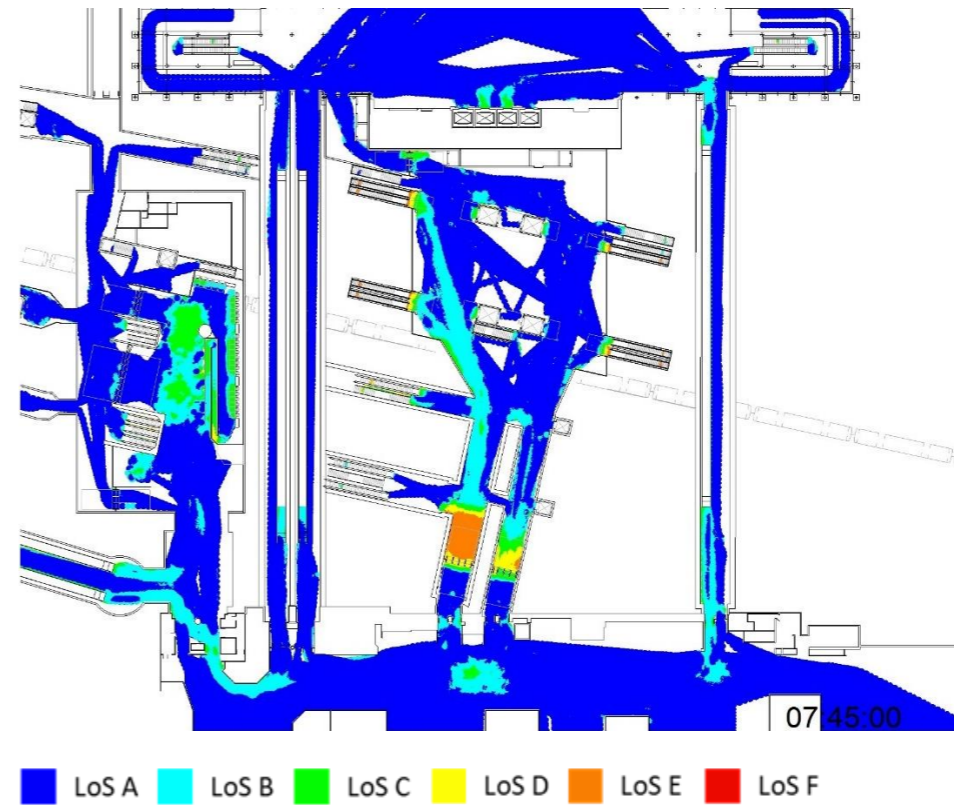


Diagram 8-4: Concourse LoS, Fruin Queues – 2029 future baseline AM peak (07:30 – 07:45)



Diagram 8-6: Concourse LoS, Fruin Queues – 2047 future baseline AM peak (07:30 – 07:45)



Diagram 8-5: Concourse LoS, Fruin Queues – 2032 future baseline AM peak (07:30 – 07:45)



Diagram 8-7: Concourse LoS, Fruin Walkways – 2029 with Project AM peak (07:30 – 07:45)

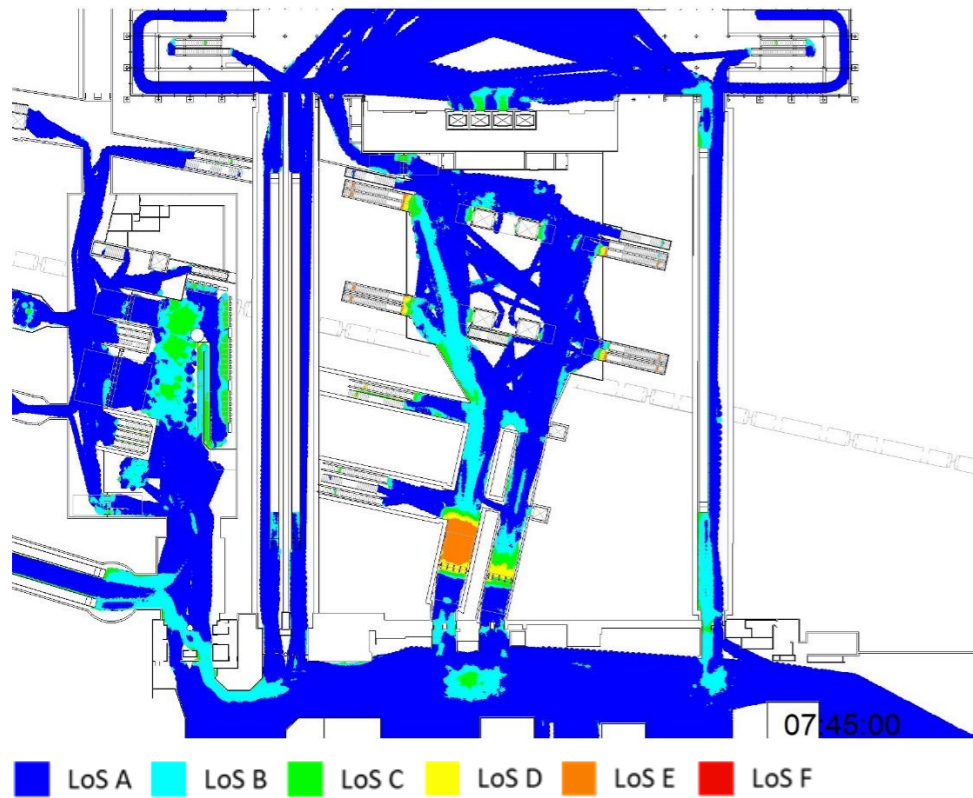


Diagram 8-9: Concourse LoS, Fruin Walkways – 2047 with Project AM peak (07:30 – 07:45)

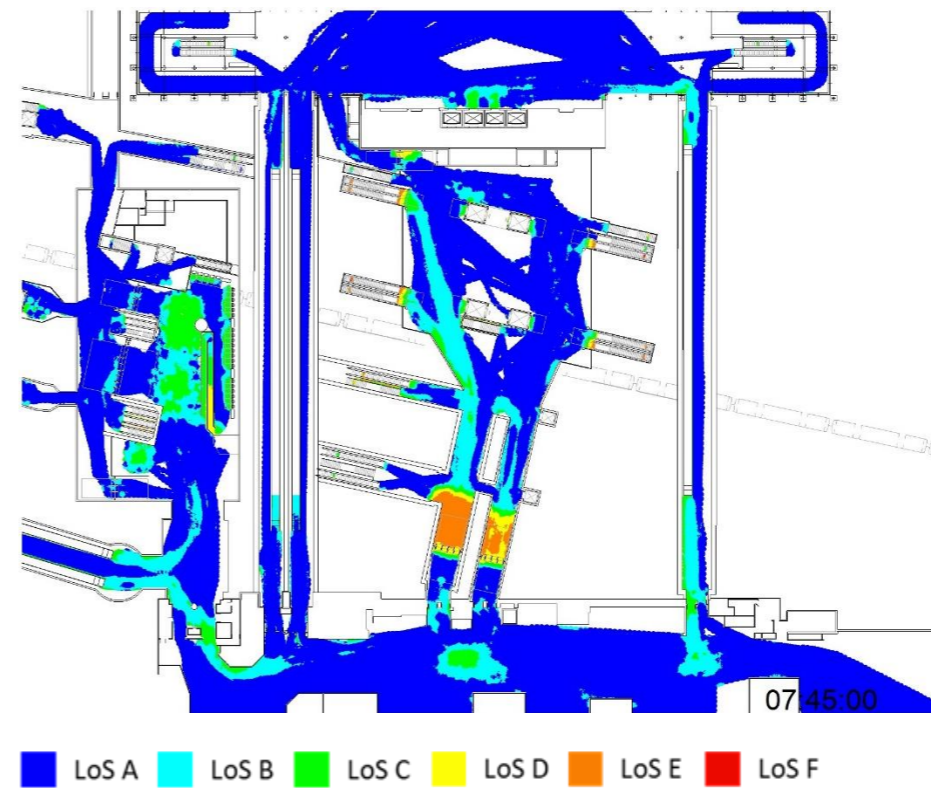


Diagram 8-8: Concourse LoS, Fruin Walkways – 2032 with Project AM peak (07:30 – 07:45)

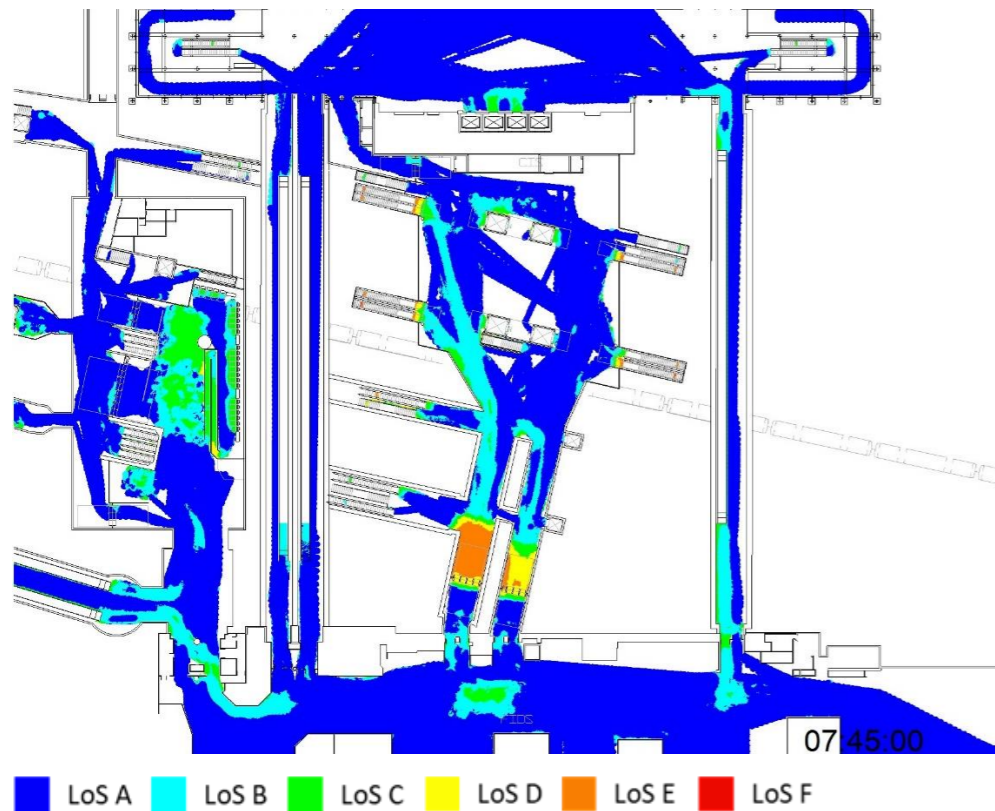


Diagram 8-10: Concourse LoS, Fruin Queues – 2029 with Project AM peak (07:30 – 07:45)

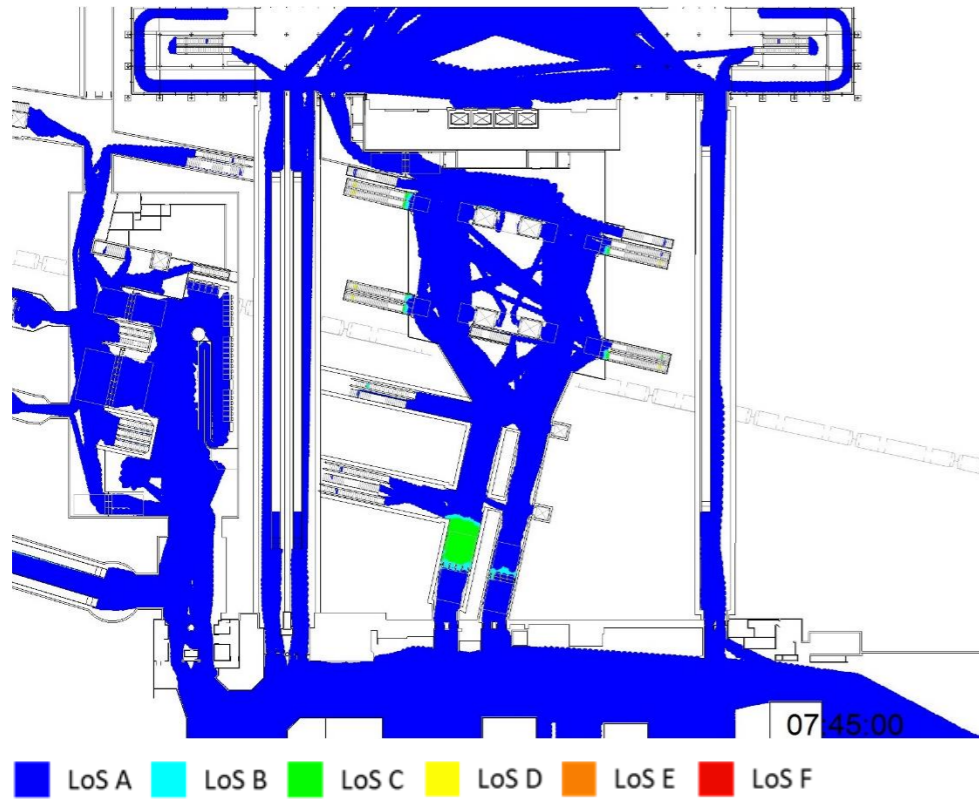


Diagram 8-11: Concourse LoS, Fruin Queues – 2032 with Project AM peak (07:30 – 07:45)

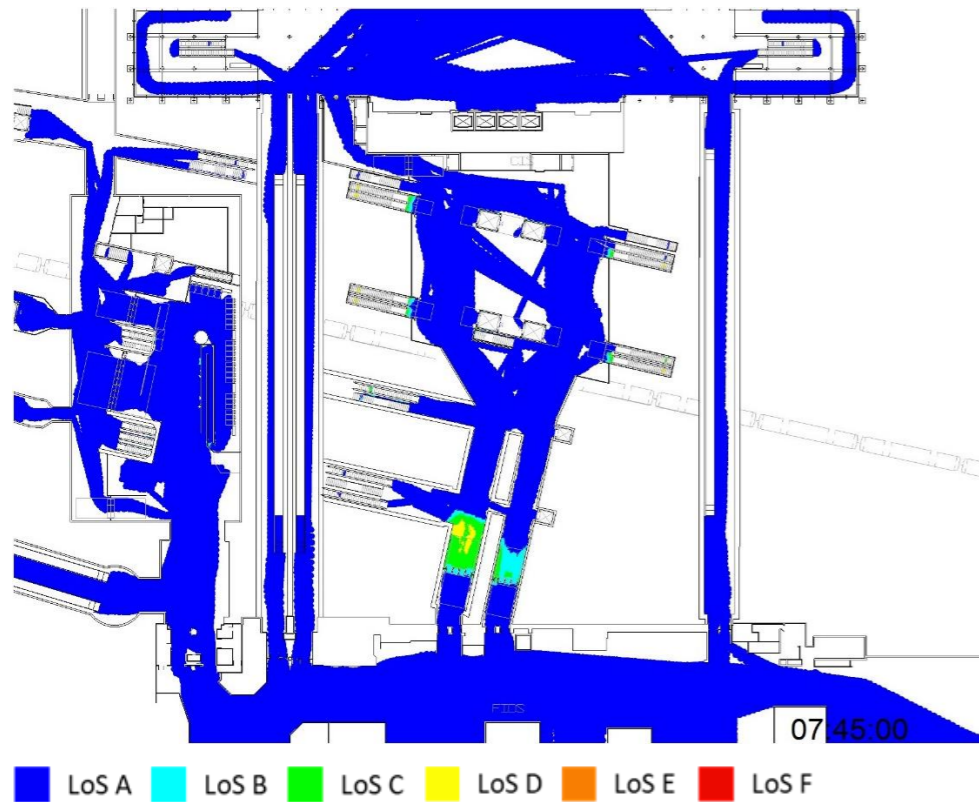
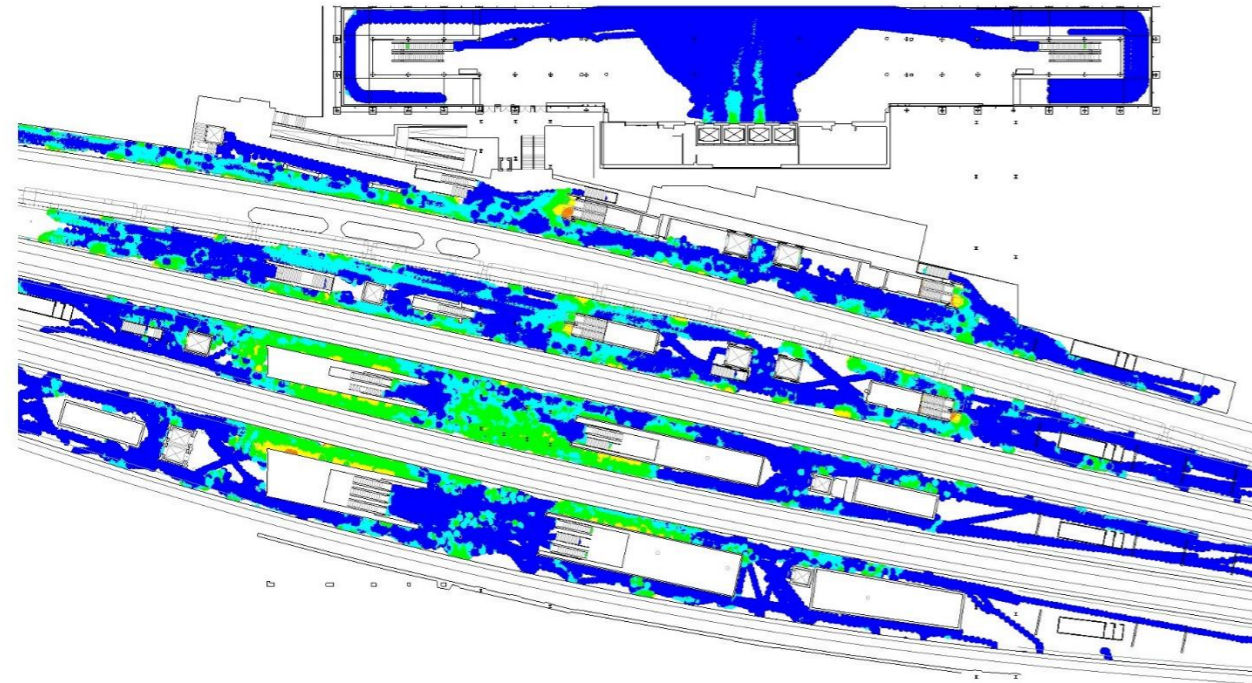


Diagram 8-12: Concourse LoS, Fruin Queues – 2047 with Project AM peak (07:30 – 07:45)

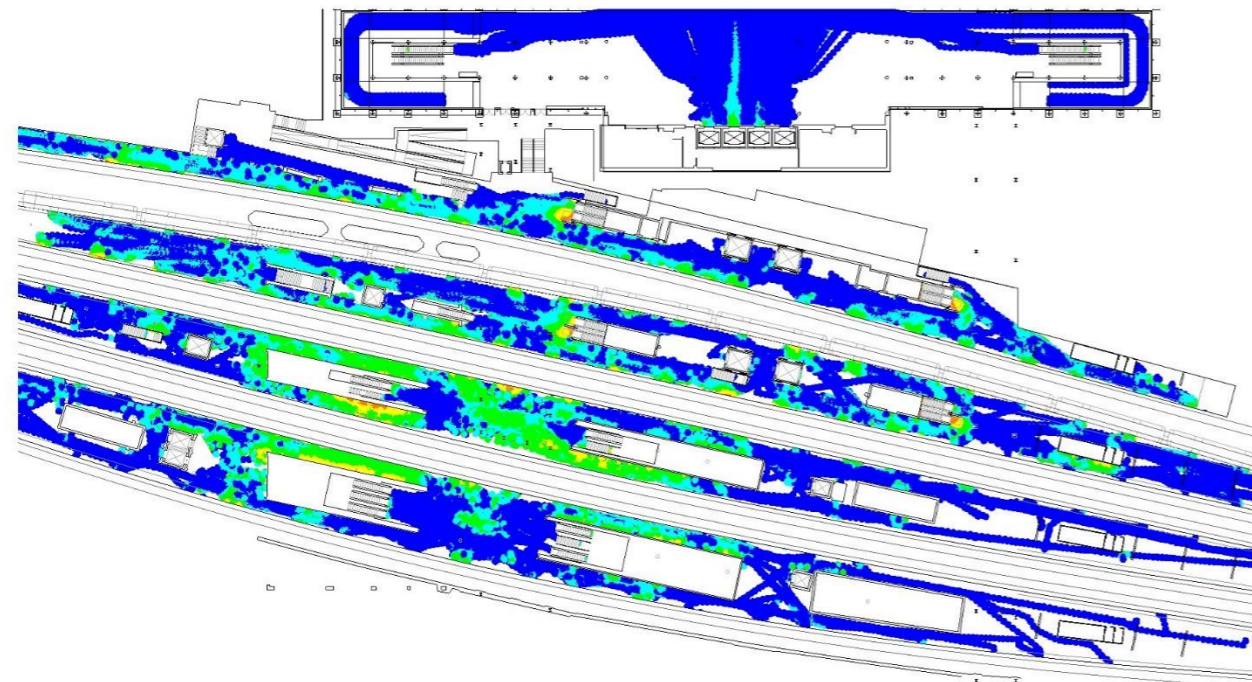


Diagram 8-13: Platform LoS, Fruin Walkways – 2029 future baseline AM peak (08:45 – 09:00)



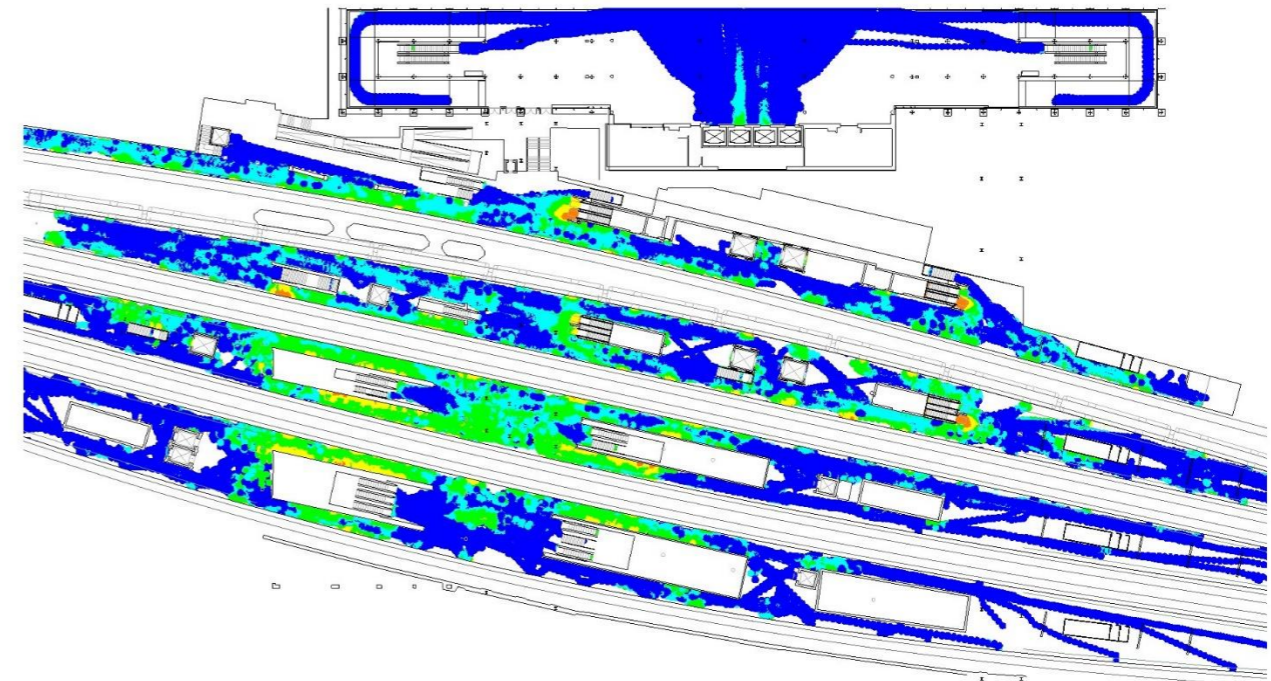
LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-14: Platform LoS, Fruin Walkways – 2032 future baseline AM peak (08:45 – 09:00)



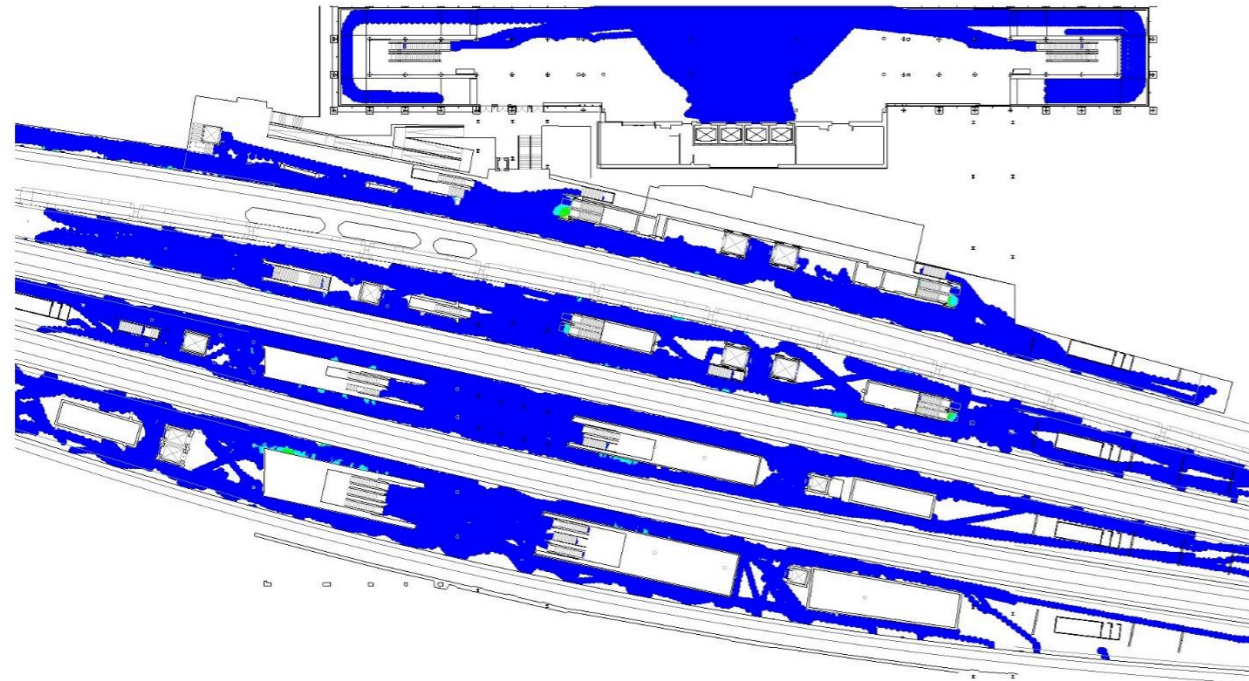
LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-15: Platform LoS, Fruin Walkways – 2047 future baseline AM peak (08:45 – 09:00)



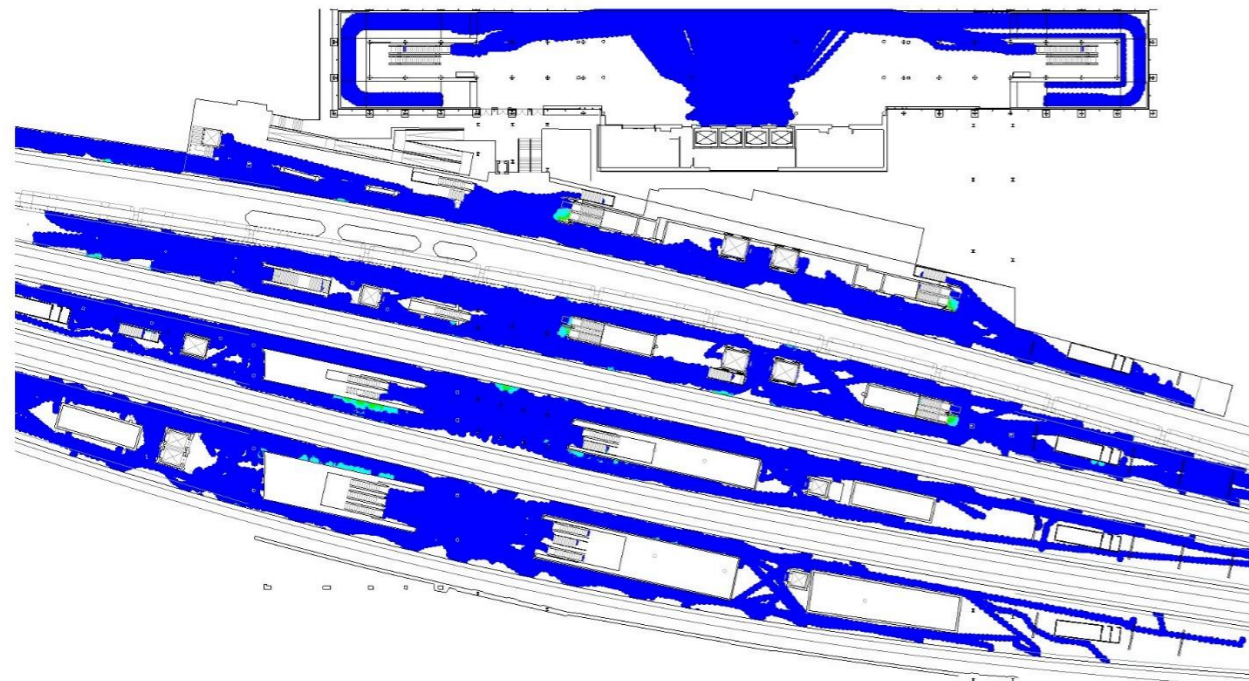
LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-16: Platform LoS, Fruin Queues – 2029 future baseline AM peak (08:45 – 09:00)



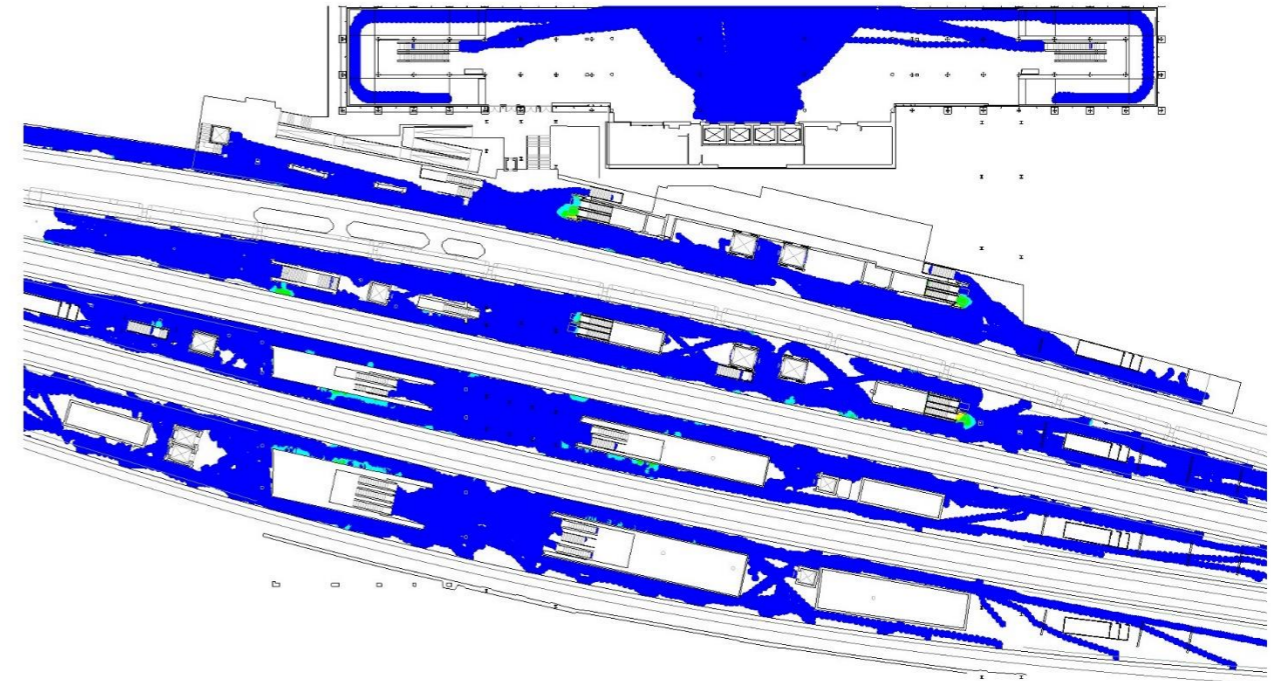
■ LoS A ■ LoS B ■ LoS C ■ LoS D ■ LoS E ■ LoS F

Diagram 8-17: Platform LoS, Fruin Queues – 2032 future baseline AM peak (08:45 – 09:00)



■ LoS A ■ LoS B ■ LoS C ■ LoS D ■ LoS E ■ LoS F

Diagram 8-18: Platform LoS, Fruin Queues – 2047 future baseline AM peak (08:45 – 09:00)



■ LoS A ■ LoS B ■ LoS C ■ LoS D ■ LoS E ■ LoS F

Diagram 8-19: Platform LoS, Fruin Walkways – 2029 with Project AM peak (08:45 – 09:00)

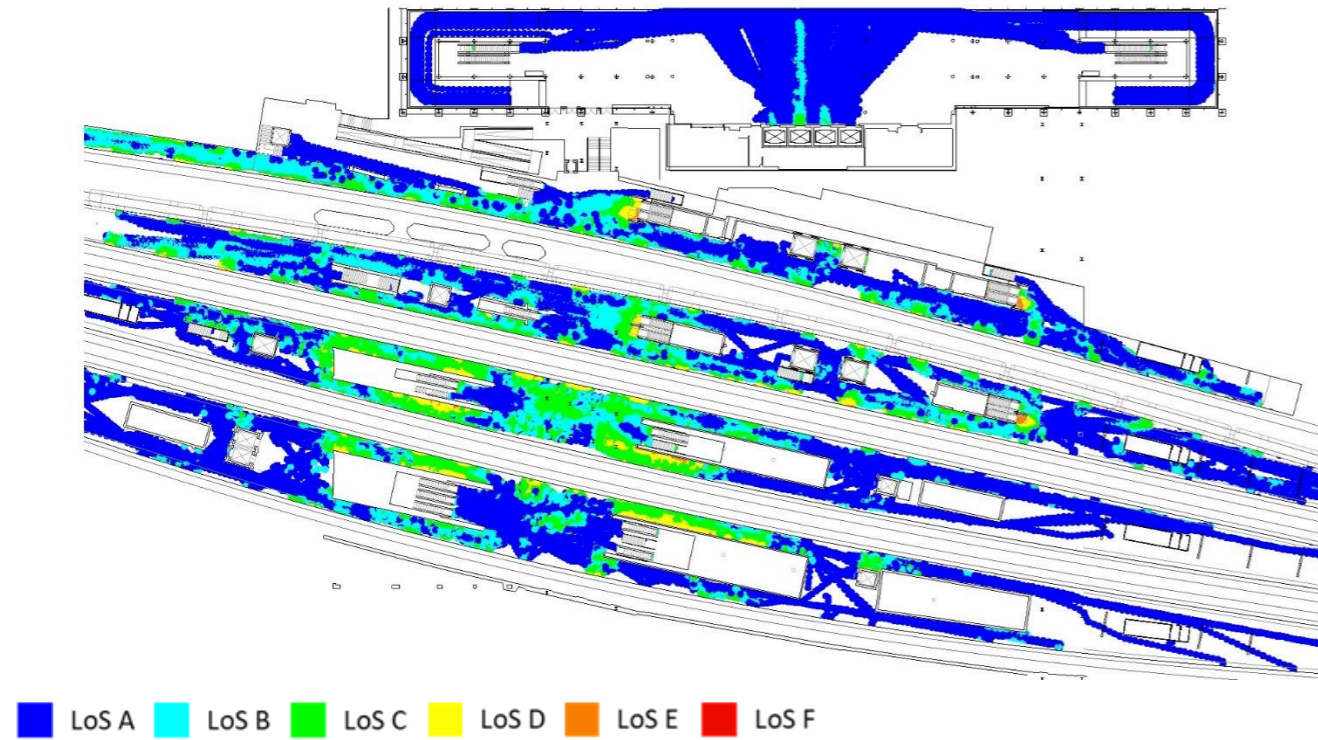


Diagram 8-21: Platform LoS, Fruin Walkways – 2047 with Project AM peak (08:45 – 09:00)

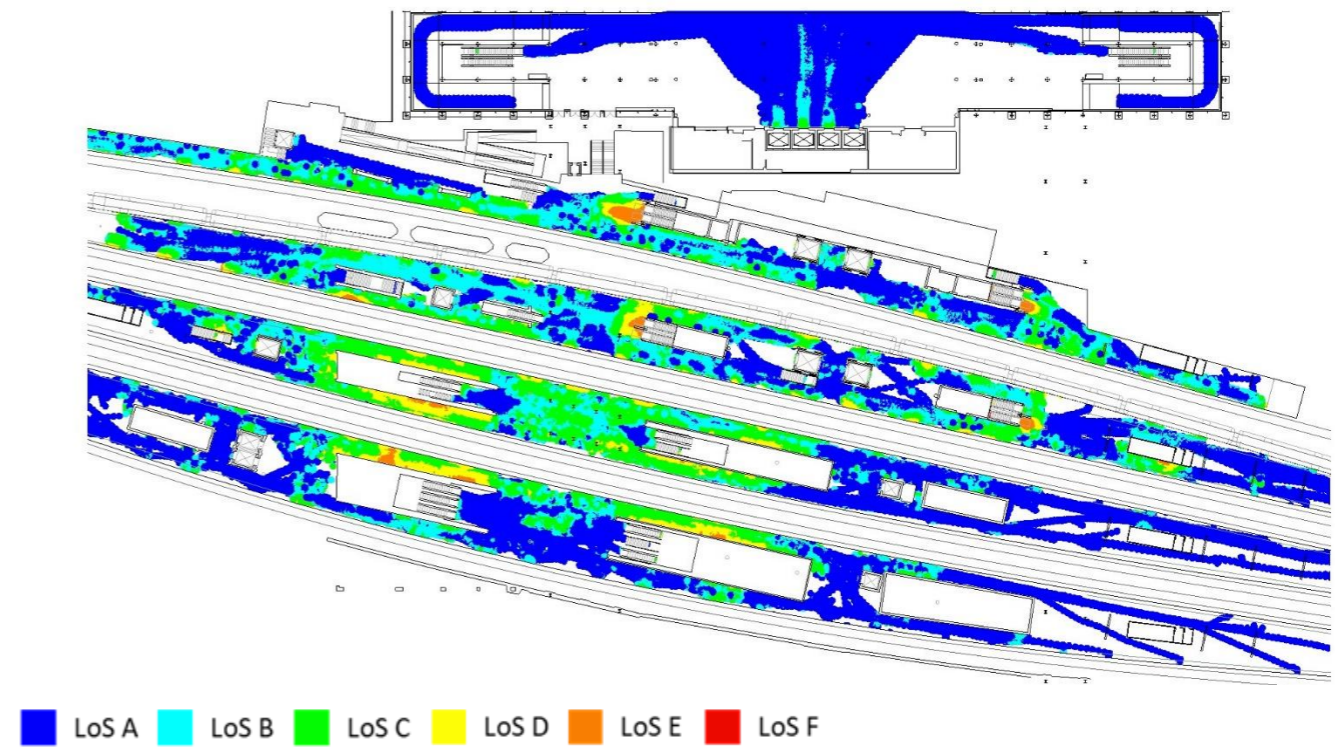


Diagram 8-20: Platform LoS, Fruin Walkways – 2032 with Project AM peak (08:45 – 09:00)

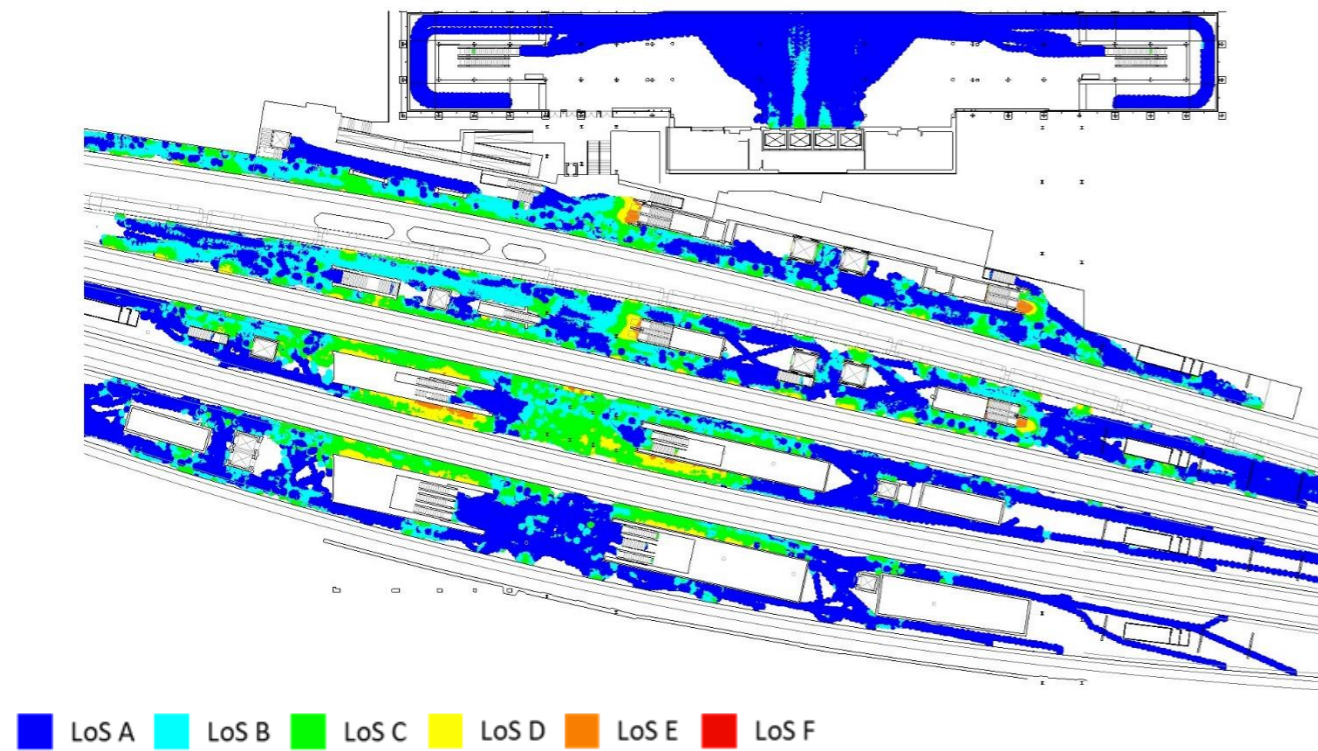
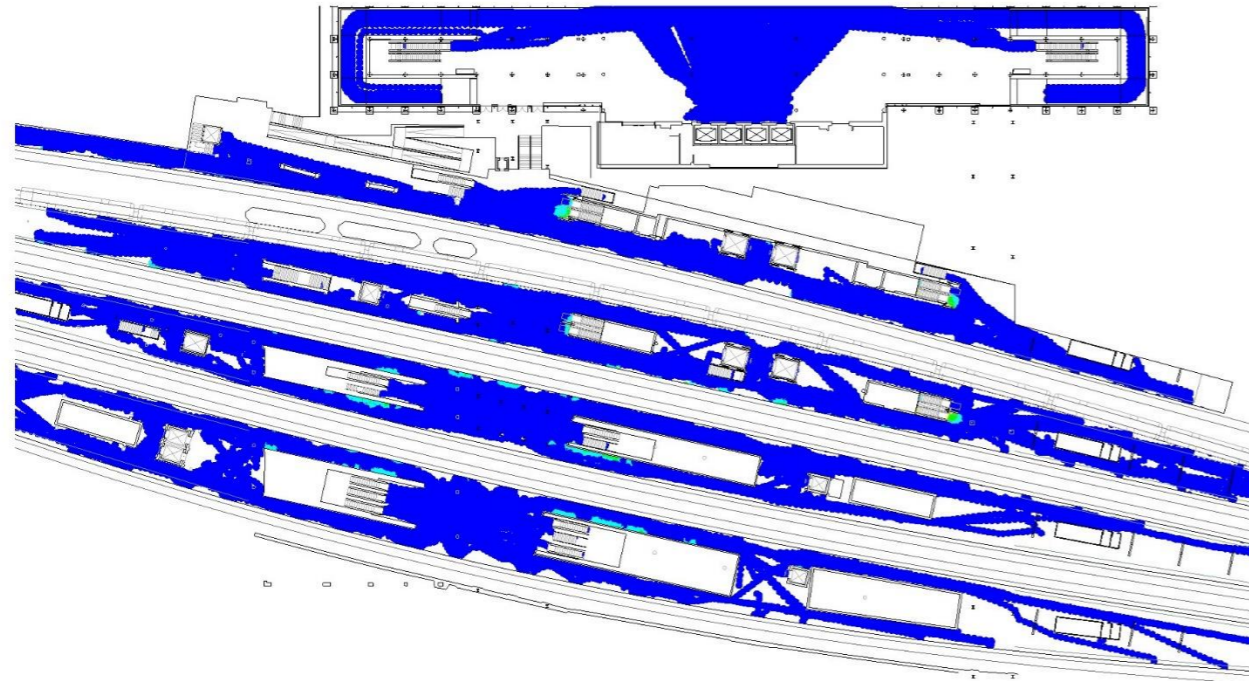
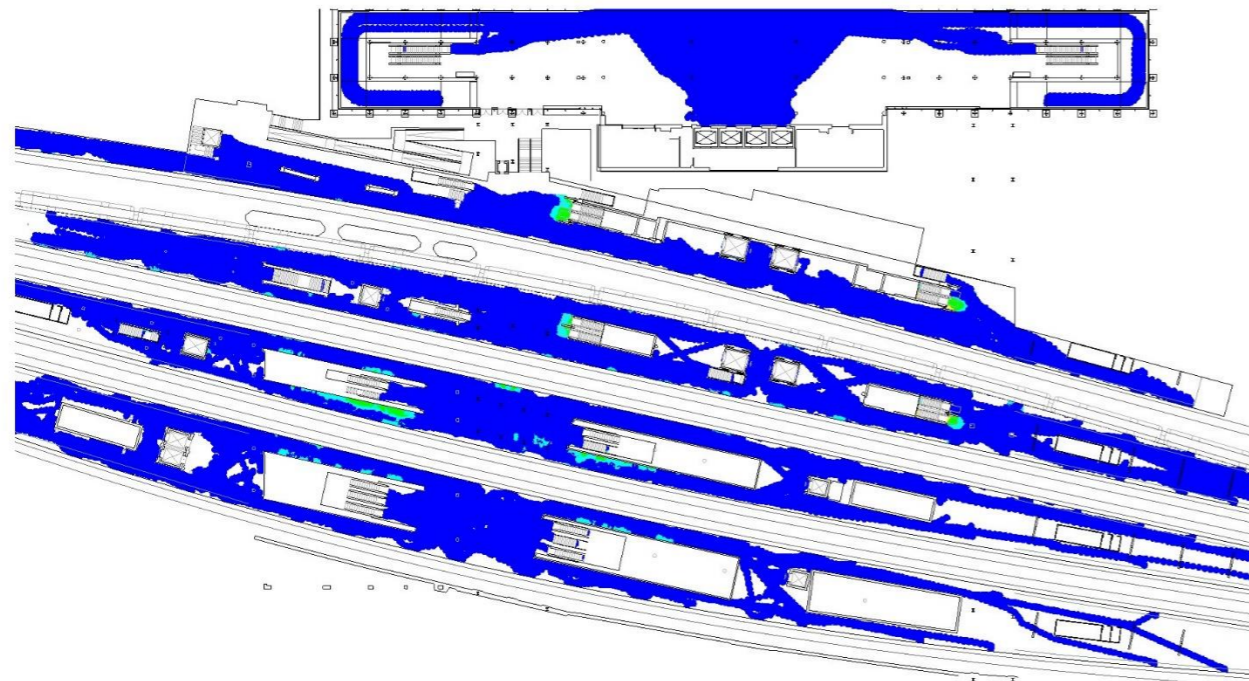


Diagram 8-22: Platform LoS, Fruin Queues – 2029 with Project AM peak (08:45 – 09:00)



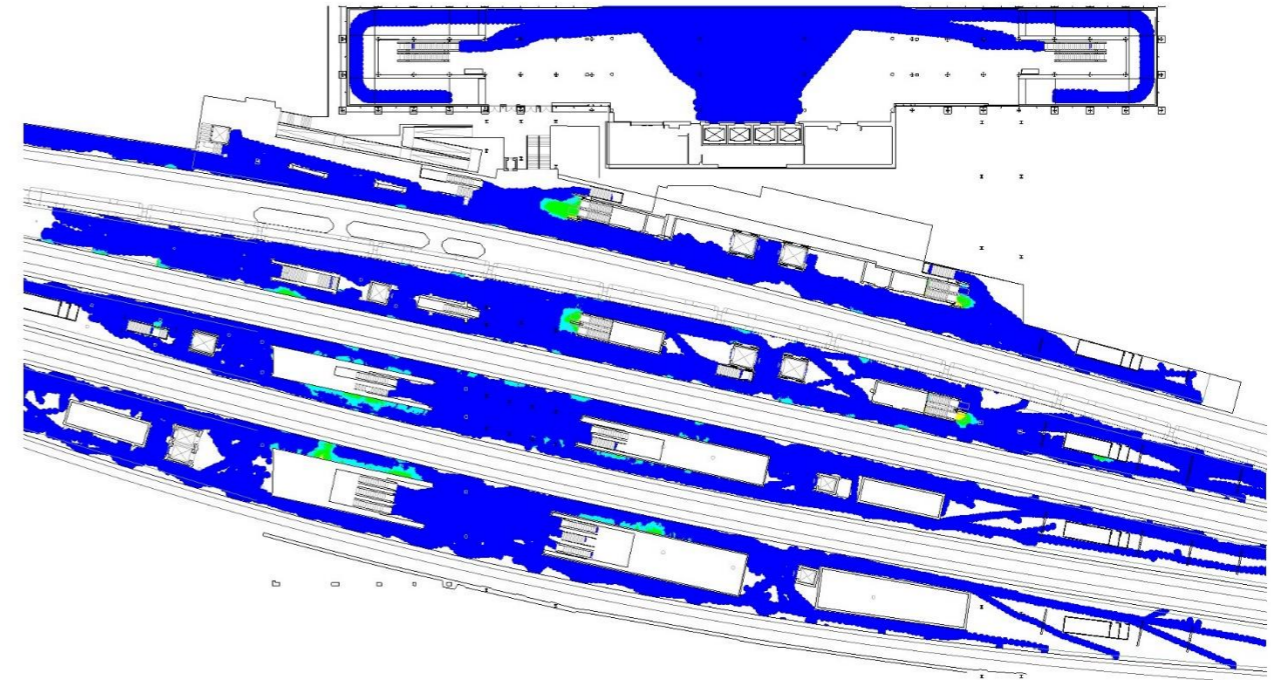
■ LoS A ■ LoS B ■ LoS C ■ LoS D ■ LoS E ■ LoS F

Diagram 8-23: Platform LoS, Fruin Queues – 2032 with Project AM peak (08:45 – 09:00)



■ LoS A ■ LoS B ■ LoS C ■ LoS D ■ LoS E ■ LoS F

Diagram 8-24: Platform LoS, Fruin Queues – 2047 with Project AM peak (08:45 – 09:00)



■ LoS A ■ LoS B ■ LoS C ■ LoS D ■ LoS E ■ LoS F

8.2 PM peak comparison of future baseline and with Project scenarios

Concourse level, future baseline

8.2.1 Diagram 8-25 to Diagram 8-27 show LoS on the concourse level for the 15-minute PM peak for 2029 through to the 2047 future baseline scenarios.

8.2.2 In general, the station concourse level performs at a comparable Level of Service out to 2047 in the future baseline, with predominantly LoS A to LoS C (Walkways) shown by modelling.

8.2.3 Higher densities are shown at the gatelines with LoS E (Walkways) shown by the model. This reflects that gatelines are queuing environments and accordingly people expect to slow down at these points of the journey and are prepared to tolerate higher densities.

8.2.4 LoS E for Walkways is equivalent to densities reducing LoS C/D, for Queues, as per Diagram 8-28 to Diagram 8-30. For the future baseline, densities do not exceed LoS C Queuing.

8.2.5 Higher densities are also shown on escalator elements which reflects people bunching on escalator treads which is typical and expected.

Concourse level, with Project

8.2.6 Diagram 8-31 to Diagram 8-33 show LoS on the concourse level for the PM peak 15 minutes for 2029 through to the 2047 with Project scenarios.

8.2.7 In general, the station concourse level performs at a comparable Level of Service out to 2047 with Project, with predominantly LoS A to LoS C shown by modelling.

8.2.8 Higher densities are shown at the gatelines with LoS E (Walkways) shown by the model. This reflects that gatelines are queuing environments and accordingly people expect to slow down at these points of the journey and are prepared to tolerate higher densities.

8.2.9 LoS E for Walkways is equivalent to densities reducing LoS C/D for Queues, as shown in Diagram 8-34 to Diagram 8-36 for 2029 to 2047 respectively. LoS C is expected and LoS D can be tolerated for queuing at gatelines for short periods at the height of the peak⁵, noting that flows at this gateline are one-way and other circulation routes are unaffected.

Platform level, future baseline

8.2.10 Diagram 8-37 to Diagram 8-39 show LoS Walkways on the platform level for the PM peak 15 minutes for 2029 through to the 2047 future baseline scenarios.

8.2.11 It can be seen that platforms perform at an appropriate Level of Service in the 2029 future baseline, with predominantly LoS C or better (Walkways) shown by the modelling. Higher densities are shown on some narrower sections of platform as well as at the base of escalator elements, in particular on Platforms 3, 5 and 7, which reflects that these are waiting or queuing environments. As described in Section 7, these higher densities are typical and expected at such locations.

8.2.12 Diagram 8-40 to Diagram 8-42 show LoS Queuing on the platform level for the PM peak 15 minutes for 2029 through to the 2047 future baseline scenarios.

8.2.13 The model shows primarily LoS A for queuing environments, ie more than 1.2m² per person, with pockets of higher density at LoS B/C, indicating acceptable conditions.

8.2.14 LoS D is shown by the model at the base of escalators indicating slower moving queues at these locations.

Platform level, with Project

8.2.15 Diagram 8-43 to Diagram 8-45 show LoS Walkways on the platform level for the PM peak 15 minutes for 2029 through to the 2047 with Project scenarios.

8.2.16 It can be seen that platforms perform at an appropriate Level of Service, with predominantly LoS C or better shown by the modelling. Higher densities are shown on some narrower sections of platform as well as at the base of escalator elements, in particular on Platforms 3, 5 and 7, which reflects that these are waiting or queuing environments.

8.2.17 Diagram 8-46 to Diagram 8-48 show LoS Queues on the platform level for the PM peak 15 minutes for 2029 through to the 2047 with Project scenarios.

8.2.18 The model shows primarily LoS A for queuing environments, ie more than 1.2m² per person, with pockets of higher density at LoS B/C. LoS D is shown on Platform 3 at a localised platform pinch point. However, there is opportunity for passengers to move into less crowded areas on Platform 3 and, in general, modelling shows acceptable conditions.

⁵ Modelling shows that LoS D is only shown for the peak 5 minutes within the peak 15 minutes.

Diagram 8-25: Concourse LoS, Fruin Walkways – 2029 future baseline PM peak (17:30-17:45)

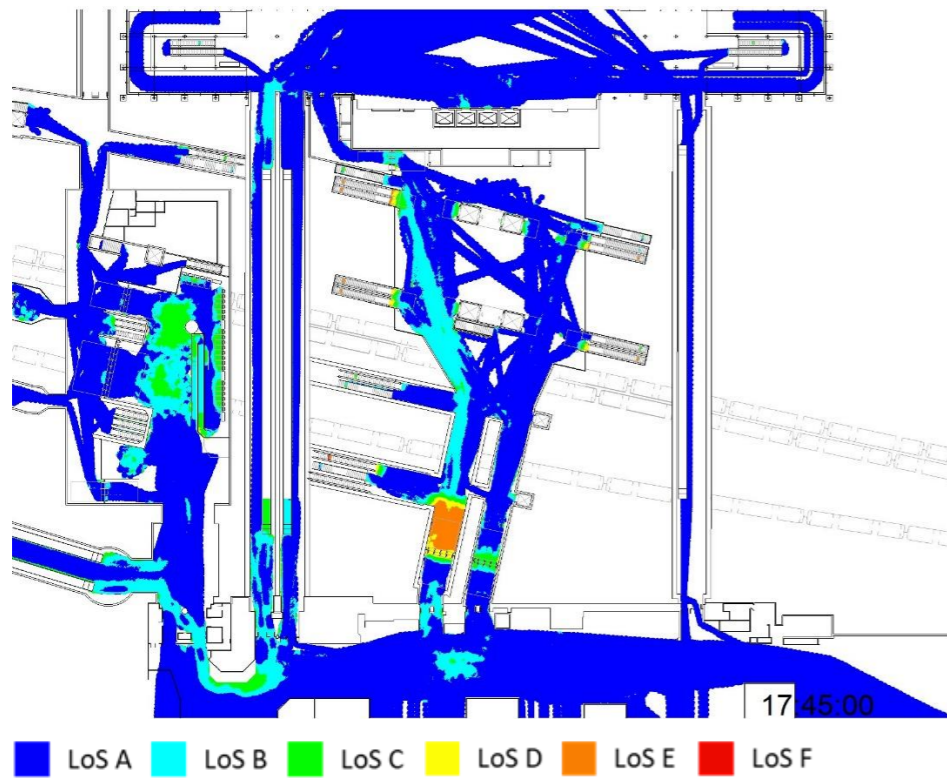


Diagram 8-26: Concourse LoS, Fruin Walkways – 2032 future baseline PM peak (17:30-17:45)

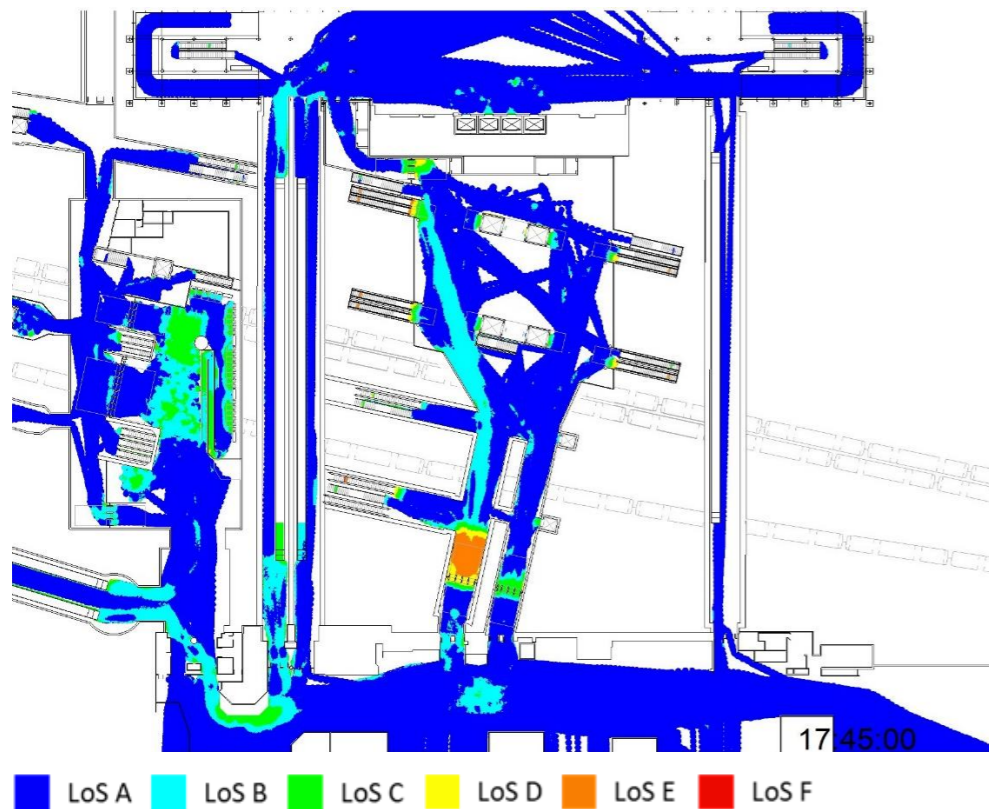


Diagram 8-27: Concourse LoS, Fruin Walkways – 2047 future baseline PM peak (17:30-17:45)

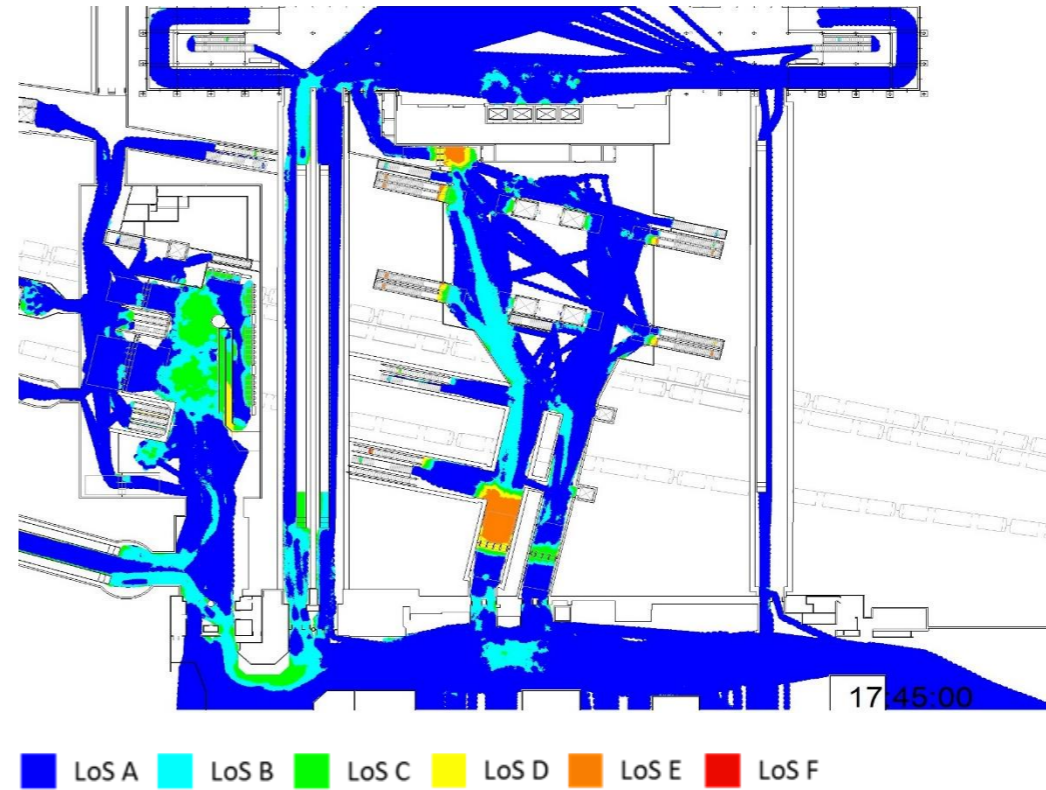


Diagram 8-28: Concourse LoS, Fruin Queues – 2029 future baseline PM peak (17:30-17:45)

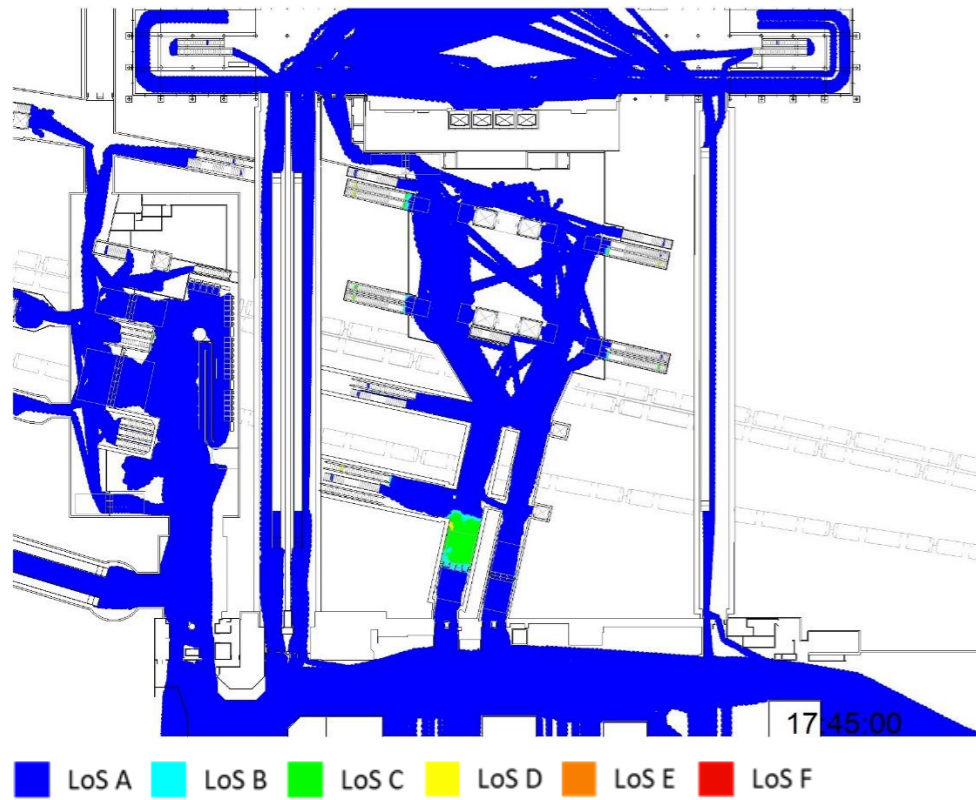


Diagram 8-29: Concourse LoS, Fruin Queues – 2032 future baseline PM peak (17:30-17:45)



Diagram 8-30: Concourse LoS, Fruin Queues – 2047 future baseline PM peak (17:30-17:45)



Diagram 8-31: Concourse LoS, Fruin Walkways – 2029 with Project PM peak (17:30-17:45)

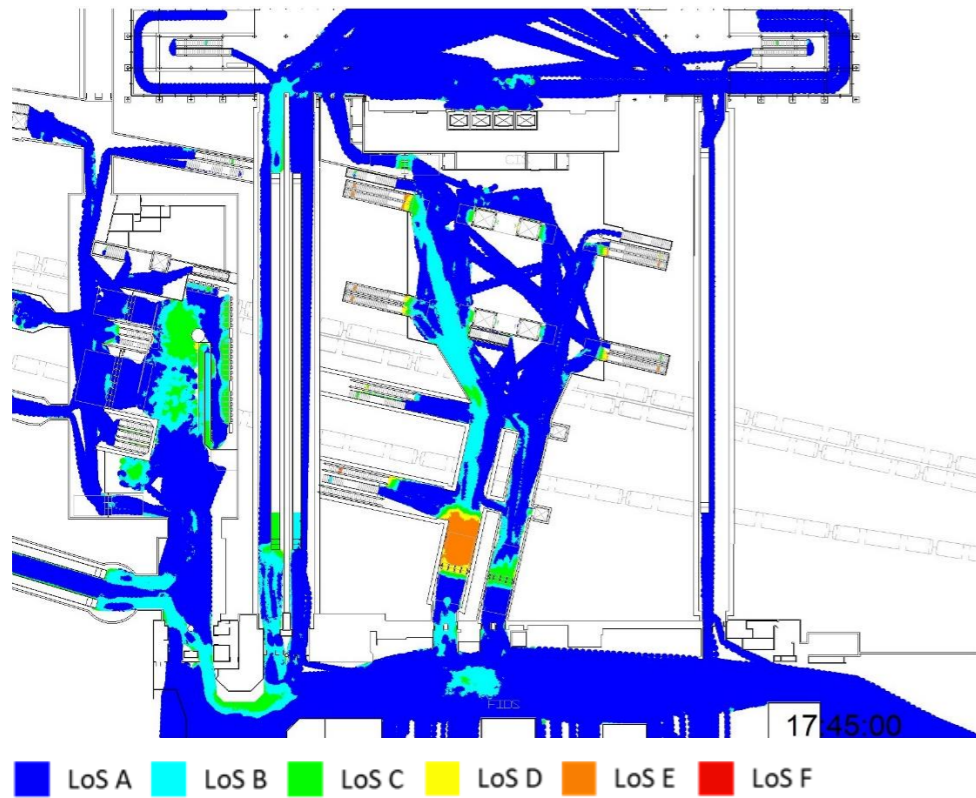


Diagram 8-33: Concourse LoS, Fruin Walkways – 2047 with Project PM peak (17:30-17:45)

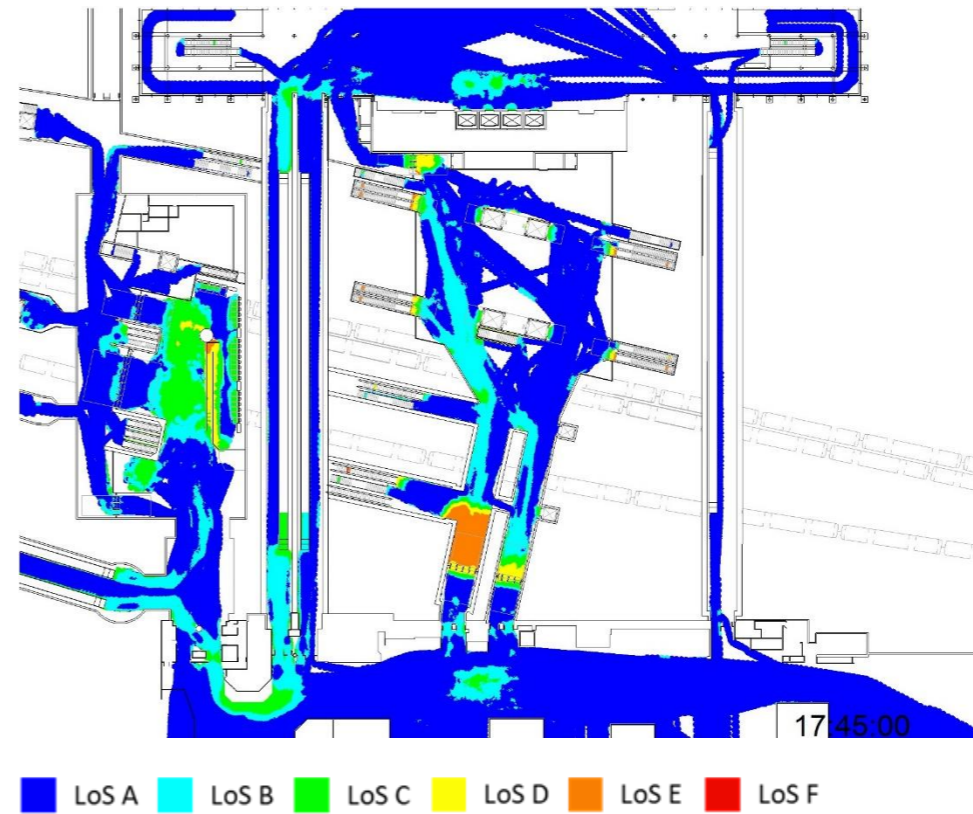


Diagram 8-32: Concourse LoS, Fruin Walkways – 2032 with Project PM peak (17:30-17:45)

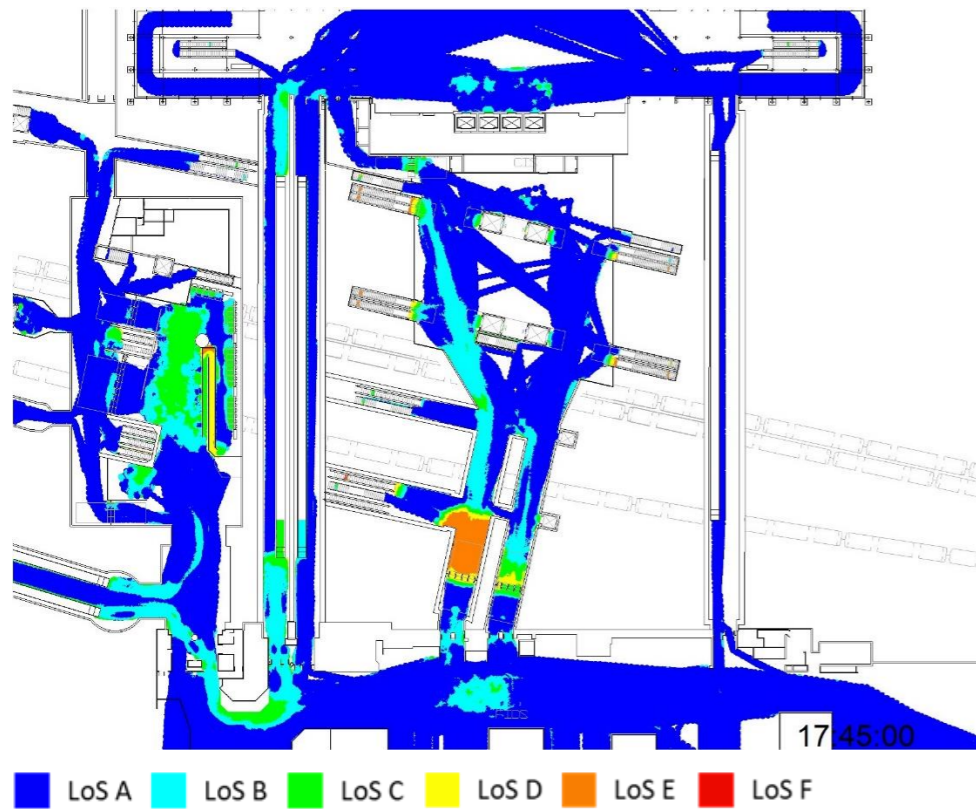


Diagram 8-34: Concourse LoS, Fruin Queues – 2029 with Project PM peak (17:30-17:45)

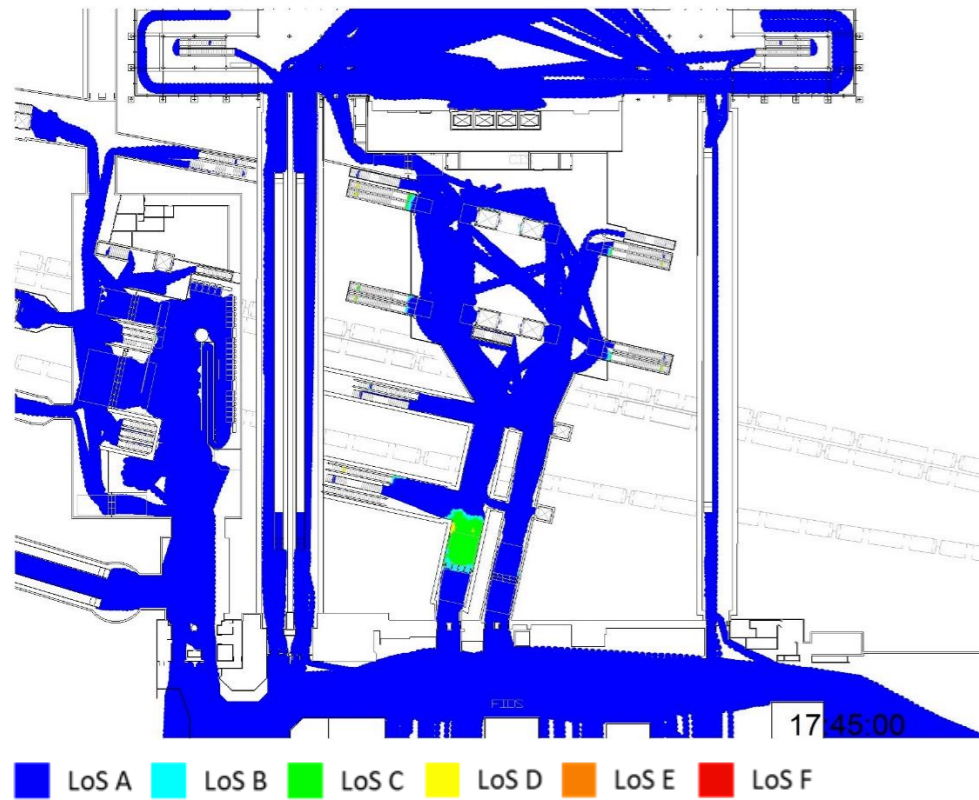


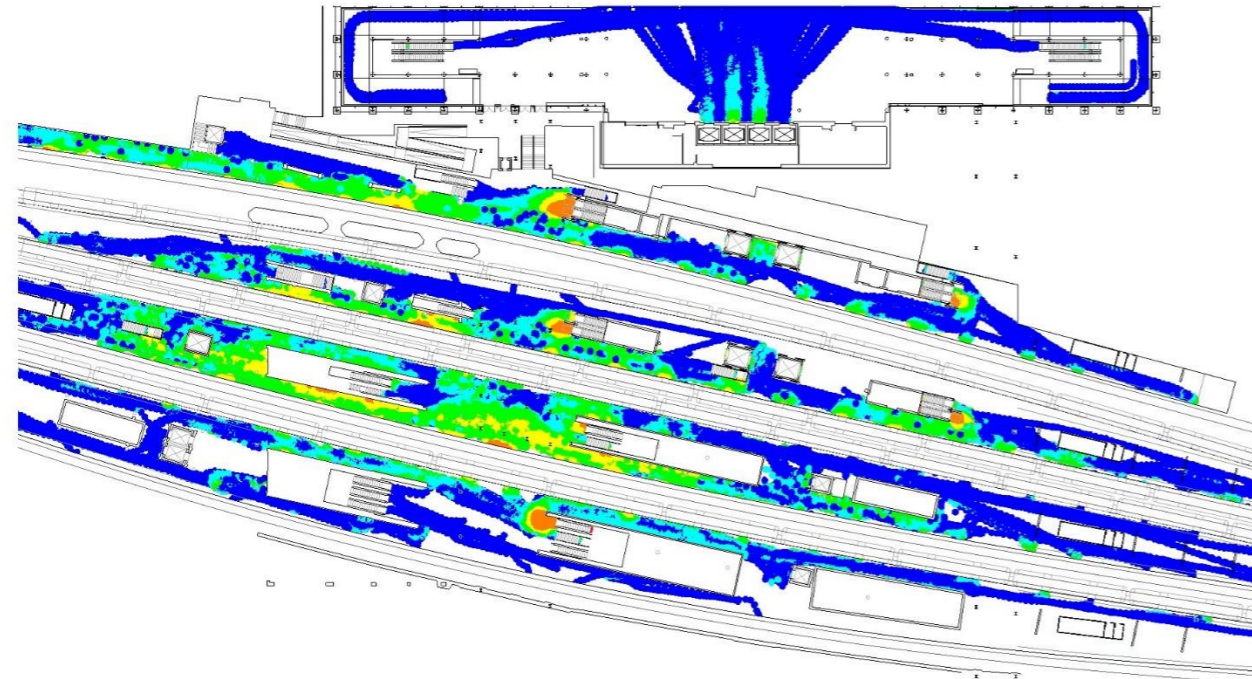
Diagram 8-35: Concourse LoS, Fruin Queues – 2032 with Project PM peak (17:30-17:45)



Diagram 8-36: Concourse LoS, Fruin Queues – 2047 with Project PM peak (17:30-17:45)

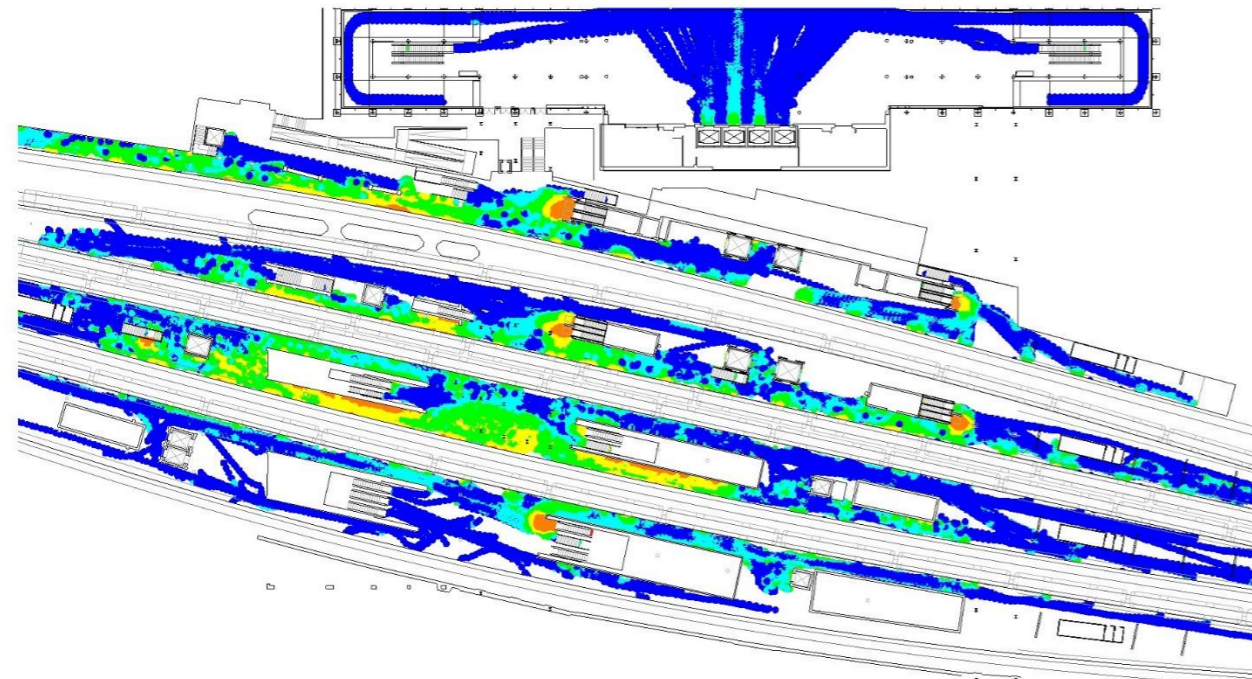


Diagram 8-37: Platform LoS, Fruin Walkways – 2029 future baseline PM peak (17:00 – 17:15)



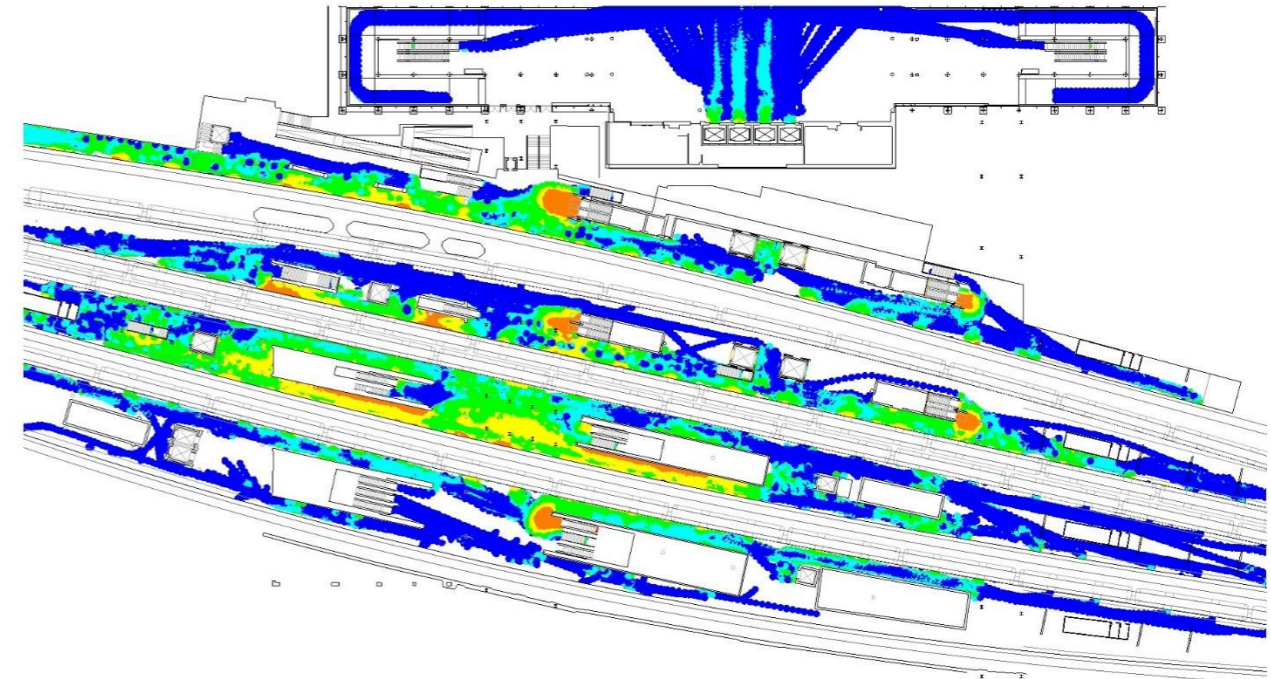
LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-38: Platform LoS, Fruin Walkways – 2032 future baseline PM peak (17:00 – 17:15)



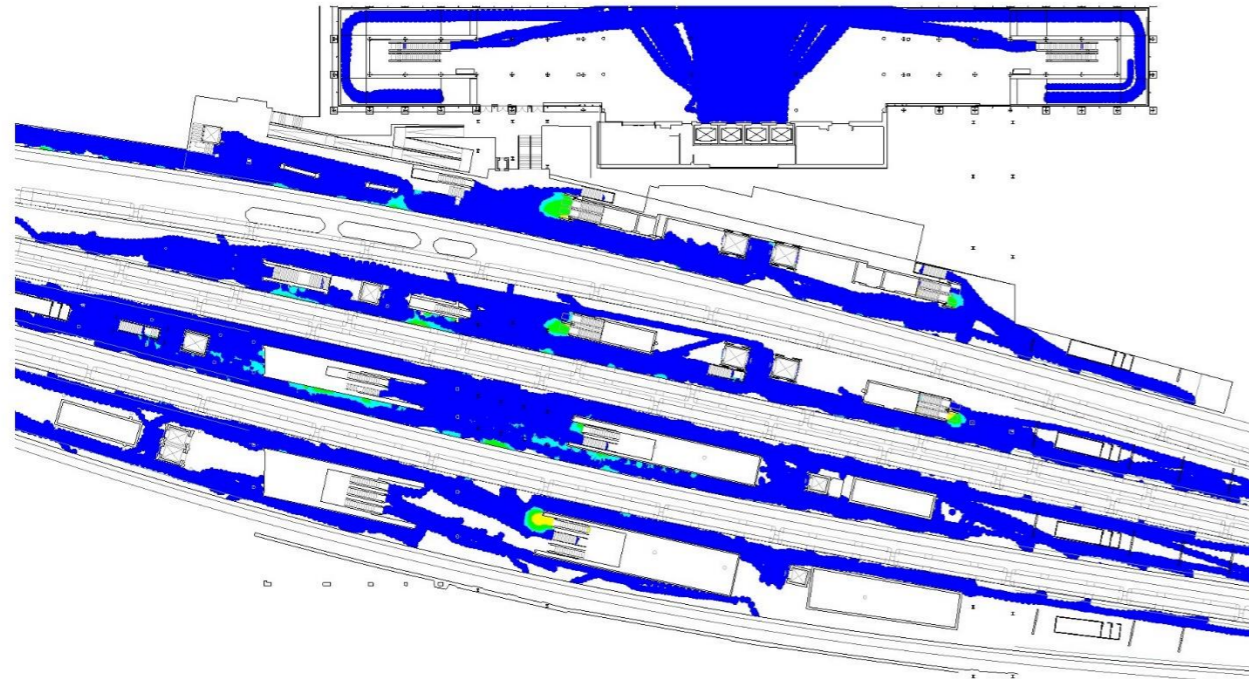
LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-39: Platform LoS, Fruin Walkways – 2047 future baseline PM peak (17:00 – 17:15)



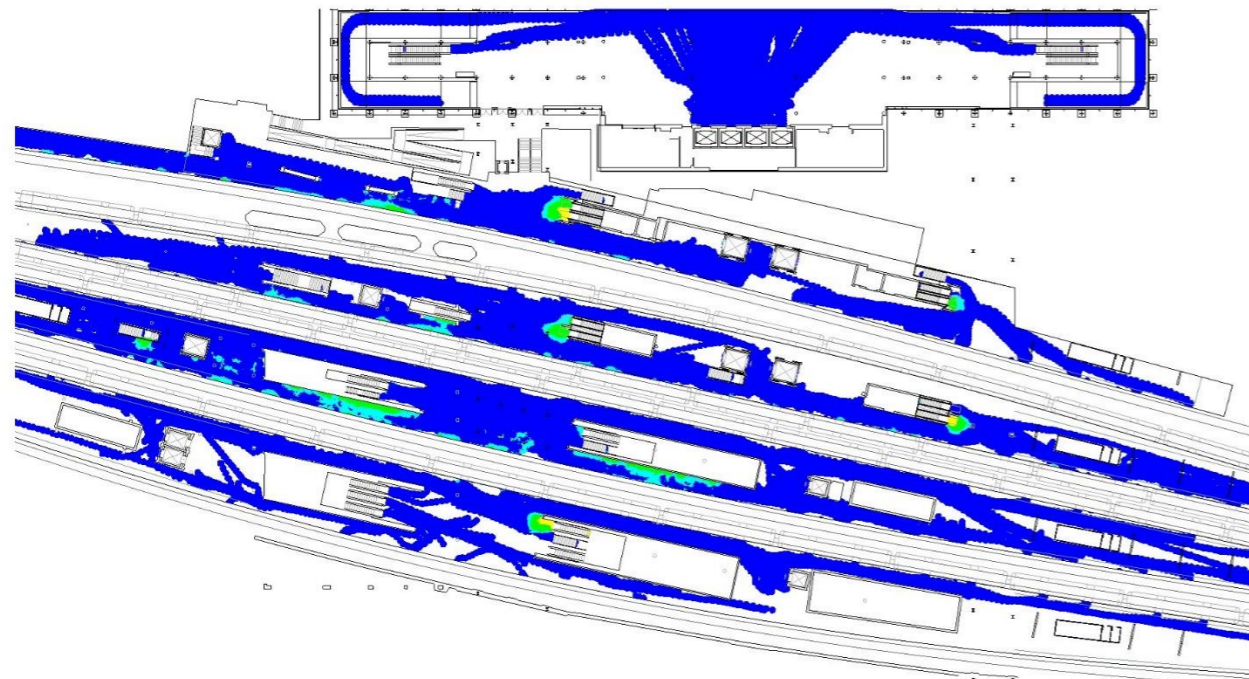
LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-40: Platform LoS, Fruin Queues – 2029 future baseline PM peak (17:00 – 17:15)



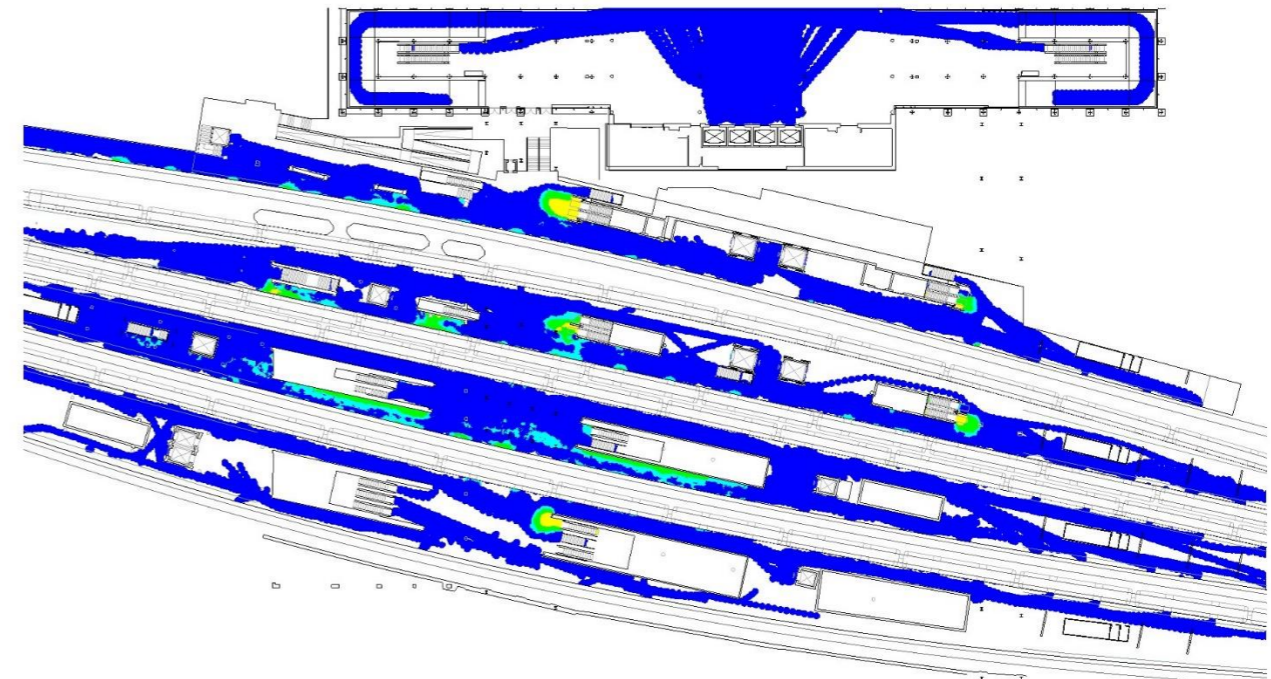
LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-41: Platform LoS, Fruin Queues – 2032 future baseline PM peak (17:00 – 17:15)



LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-42: Platform LoS, Fruin Queues – 2047 future baseline PM peak (17:00 – 17:15)



LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-43: Platform LoS, Fruin Walkways – 2029 with Project PM peak (17:00 – 17:15)

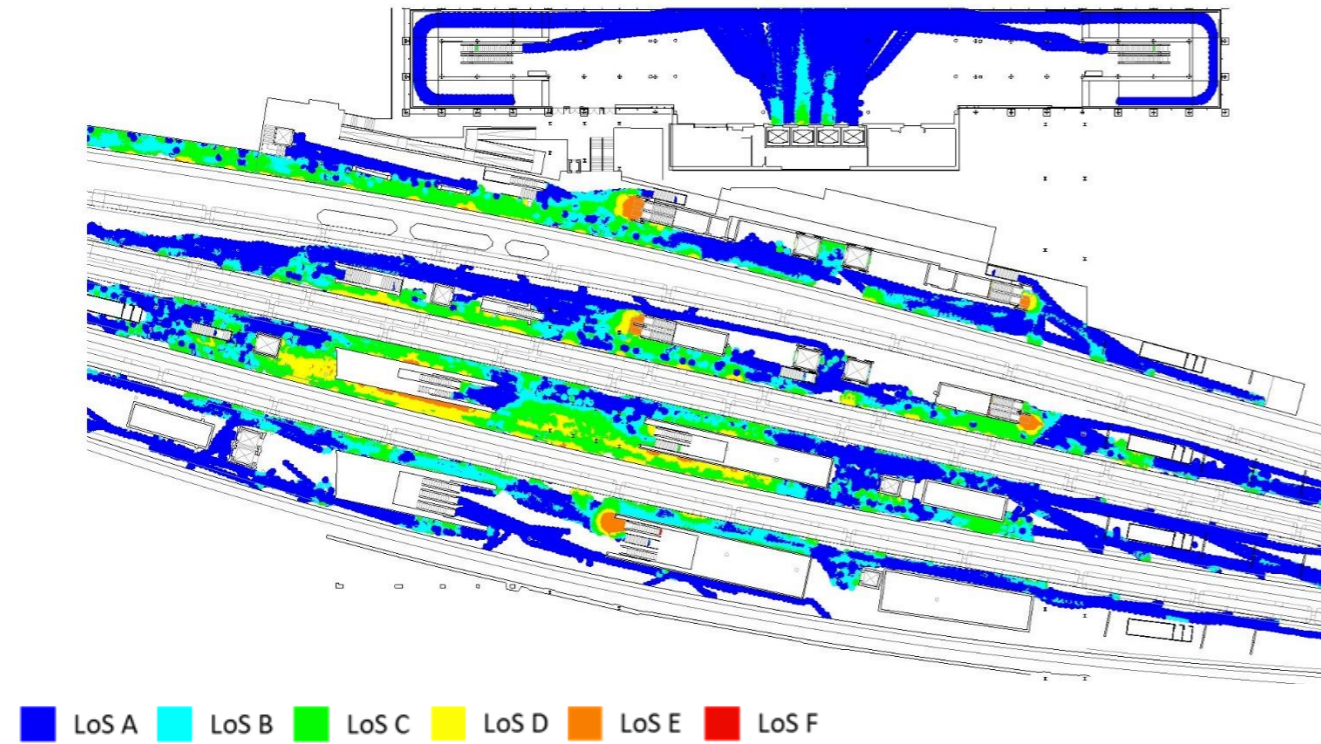


Diagram 8-45: Platform LoS, Fruin Walkways – 2047 with Project PM peak (17:00 – 17:15)

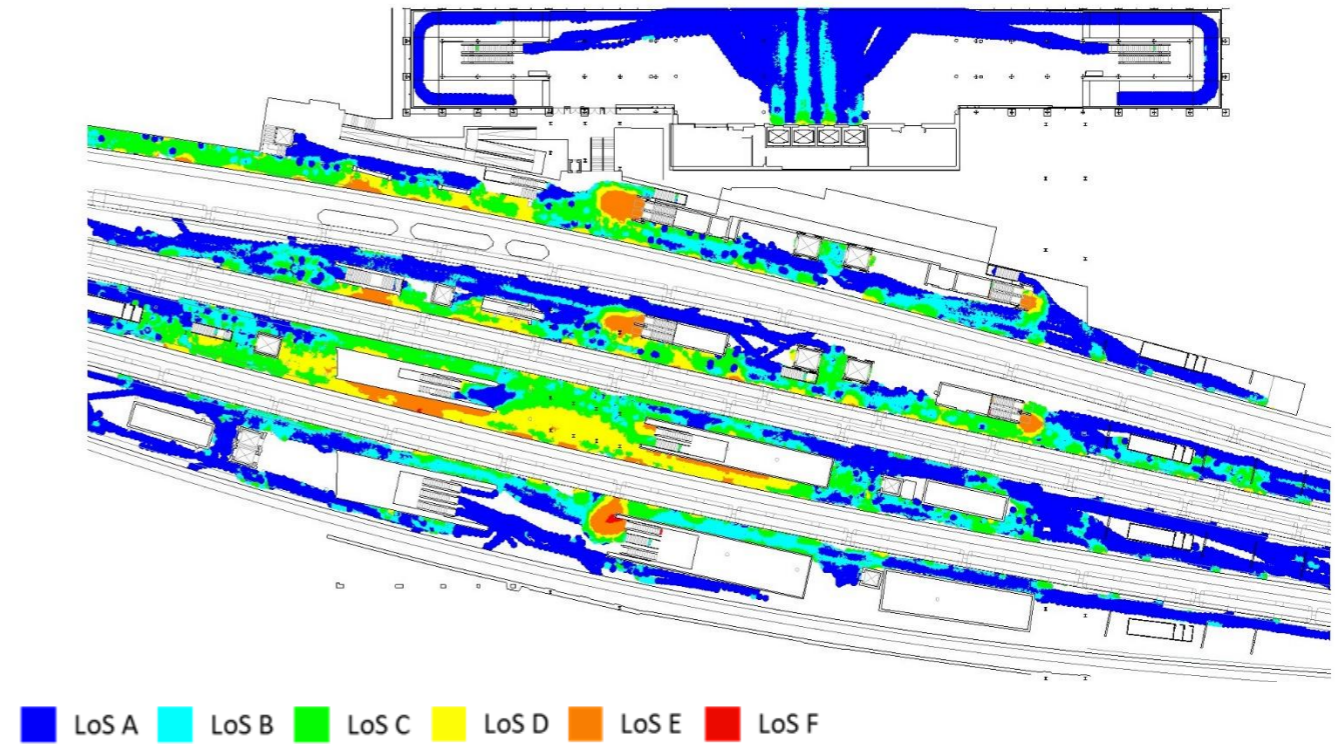


Diagram 8-44: Platform LoS, Fruin Walkways – 2032 with Project PM peak (17:00 – 17:15)

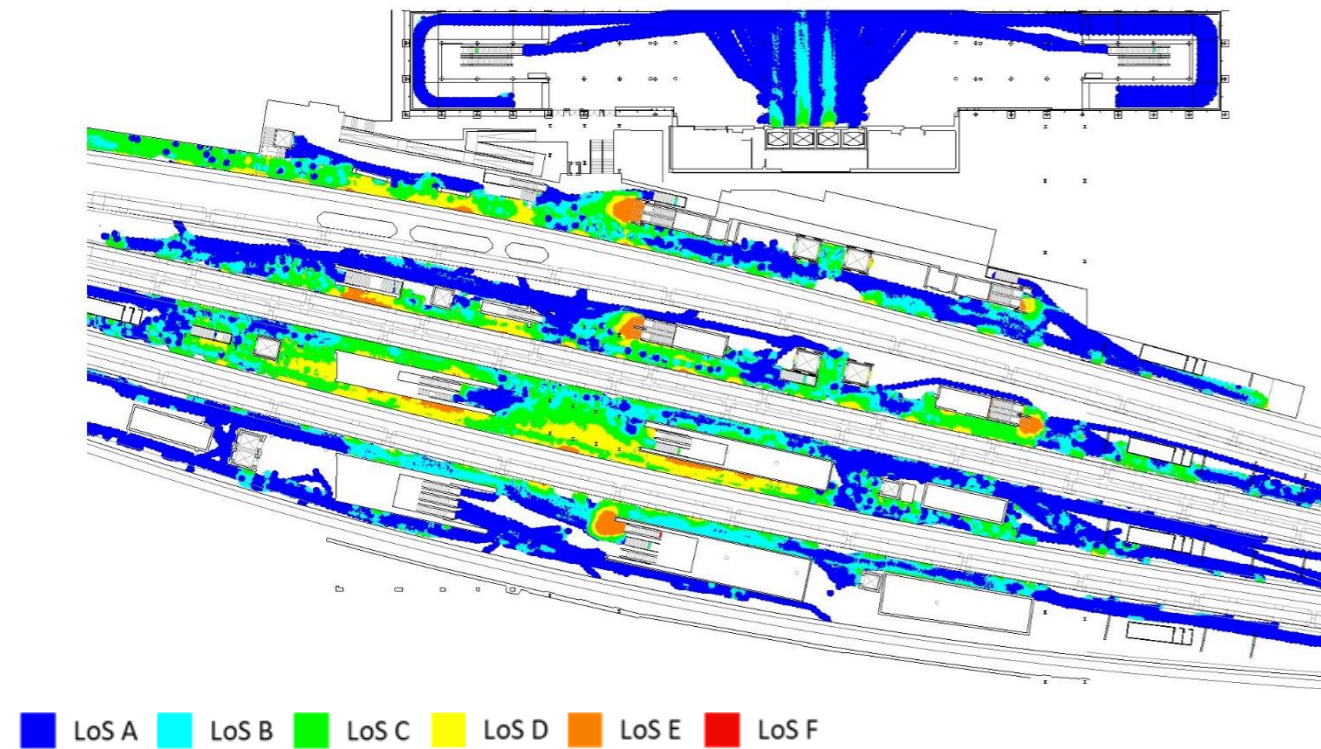
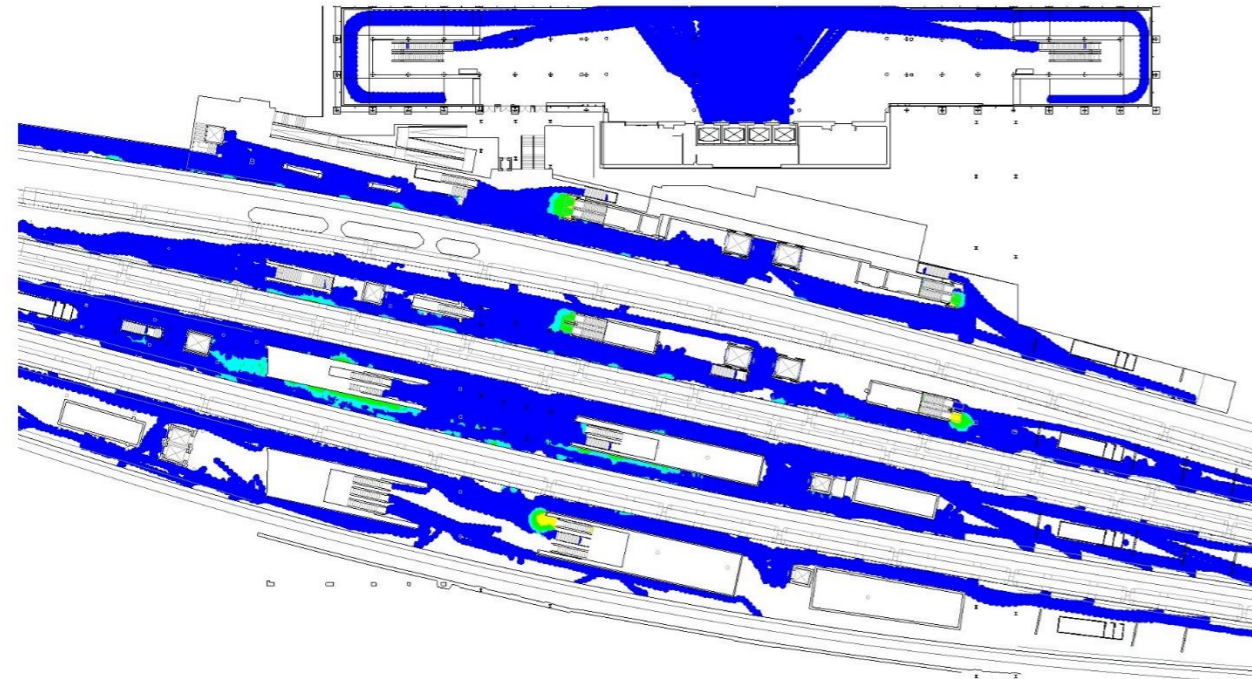
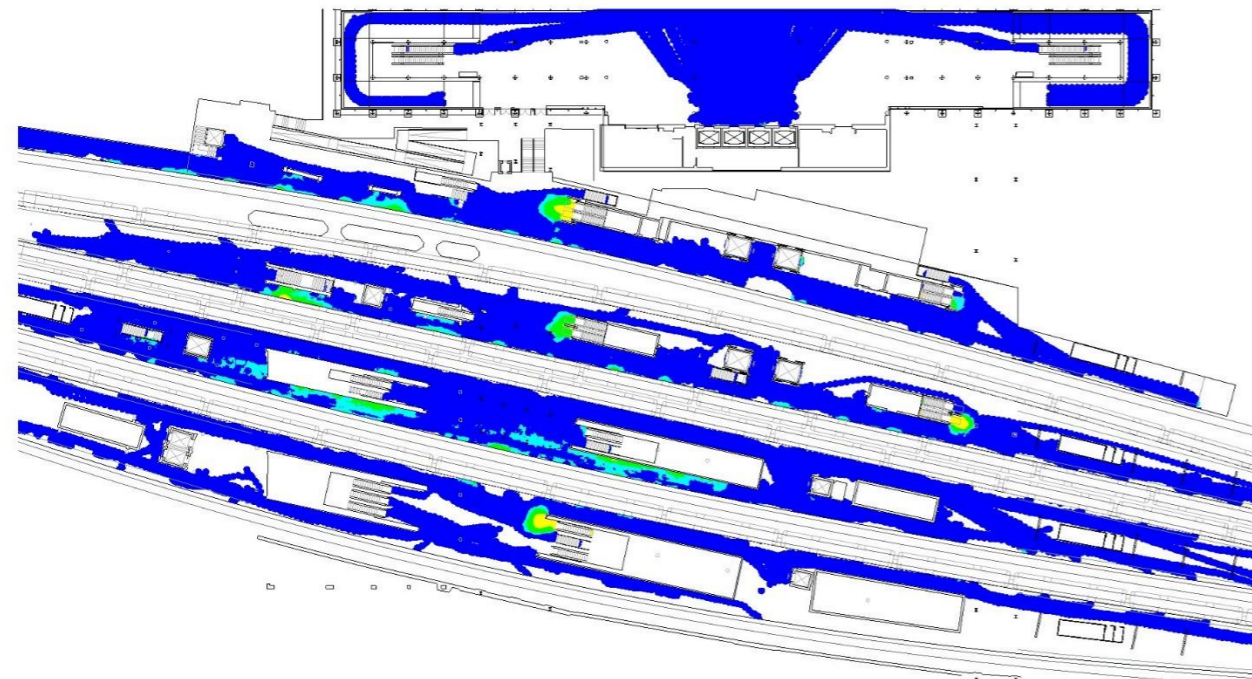


Diagram 8-46: Platform LoS, Fruin Queues – 2029 with Project PM peak (17:00 – 17:15)



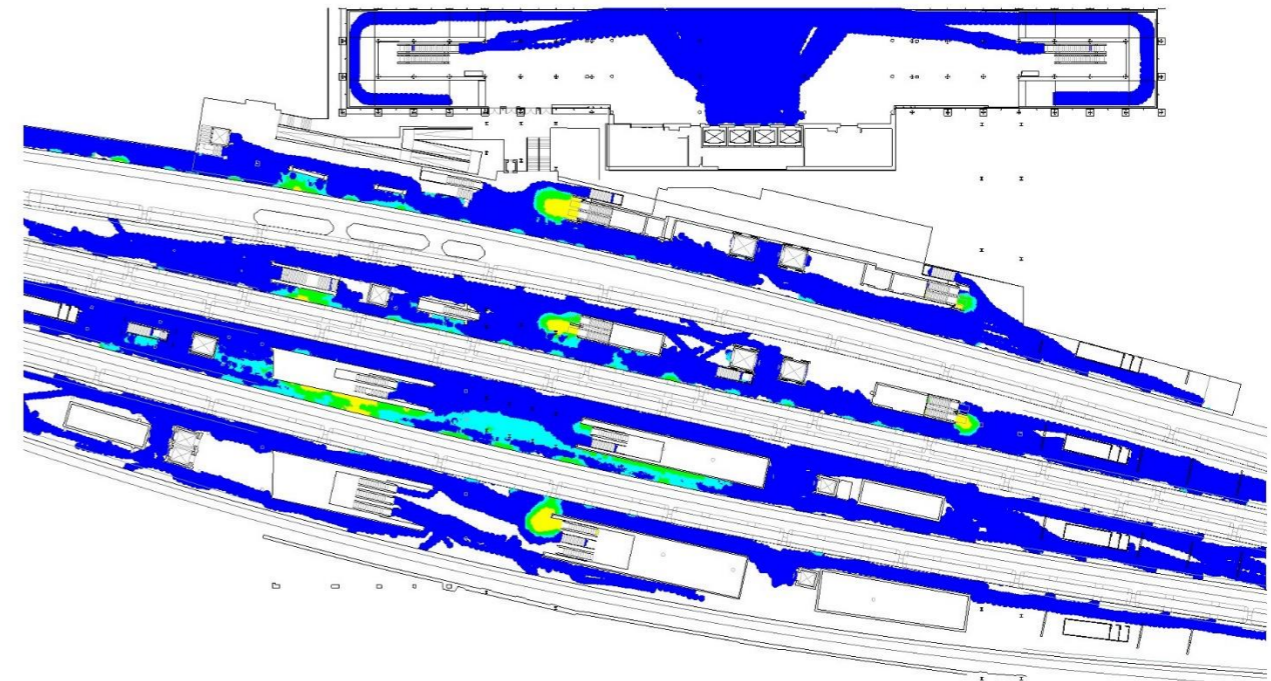
LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-47: Platform LoS, Fruin Queues – 2032 with Project PM peak (17:00 – 17:15)



LoS A LoS B LoS C LoS D LoS E LoS F

Diagram 8-48: Platform LoS, Fruin Queues – 2047 with Project PM peak (17:00 – 17:15)



LoS A LoS B LoS C LoS D LoS E LoS F

8.3 Summary of station performance

AM peak

8.3.1 The Walkways Level of Service peak hour performance across all scenarios for the Station Entry and Airport Entry concourses is shown in Diagram 8-49 and Table 8.3.1, excluding escalator elements.

8.3.2 The percentage of passenger time spent at different Level of Service ranges varies between scenarios however all future years show station performance at concourse level being predominantly LoS C or better for Walkways (85% to 93% of passenger time at LoS C or better depending on scenario)⁶. The chart and table show that there is no material difference in performance between the future baseline and with Project scenarios and that performance is generally acceptable and appropriate.

8.3.3 This is reconfirmed by the LoS Queuing outputs for the concourses in Diagram 8-50 and Table 8.3.2 which show 86% to 95% at LoS A depending on the scenario. The crowding at the gateline in the North Bridge of the Station Entry concourse is the primary cause of the 1% to 4% of passenger time spent at LoS D.

Diagram 8-49: Concourse LoS, Fruin Walkways – all scenarios, AM (07:00 – 08:00)

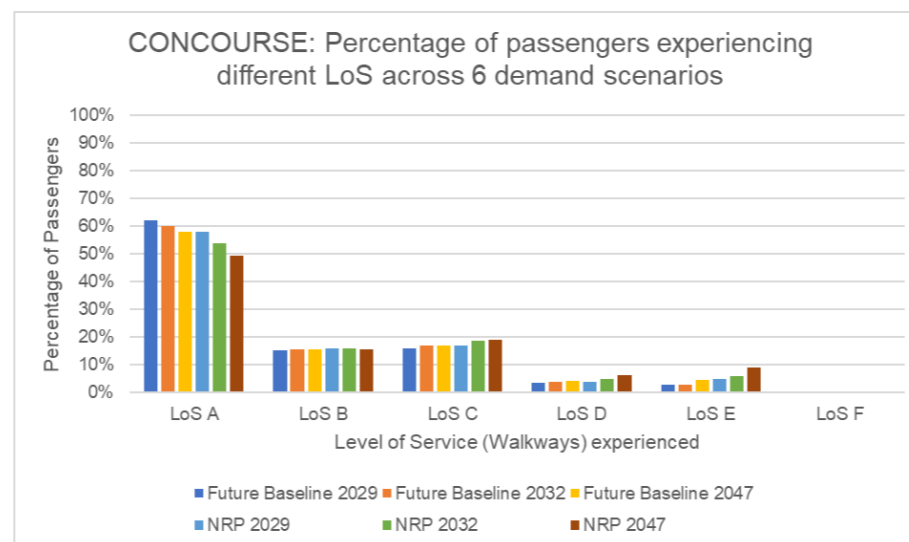


Table 8.3.1: Concourse LoS, Fruin Walkways – all scenarios, AM (07:00 – 08:00)

	AM Level of Service Walkways					
	Future baseline			Project		
	2029	2032	2047	2029	2032	2047
LoS A	62%	60%	58%	58%	54%	49%
LoS B	15%	16%	16%	16%	16%	16%
LoS C	16%	17%	17%	17%	19%	19%
LoS D	4%	4%	4%	4%	5%	6%
LoS E	3%	3%	5%	5%	6%	9%
LoS F	0%	0%	0%	0%	0%	0%

Diagram 8-50: Concourse LoS, Fruin Queueing – all scenarios, AM (07:00 – 08:00)

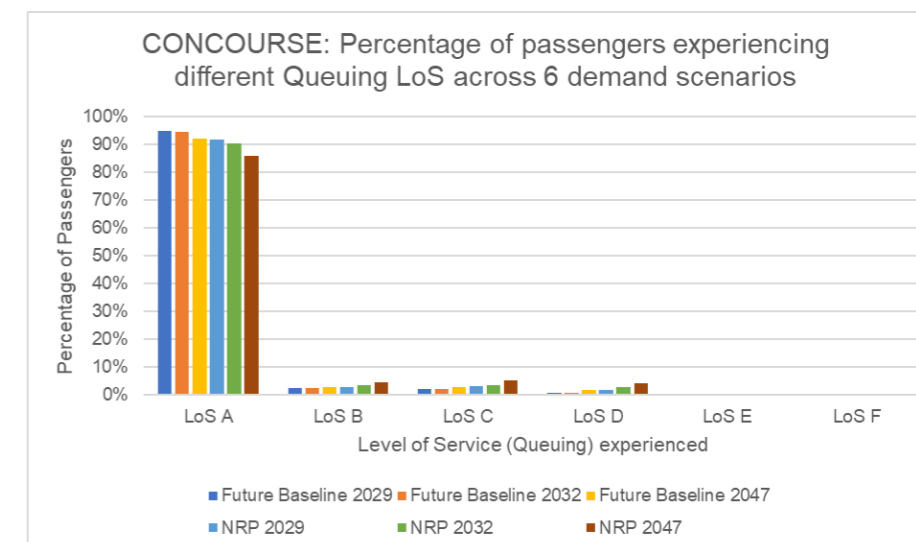


Table 8.3.2: Concourse LoS, Fruin Queueing – all scenarios, AM (07:00 – 08:00)

	AM Level of Service Queueing					
	Future baseline			Project		
	2029	2032	2047	2029	2032	2047
LoS A	95%	94%	92%	92%	90%	86%
LoS B	2%	3%	3%	3%	3%	4%
LoS C	2%	2%	3%	3%	4%	5%
LoS D	1%	1%	2%	2%	3%	4%
LoS E	0%	0%	0%	0%	0%	0%
LoS F	0%	0%	0%	0%	0%	0%

⁶ Please note tables in this section have been rounded to the nearest integer.

Diagram 8-51: Platforms LoS, Fruin Walkways – all scenarios, AM (08:00 – 09:00)

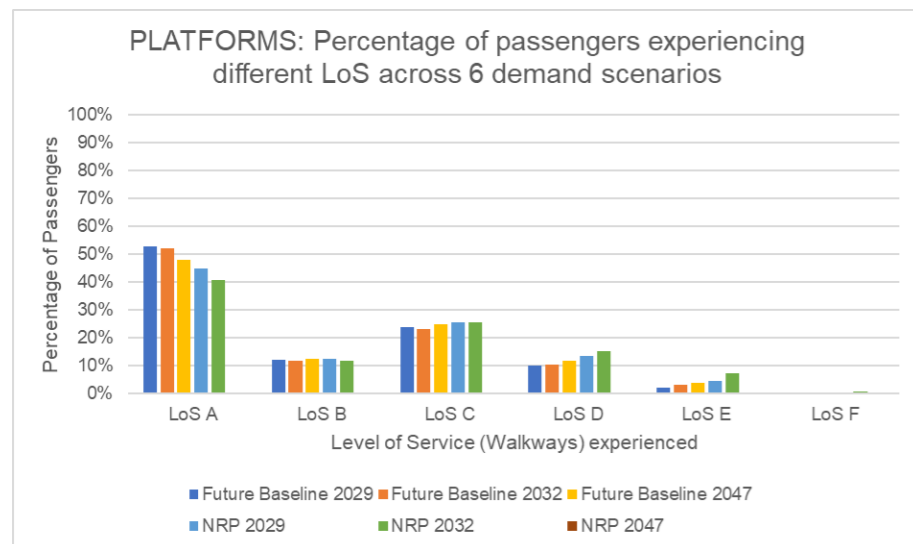
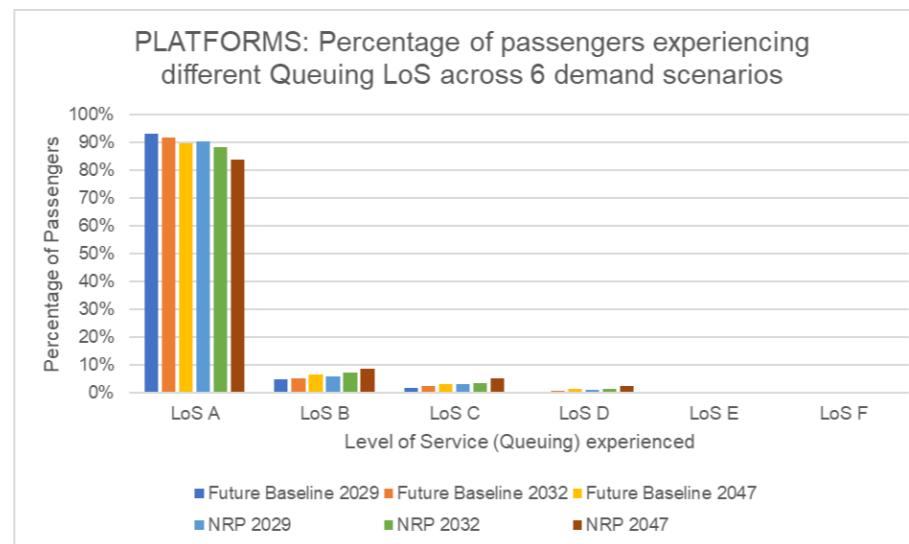


Diagram 8-52: Platforms LoS, Fruin Queuing – all scenarios, AM (08:00 – 09:00)



8.3.7

The Level of Service performance across all scenarios for the station platforms is shown in Diagram 8-52 and Table 8.3.4 using Fruin Queuing Level of Service criteria, excluding escalator-related elements. This shows performance at predominantly LoS B or better in terms of Fruin Queuing (93% to 98% of passengers depending on scenario), so the conditions are acceptable. Small areas of localised congestion do occur, with a low proportion of passenger time sent at LoS D (2% or lower depending on scenario).

Table 8.3.3: Platform LoS, Fruin Walkways – all scenarios, AM (08:00 – 09:00)

AM Level of Service Walkways						
	Future baseline			Project		
	2029	2032	2047	2029	2032	2047
LoS A	53%	52%	46%	48%	45%	40%
LoS B	12%	12%	12%	12%	12%	12%
LoS C	24%	23%	25%	25%	25%	25%
LoS D	10%	10%	12%	11%	13%	15%
LoS E	2%	3%	4%	4%	4%	7%
LoS F	0%	0%	0%	0%	0%	0%

Table 8.3.4: Platform LoS, Fruin Queuing – all scenarios, AM (08:00 – 09:00)

AM Level of Service Queuing						
	Future baseline			Project		
	2029	2032	2047	2029	2032	2047
LoS A	93%	92%	89%	90%	88%	84%
LoS B	5%	5%	6%	6%	7%	9%
LoS C	2%	2%	3%	3%	3%	5%
LoS D	0%	1%	1%	1%	1%	2%
LoS E	0%	0%	0%	0%	0%	0%
LoS F	0%	0%	0%	0%	0%	0%

8.3.4 The Walkways Level of Service performance across all scenarios for the station platforms is shown in Diagram 8-51 and Table 8.3.3, excluding escalator queuing areas and escalator elements, using a Walkways comparison, ie as if the platforms were circulation environments.

8.3.5 All future years show station performance at platform level at predominantly LoS C or better (78% to 89% of passengers experience LoS C or better depending on scenario).

8.3.6 It should be noted that platforms are considered more of a queuing environment than a typical walking environment as platforms typically have a mix of passengers waiting and standing still (essentially queuing) or walking at slower speeds to either move along or exit from the platform. To reflect this type of environment, Network Rail recommends using Fruin Queuing Level of Service for platforms, which represents a lower overall space requirement per passenger. The guidance states that platforms should perform at Queuing LoS B/C or 0.93 m² per person or better.

PM peak

8.3.8 The Walkways Level of Service peak hour performance across all scenarios for the Station Entry and Airport Entry concourses is shown in Diagram 8-53 and Table 8.3.5, excluding escalator elements.

8.3.9 The percentage of passengers experiencing different Level of Service ranges varies between scenarios however all future years show station performance at concourse level being predominantly LoS C or better for Walkways (81% to 91% of passengers experience LoS C or better depending on scenario). The chart and table show that there is no material difference in performance between the future baseline and with Project scenarios and that performance is generally acceptable and appropriate.

8.3.10 This is reconfirmed by the LoS Queuing outputs for the concourses in Diagram 8-54 and Table 8.3.6 which show 84% to 92% at LoS A depending on the scenario. The crowding at the gateline in the North Bridge of the Station Entry concourse is the primary cause of the 2% to 5% of passenger time spent at LoS D.

Diagram 8-53: Concourse LoS, Fruin Walkways – all scenarios, PM (17:00 – 18:00)

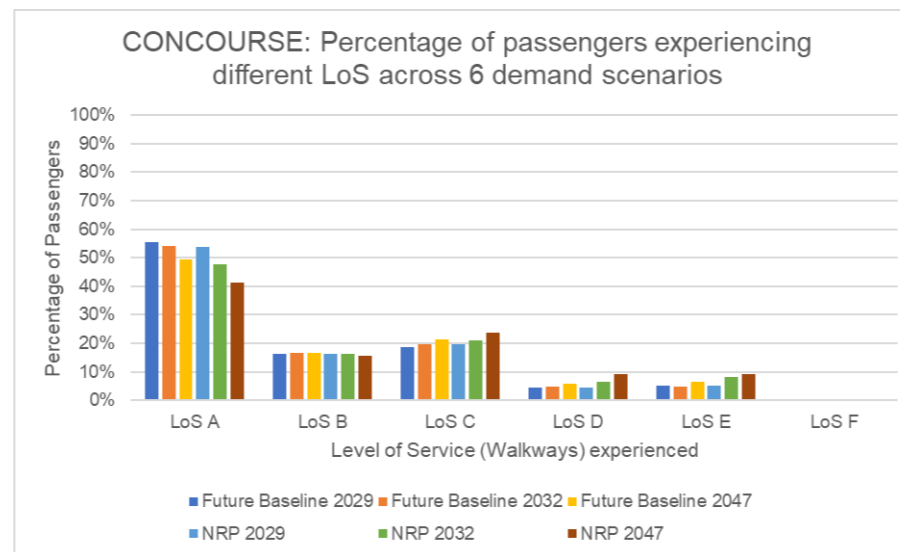


Table 8.3.5: Concourse LoS, Fruin Walkways – all scenarios, PM (17:00 – 18:00)

	PM Level of Service Walkways					
	Future baseline			Project		
	2029	2032	2047	2029	2032	2047
LoS A	55%	54%	49%	54%	48%	41%
LoS B	16%	17%	17%	16%	16%	16%
LoS C	20%	20%	21%	20%	21%	24%
LoS D	4%	5%	6%	5%	6%	9%
LoS E	5%	5%	6%	5%	8%	9%
LoS F	0%	0%	0%	0%	0%	1%

Diagram 8-54: Concourse LoS, Fruin Queueing – all scenarios, PM (17:00 – 18:00)

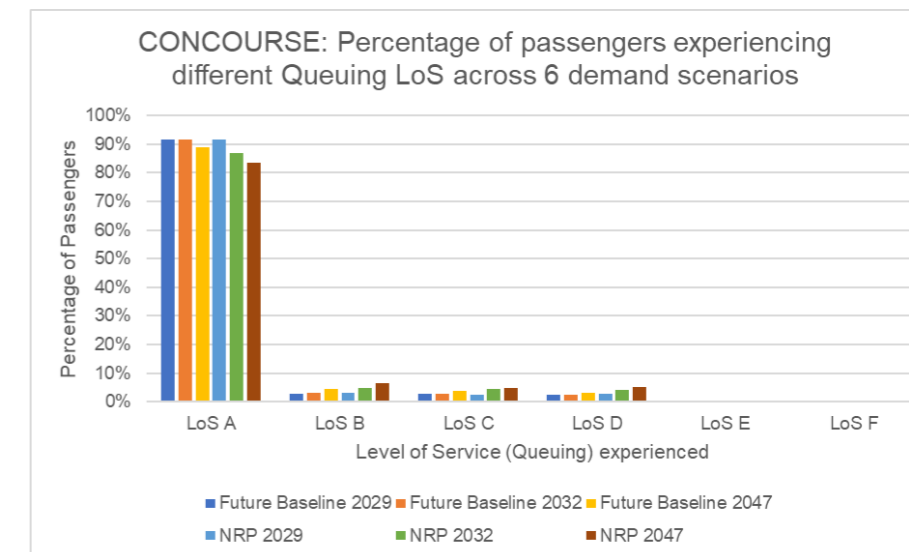


Table 8.3.6: Concourse LoS, Fruin Queueing – all scenarios, PM (17:00 – 18:00)

	PM Level of Service Queueing					
	Future baseline			Project		
	2029	2032	2047	2029	2032	2047
LoS A	92%	92%	89%	91%	87%	84%
LoS B	3%	3%	4%	3%	5%	7%
LoS C	3%	3%	4%	3%	4%	5%
LoS D	3%	2%	3%	3%	4%	5%
LoS E	0%	0%	0%	0%	0%	0%
LoS F	0%	0%	0%	0%	0%	0%

Diagram 8-55: Platforms LoS, Fruin Walkways – all scenarios, PM (17:00 – 18:00)

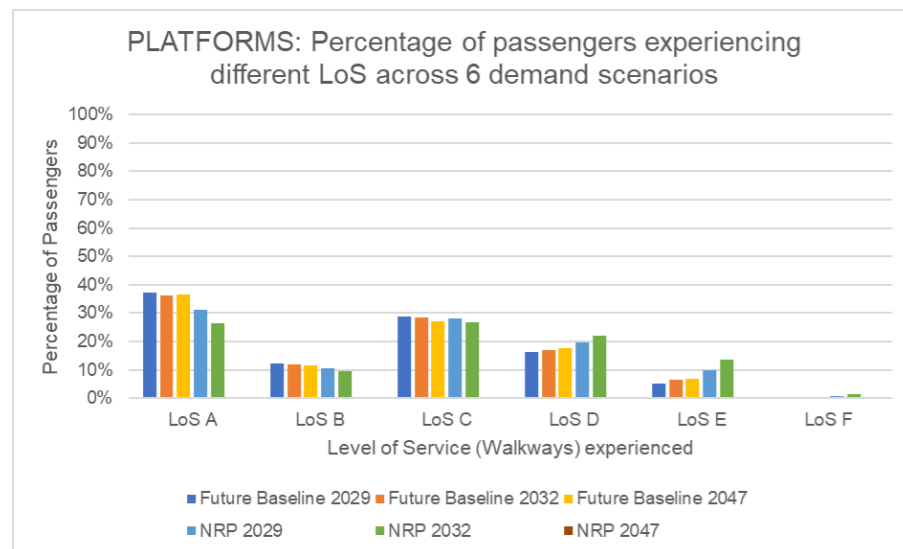
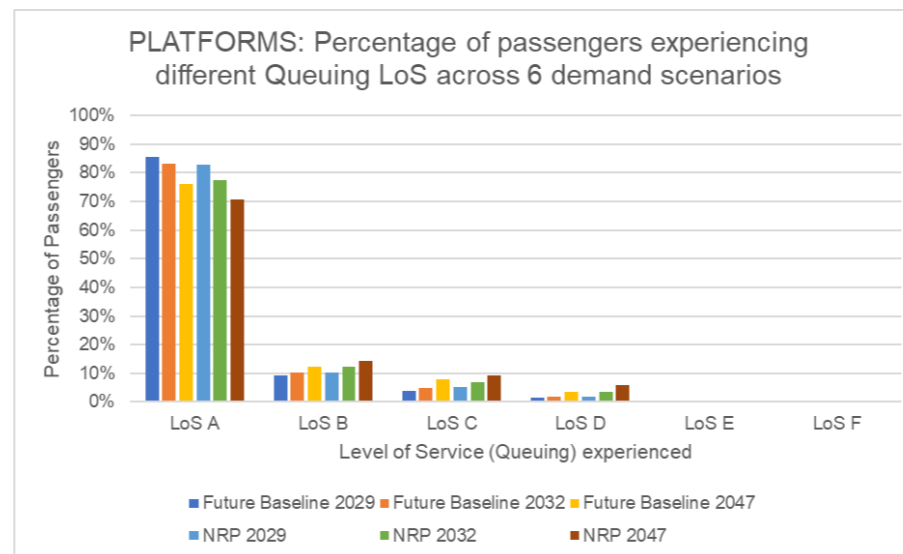


Diagram 8-56: Platforms LoS, Fruin Queuing – all scenarios, PM (17:00 – 18:00)



Fruin Queuing Level of Service criteria, excluding escalator-related elements. This shows performance at predominantly LoS B or better in terms of Fruin Queuing (85% to 95% of passengers depending on scenario), so the conditions are acceptable. Small areas of localised congestion do occur, with a low proportion of passenger time sent at LoS D (6% or lower depending on scenario).

Table 8.3.7: Platform LoS, Fruin Walkways – all scenarios, PM (17:00 – 18:00)

PM Level of Service Walkways						
	Future baseline			Project		
	2029	2032	2047	2029	2032	2047
LoS A	37%	36%	31%	36%	31%	26%
LoS B	12%	12%	10%	12%	11%	10%
LoS C	29%	28%	27%	27%	28%	27%
LoS D	16%	17%	20%	18%	20%	22%
LoS E	5%	6%	11%	7%	10%	14%
LoS F	0%	0%	1%	0%	1%	1%

Table 8.3.8: Platform LoS, Fruin Queuing – all scenarios, PM (17:00 – 18:00)

PM Level of Service Queuing						
	Future baseline			Project		
	2029	2032	2047	2029	2032	2047
LoS A	86%	83%	76%	83%	77%	71%
LoS B	9%	10%	12%	10%	12%	14%
LoS C	4%	5%	8%	5%	7%	9%
LoS D	1%	2%	4%	2%	4%	6%
LoS E	0%	0%	0%	0%	0%	0%
LoS F	0%	0%	0%	0%	0%	0%

8.3.11 The Walkways Level of Service performance across all scenarios for the station platforms is shown in Diagram 8-55 and Table 8.3.7, excluding escalator queuing areas and escalator elements, using a Walkways comparison, ie as if the platforms were circulation environments.

8.3.12 All future years show station performance at platform level at predominantly LoS C or better (63% to 78% of passengers experience LoS C or better depending on scenario).

8.3.13 However, it should be noted that platforms are considered more of a queuing environment than a typical walking environment as platforms typically have a mix of passengers waiting and standing still (essentially queuing) or walking at slower speeds to either move along or exit from the platform. To reflect this type of environment, Network Rail recommends using Fruin Queuing Level of Service for platforms, which represents a lower overall space requirement per passenger. The guidance states that platforms should perform at Queuing LoS B/C or 0.93 m² per person or better.

8.3.14 The Level of Service performance across all scenarios for the station platforms is shown in Diagram 8-56 and Table 8.3.8 using

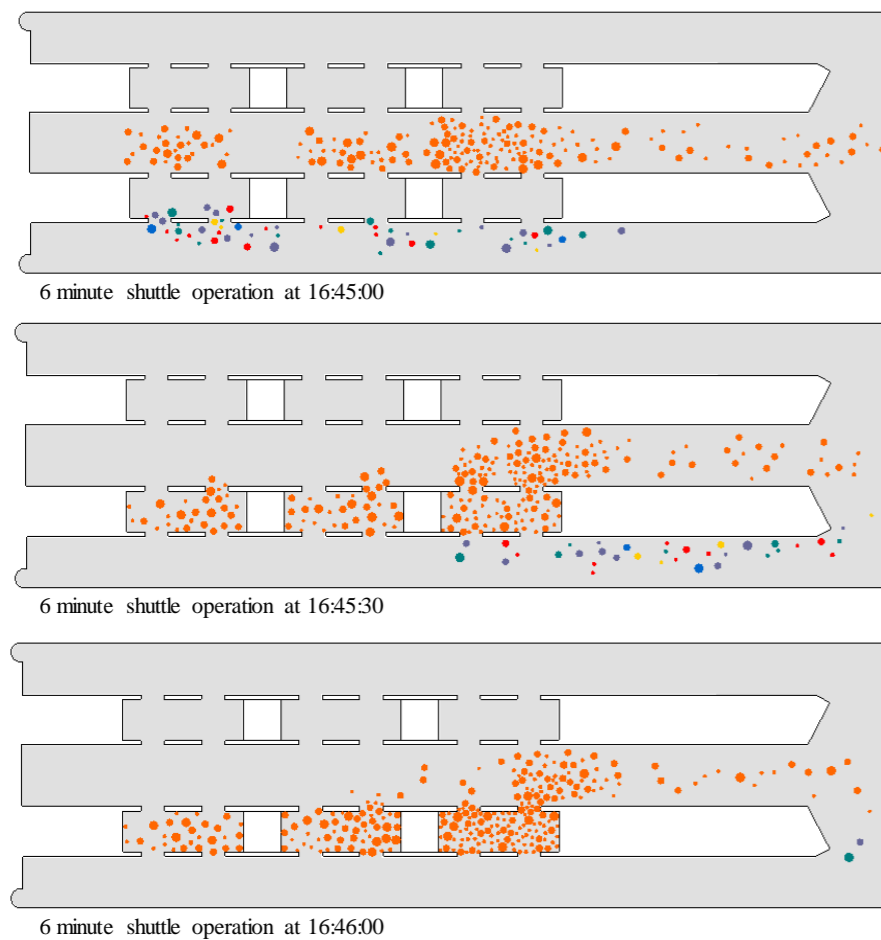
8.4 Shuttle station

2047 with Project

8.4.1 Modelling to 2047 with the Project shows that the boarding platform of the shuttle stations, particularly at the South Terminal, can become congested at peak times and that congestion blocks the platform and prevents full use of shuttle capacity.

8.4.2 Diagram 8-57 shows platform loading in 2047 assuming a 6-minute shuttle headway, which is the current peak frequency (which with two trains each operating on their own track, means that passengers never wait more than 3 minutes for a train at peak times).

Diagram 8-57: Shuttle platform loading, PM peak (16:45 – 16:46), 6 minute headway



8.4.3 The first image shows peak passenger queuing on the boarding platform just before the shuttle doors open. The second image shows passengers moving to the shuttle car closest to them and

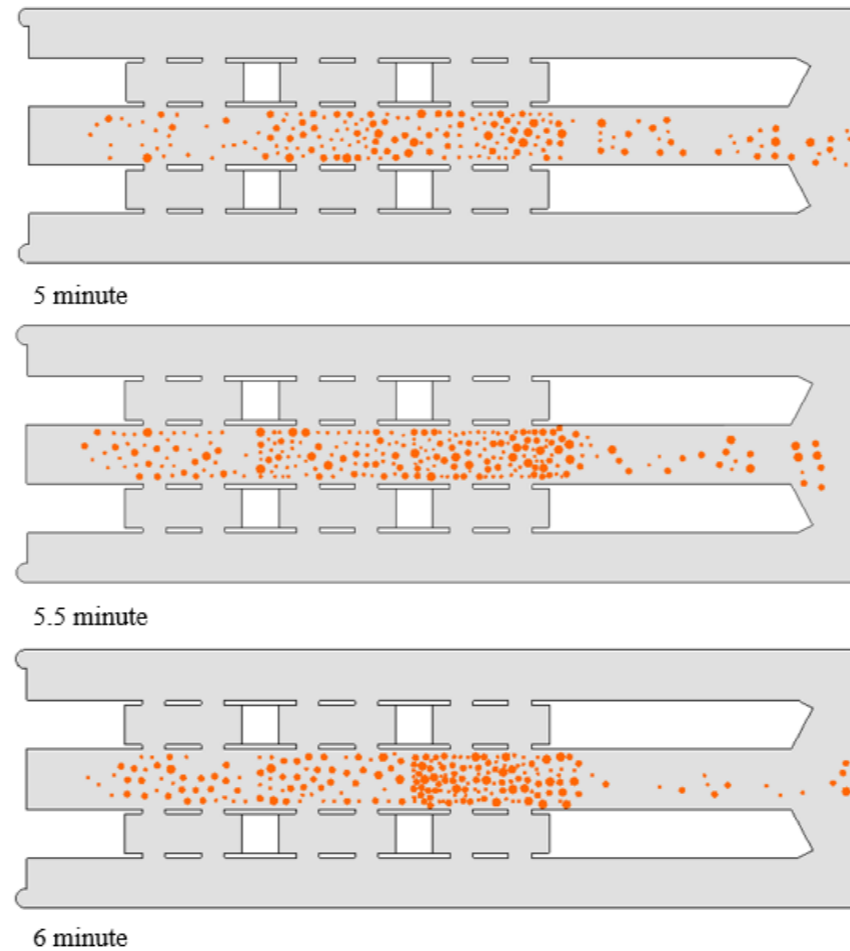
boarding. The final image shows the spare capacity in the northern car with the remaining passengers left on the platform at the southern end. These are predominantly passengers who have just arrived on the boarding platform at the southern end of the South Terminal shuttle station.

2047 with Project and potential amendments

Changing shuttle headway

8.4.4 The shuttle operation has therefore been assessed to see what the impact of 5, 5.5 and 6-minute shuttle headways will have on crowding levels at the shuttle boarding platforms.

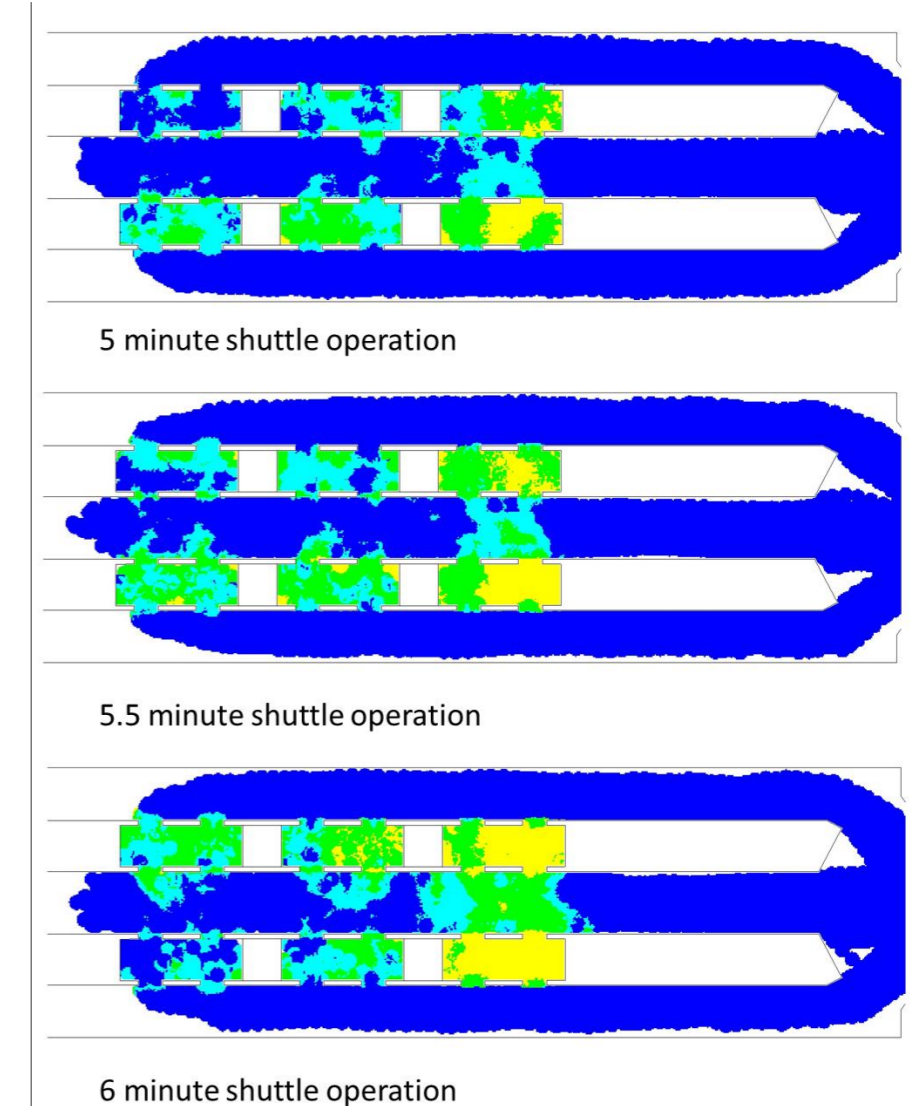
Diagram 8-58: Shuttle platform loading, PM peak (16:45 – 16:46), various headways



8.4.5 As can be seen from Diagram 8-58, the busyness at the southern end of the platform and in the southern shuttle car is reduced with a shorter headway. This is reaffirmed by the Level of Service analysis in Diagram 8-59 which shows reduced congestion and improvement to LoS B on the boarding platform with a 5-minute headway.

8.4.6 Analysis shows that this reduction in congestion leads to a more efficient loading of the shuttle.

Diagram 8-59: Shuttle platform Level of Service, Fruin Queuing, PM peak (16:45 – 16:46), various headways



Four-car shuttle operation

8.4.7 Additionally, a test model considers the impact of the shuttle comprising four cars rather than the current configuration of three cars, ie a potential 33% uplift in capacity, to understand what this enhancement might provide. This analysis shows that adding an additional shuttle car reduces density and number of passengers left on the platform during the peak period as per the Level of Service comparison between 3 car and 4 car operations in Diagram 8-61. However, no discernible improvement occurs outside of the peak period and indeed the peak benefits are nominal, owing to congestion on the boarding platform preventing full and even utilisation of the fourth car, as shown in Diagram 8-60.

Diagram 8-60: Shuttle crowding 6-minute headway – 4 cars

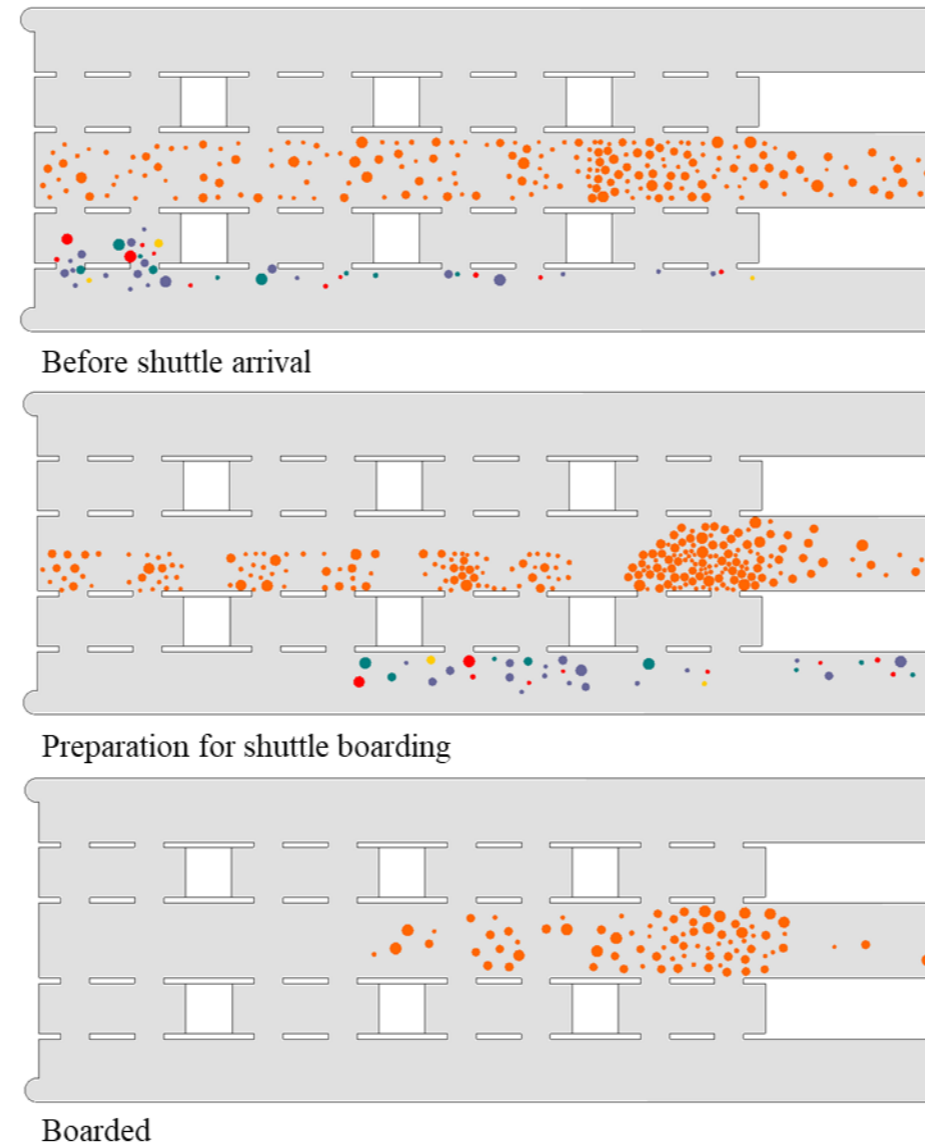
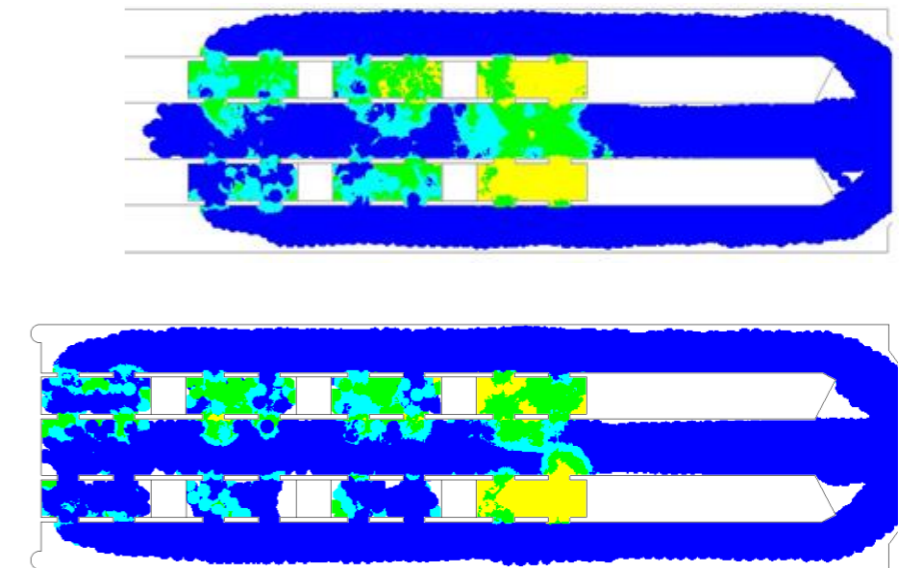


Diagram 8-61: Shuttle Level of Service, 6 minute headway – comparison of 3 and 4 car operations



9 Conclusion

9.1.1 Gatwick Airport has developed a suite of transport models to inform development of a sustainable surface access strategy for the future of the airport. The models enable different travel policies at the airport to be assessed to help reduce the impact of increased passenger demand on the surface transport network.

9.1.2 This Station and Shuttle Legion Modelling Report describes work undertaken to demonstrate the performance of the railway station and the inter-terminal shuttle at different assessment years, using a base model provided to GAL by Network Rail.

9.1.3 The Legion model takes rail demand from Gatwick's multi-modal strategic transport model to inform usage of the station.

9.1.4 Improvements to Gatwick Station are the subject of a separate consenting process, with a planning application submitted by Network Rail to Crawley Borough Council in April 2018. Consent has been granted and these improvements are currently under construction and will be complete by the time the Project is operational. Construction works are currently scheduled to finish in 2023. Accordingly, the above works form the basis of the Legion model used for testing the impact of the Project.

9.1.5 Analysis and modelling with the Project to 2047 shows that no major improvements will be required to the railway station concourse or platforms beyond these works.

Assessment criteria

9.1.6 The analysis has been undertaken against Network Rail's Station Capacity Planning Design Manual (December 2021). The assessment of crowding is based on Fruin Level of Service criteria.

9.1.7 Level of Service (LoS) is used to describe pedestrian movement, relating density of pedestrians and flow rates for walkways and

circulation areas, stairs and in waiting environments (eg platforms) or queues.

9.1.8 Criteria used in the assessment have been taken from the Network Rail guidance and include:

- concourse circulation areas – LoS C Walkways or better;
- concourse waiting areas – LoS B Queuing or better;
- gateline queues – LoS D Queuing or better; and
- platforms – LoS B/C Queuing or better

Station performance, AM peak

9.1.9 In the AM peak, modelling shows station performance at concourse level being predominantly LoS C or better for Walkways (85% to 93% of passenger time at LoS C or better depending on scenario) and LoS A Queuing (86% to 95% of passengers at LoS A depending on scenario), meaning acceptable conditions.

9.1.10 One location where congestion does occur is the gateline in the North Bridge of the Station Entry concourse and this is the main cause of passenger time spent at LoS D Queuing by 2047 with Project (up to 4% of passenger time in the AM peak as compared to 2% in 2047 in the future baseline). This level of queuing at LoS D is acceptable as it is only for short periods, with flows being one-way and other circulation routes being unaffected.

9.1.11 The modelling shows station performance at platform level being predominantly LoS B or better in terms of Fruin Queuing (93% to 98% of passengers depending on scenario), meaning acceptable conditions. Small areas of localised congestion do occur, with a low proportion of passenger time spent at LoS D (3% or lower depending on scenario).

Station performance, PM peak

9.1.12 In the PM peak, modelling shows station performance at concourse level being predominantly LoS C or better for Walkways (81% to 91% of passengers experience LoS C or

better depending on scenario) and LoS A Queuing (84% to 92% of passengers at LoS A depending on scenario).

9.1.13 As in the AM peak, congestion does occur at the gateline in the North Bridge of the Station Entry concourse and this is the main cause of passenger time spent at LoS D Queuing by 2047 with Project (up to 5% of passenger time in the PM peak as compared to 3% in 2047 in the future baseline). This level of queuing at LoS D is acceptable as it is only for short periods, with flows being one-way and other circulation routes being unaffected.

9.1.14 The modelling shows station performance at platform level being predominantly LoS B or better in terms of Fruin Queuing (85% to 95% of passengers depending on scenario), so acceptable conditions. Small areas of localised congestion do occur, with a low proportion of passenger time spent at LoS D (6% or lower depending on scenario).

Inter-terminal shuttle

9.1.15 Modelling to 2047 with the Project shows that the boarding platform of the shuttle stations, particularly at the South Terminal, can become congested at peak times and that congestion blocks the platform and prevents full use of shuttle capacity. Analysis indicates that reducing the headway of the system from 6 minutes down to 5 minutes could have benefits by providing additional capacity. Adding a fourth car to the system does not provide an additional 33% capacity as the boarding platform remains congested unless the shuttle headway is changed. GAL therefore proposes to reduce the shuttle headway to achieve appropriate additional capacity in peak periods by 2047.

Stakeholder engagement

9.1.16 Model files and outputs have been shared with Network Rail as part of the DCO process. At a meeting held to discuss the modelling on 1 December 2022, Network Rail indicated that the modelling approach was logical and that results were expected and proportionate.