Oxford Corridor Phase 2 Pedestrian Modelling – Oxford Station

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Contents

Part A: **Executive Summary**

A.01 Project

The Network Rail Station Capacity Team were remitted to deliver an updated station capacity assessment of Oxford Station for the described future infrastructure and growth scenarios. This was done by refreshing passenger count data at the station and testing options by dynamic modelling in LEGION. The driver behind the changes is the Oxford Rail Corridor Study (ORCS), which is delivering new through platforms and services at Oxford in the future.

A.02 Incoming Data

Data for this study was gathered through a pedestrian count survey to determine passenger volumes, accompanied by an interview survey to infer the origin and destination of passengers.

The future years and infrastructure configurations were chosen as:

a) **2024 (+27.6%) do nothing;**

b) **2033 (+62.2%) Phase 2, which is the addition of a through platform 5 and a stub subway connecting the new island to the west of the station;**

c) **2050 (+106.5%) ORCS, which includes the platform 1 becoming a through platform and the extension of the stub subway through the whole station, as well as the extension of the existing footbridge to platform 1.**

For all growth scenarios, an adjustment for the roughly 7% drop off seen due to COVID-19 travel advisories which were active at the time of the survey has been included.

A.03 Analysis

For all scenarios, dynamic modelling in the software Bentley LEGION was conducted to determine the probable level of service (LOS) experienced at all parts of the station. LOS maps are available at relevant times throughout the analysis and in the appendices.

In 2024, the main observations included increased crowding around the bottom of the platform 4 stairs, queues for the main gateline and congestion along platform 3 due to the benches and structures.

By 2033, the P4 stair queueing is improved, with an alternate option available to exit the platform via the stub subway. This also provides some relief to the main gateline, which still experiences queues following large alighting loads from P1-3.

In 2050, the connected subway attracts the vast majority of alighters, resulting in crowding and queueing at the top of the subway stairs in the AM peak, at both ends of the stairs in the PM peak and significantly increased platform clearance times. The western gateline has improved performance compared to the 2033 model, as passengers can choose their preferred direction of east from the bottom of the subway stairs.

A.04 Conclusions and Recommendations

2024 - Do Nothing

A.04.01 By 2024, queueing on P4 will reach the platform edge. It is advised to provide an alternative route off the platform if phase 2 works are delayed.

A.04.02 The main gateline queues continue to back up further onto platform 3 in 2024. At this time, interventions to increase the gateline capacity or encourage more alighters to use the secondary gateline are recommended.

A.04.03 The platform furniture on P3 causes congestion. This area of the station should be decluttered by 2024.

Up to 2033 - Phase 2

A.04.04 The crowding at the bottom of the P4/5 stairs is slightly reduced in 2033, even though passenger growth has been applied, due to the alternative means of egress provided.

A.04.05 The queueing at the main gateline is slightly reduced in 2033 despite passenger growth, due to provision of the new western entrance. If possible, an effort should be made in the AM peak to direct more passengers to the secondary gateline, which experiences less queueing.

A.04.06 In 2033, there is increased congestion at the narrower locations along platforms 3 and 4 after alighting services in this part of the station. This includes the platform furniture, as well as the pinch point created by the overbridge stairs. In addition to the decluttering, any way of removing passengers from platform 3 to the north of this point, such as new stairs to a widened footbridge, would see a significant benefit.

Up to 2050 - ORCS

A.04.07 The stairs to the subway suffer significant congestion at the top in the AM peak by 2050, and at both top/bottom in the PM peak, with increased platform clearance times for P2-5. Options for beyond Phase 2 should include multiple equally attractive routes of egress. In addition, future designs should ensure a protected route of access to the platforms from the subway in the PM peak.

A.04.08 By 2050, narrower points beside buildings along each of the platforms result in crowding due to their reduced width and the need for the majority of passengers to pass through them from each alighting service. Solutions should maximise available width along the platform (e.g. non-provision of seats in these areas).

A.04.09 The main gateline to the east of the subway is by far the most attractive way to exit the station with the connected subway in 2050. A gateline as provided in the model does appear to be sufficient to deal with demand.

A.04.10 The secondary gateline has been slightly extended and moved away from the platform edge for 2050, and this copes with demand.

A.04.11 The western gateline has a reduction in demand in 2050, due to the majority of passengers to the east now using the subway rather than the western entrance, so can cope with ongoing demand.

2050 Alternate Options

A.04.12 Option A is a widened subway with two points of access from each platform, except P1, from which the majority will still exit via the secondary gateline. One stair is protected as an access route in the PM peak.

A.04.13 Option B is a widened or new footbridge with two stairs from either side, except for P1. The western stub subway remains as a way to manage entries and exits between the more popular east side and the west side.

A.04.14 Option C is a combination of a widened footbridge and a subway, allowing access to all platforms from both sides of the station and improved platform clearance times, but additional gates would be required on P1. This is our preferred option.

Part B: **Background**

B.01 Oxford Station Background

Oxford station is situated to the west of Oxford city centre and is managed by GWR. It's served by fast GWR services between London Paddington and Hereford or Great Malvern via Worcester, with a number of fast service terminating at/starting from Oxford. GWR also operate stopping services between Banbury and Reading via Didcot Parkway. CrossCountry operate services between Manchester Piccadilly/Newcastle and the south coast via Birmingham New Street. And since December 2016, Chiltern Railways have operated services between Oxford and London Marylebone.

The station is used by several different passenger groups including commuters to and from Oxford and its surroundings, tourists and other leisure travels visiting Oxford and passengers interchanging between services.

Alternations have occurred to the station layout in recent years, with more proposed in future. To accommodate the Marylebone services, two new bay platforms were provided on the east side of the station and subsequently a secondary gateline has been introduced to relieve congestion at the main gateline.

The proposed Oxford Corridor Phase 2 layout will see the introduction of another through platform on the west side of the station. A new western entrance will also be introduced with a subway linking it to the newly created platform island.

After this, the proposed Oxford Rail Corridor Study (ORCS) layout will see the easternmost bay platform extended to create a through platform on the east side of the station. This will lead to the relocation of the main station building as it stands in the way.

The drivers for these changes are aspirations to operate more services at the station, both in terms of increasing the frequency of the existing service groups and operating new services to destinations such as Milton Keynes, Bedford and Cambridge (via East West Rail), Bristol and Cowley.

B.02 Project Remit

The Network Rail Station Capacity Team (SCT) were remitted to deliver an updated station capacity assessment of the station. A number of studies have been conducted since 2014 by both the SCT and consultants, however the last time a full pedestrian count survey took place at the station was in 2015, prior to the commencement of Marylebone services and GWR's increased IET timetable upgrade. This lack of recent data presented an obstacle to providing guidance on what the station needed to accommodate passenger demand, especially in light of proposals to alter the station layout to enable new and additional services to operate.

To remedy this lack of up to date data and to provide requirements and guidance for future layout of the station, the SCT would:

- Commission a pedestrian count survey;
- Update the existing simulation model with data from the survey;
- Model the existing station layout with current and forecast demand levels to identify any congested areas;
- Model the Phase 2 and ORCS layouts with forecast demand levels to identify capacity requirements and assure that aspects of the Phase 2 layout will not become a barrier to progressing to the ORCS layout in the mid-term.

Part C: **Incoming Data**

C.01 Pedestrian Count Surveys

Pedestrian count surveys were commissioned for Oxford Station in March 2020. These surveys included passenger counts at all station entrances, gatelines and stairs. The locations of these counts are shown in figure 1.

In addition, external station counts were commissioned, including a survey which was used to determine where passengers originated and their ultimate destinations upon leaving the station.

Counts were completed for Tuesday the 10th of March, Wednesday the 11th and Saturday the 14th.

In summary Fridays are the busiest day of the week (with circa 8% greater footfall than other weekdays but with the evening peak spread slightly wider). Morning peak is around 90% of the evening peak, as again this is spread over a wider time period. Saturdays are around 1% busier than Monday to Thursday but with the high footfall spread over around 10 hours (so greater than weekday in the middle of the day but less than the weekday peaks). Sunday is around 65% of the Monday-Thursday footfall. For detailed results see the analysis in appendix A.

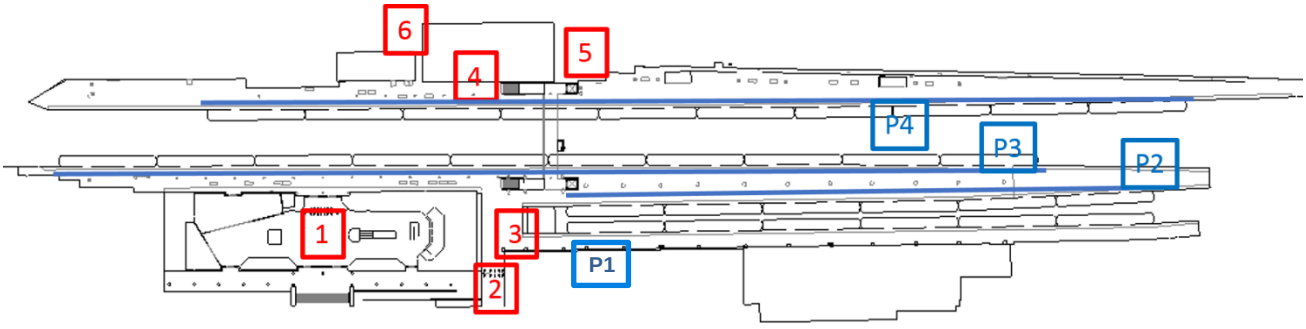


Figure 1: Sites for Oxford Station passenger counts.

C.02 Infrastructure Options Tested

Three infrastructure scenarios were tested in this study. For each layout, an appropriate year was chosen to assess. Each year was chosen as a predicted final year that the infrastructure layout would be in place. For the current layout and Phase 2, existing full designs were used. For the final scenario (referred to in this paper as ORCS), a basic feasibility design was agreed upon and tested for this study.

C.02.01 Base

The base scenario is the layout of Oxford Station as it currently exists. The main gateline is to the bottom left of the below figure, with the secondary gateline to the right side near platform 1, which is at the bottom of the image. A small exit is available from the top of platform 4 and an overbridge connects the platforms. This layout is shown in figure 2. For this infrastructure layout, the modelling year was decided to be 2024, as the final year in which it will be in operation.

At present, the main gateline has 6 Automatic Ticket Gates (ATGs) and 2 Wide Aisle Gates (WAGs). There is a secondary gateline near P1 which has 3 ATGs and 1 WAG. There is an additional exit off P4 which is open at peak times only.

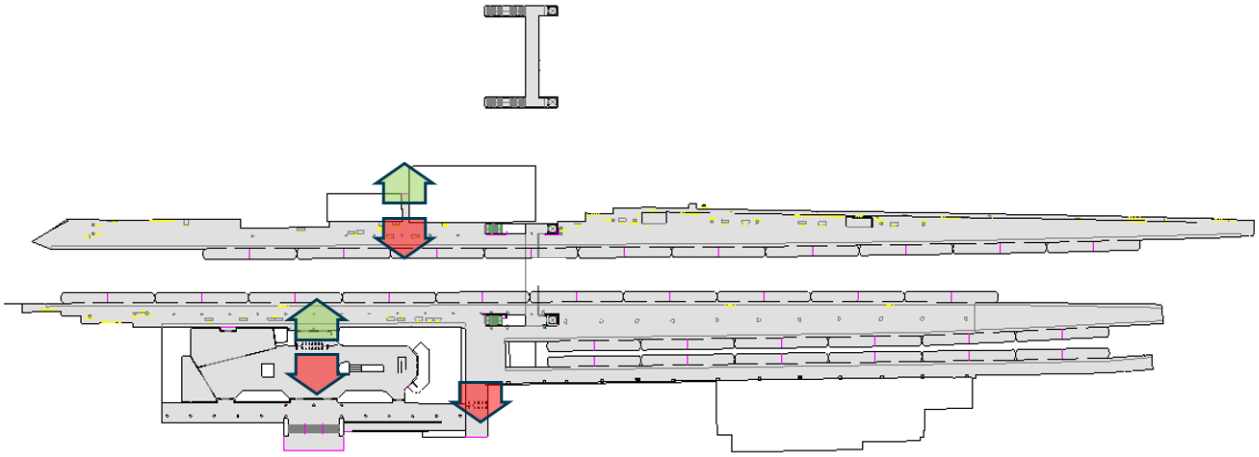


Figure 2: Base layout.

C.02.02 Phase 2

In the scenario referred to as Phase 2, platform 5 is added as an additional through platform. A stub subway is created, with a stair leading to it from P4 and 5. The new gateline has 5 ATGs and 2 WAGs. This layout is detailed in figure 3. For this layout, the modelling year agreed upon is 2033, the final year before the next layout is likely to be constructed.

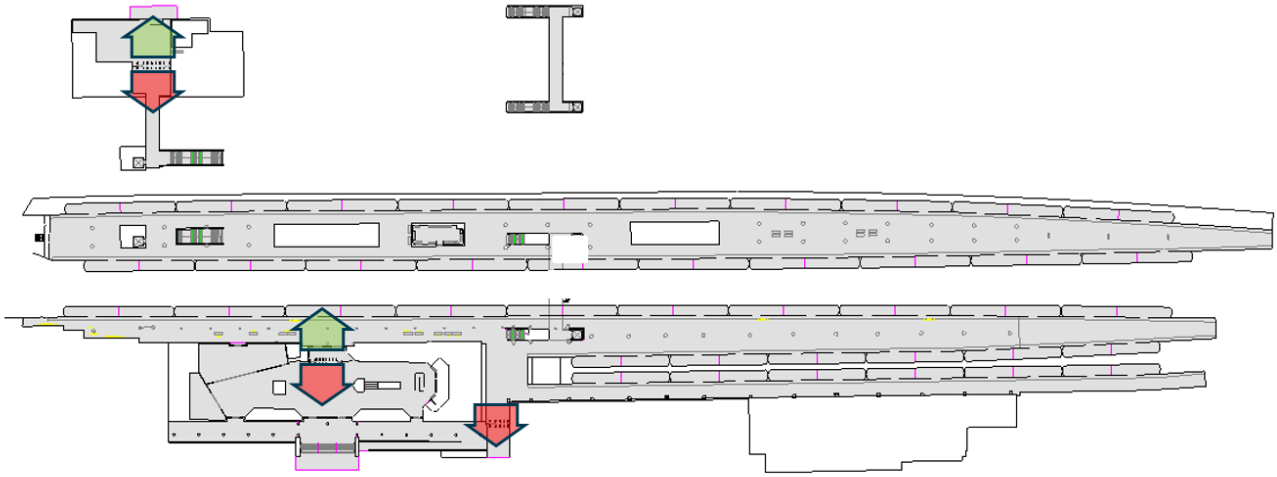


Figure 3: Phase 2 layout.

C.02.03 ORCS

For the final stage, referred to here as ORCS, there was no extant detailed design, as the project is only currently at GRIP1. For this reason, much of what is proposed has been done in order to minimise modelling time, with a view to outputs from this study informing the final design. The stub subway from P4/5 has been connected to a full subway with a width of 7m at the main concourse gateline end. The main gateline has been extended to contain 10 ATGs and 2 WAGs, as it must be able to accommodate both an uplift in demand and additional passengers from P4/5.

On P4/5, the space between the buildings and the platform edge have been included as specified in the phase 2 design proposals, but the blocks may consist of multiple buildings in the final design.

The secondary gateline has been set back from the platform edge to allow for the placement of new stairs and an extension of the existing footbridge, which is likely to be used mainly for interchange.

The new stairs which have been added to the subway from P2/3 and P1 have been assumed the same width as the designed stairs from the subway to P4/5. It is possible for these stairs to be made wider in detailed design, which can be easily tested in this model. Similarly, the extended overbridge maintains its existing width and the new stair from it to P1 has been assumed identical to the other two overbridge stairs.

Due to the longevity required from this design, the agreed modelling year was 2050, to test the layout with long term demand growth.

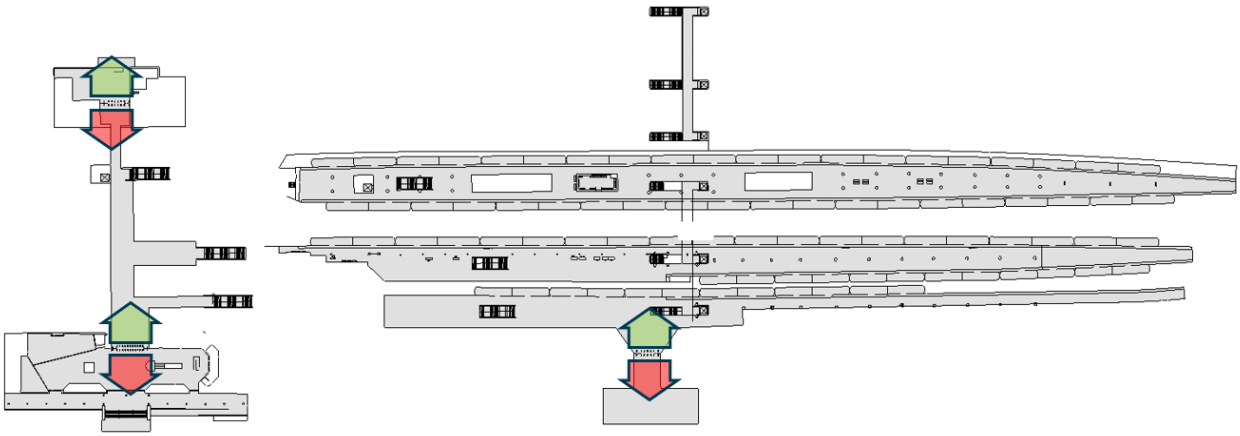


Figure 4: ORCS layout.

C.03 Passenger Growth Data

Due to the impacts of COVID-19 on passenger travel, an initial adjustment was added to the counts to correct for a 7% drop-off in footfall, with the counts occurring a week before 'lockdown' was implemented. This number was derived from drop-offs seen at automatic footfall sensors at comparable Network Rail managed stations, which were Bristol Temple Meads and Reading. This value was verified by gateline data from GWR specific to Oxford, which showed a 6% drop-off.

Passenger growth data for future years was provided with two possibilities, which will be referred to as the DfT central case (WebTAG) and the Oxford Planned Growth Scenario (OPGS). The growth rates used are specified below, with the COVID-19 adjustment included.

Growth	Actual survey data	COVID Adjusted Survey Data	Up to 2024 (Base)	Up to 2033 (Phase 2)	Up to 2050 (ORCS)
WebTAG	100%	107.0%	124.2%	150.9%	192.1%
OPGS	100%	107.0%	127.6%	162.2%	206.5%

Figure 5: Growth data table.

C.04 Modelling Assumptions

C.04.01 Base (up to 2024)

Survey data was analysed to determine the routings of passengers in the model. Exit splits from the data were applied, with the results shown in figure 6. In the morning peak, the majority of passengers enter and leave through the main gateline. In the evening peak more alighters (and a higher proportion of alighters) utilise the secondary gateline. Routings were applied to the model based on these results.

1 in and 1 out WAG were maintained at the main gateline for all models. In the base and Phase 2 scenarios, the configuration was 2 ‘in’ ATGs and 4 ‘out’ ATGs for the AM peak, and 3 ‘in’ ATGs and 3‘out’ ATGs for the PM peak. The secondary gateline was maintained as ‘exit only’ at all times after initial modelling tests with an in ATG resulted in significant overcrowding and stationary passengers..

Finally, the interchange rate was set at 10%. This is because the ORR station usage statistics for Oxford show an interchange rate of 6% today, and the addition of new connectivity from future services is likely to increase this rate.

Figure 6: Entry and exit splits.

C.04.02 Phase 2 (up to 2033)

For Phase 2, additional capacity and ticket gates are provided for the western side of the station. In order to determine the probable usage of this entrance, results from the interview survey data have been used. The breakdown of this survey is detailed in figure 7. Based on a further assumption that only those who arrive by walking or cycling will use the new western entrance, the assumption made is that 10% of all passengers will use the new entrance. This compares with 6% from the March 2020 surveys (with a lower quality entrance and poor Botley Road pavement arrangements).

However, as the two entrances are close to each other and access different platforms, this number would certainly be greater for passengers arriving for P4/5. Based on the relative journey times for each route, it was assumed that an additional 30% of remaining P4/5 passengers would utilise the western entrance. A similar assumption is made for alighting passengers from P4/5, which will use the closer platform exit, except for the 10% which will always use the western exit due to their onwards destination.

Gateline configurations remain the same as in the base model. For the Western entrance, 1 ‘in’ and 1 ‘out’ WAG were accompanied by 3 ‘out’ ATGs and 1 ‘in’ ATG for both peaks.

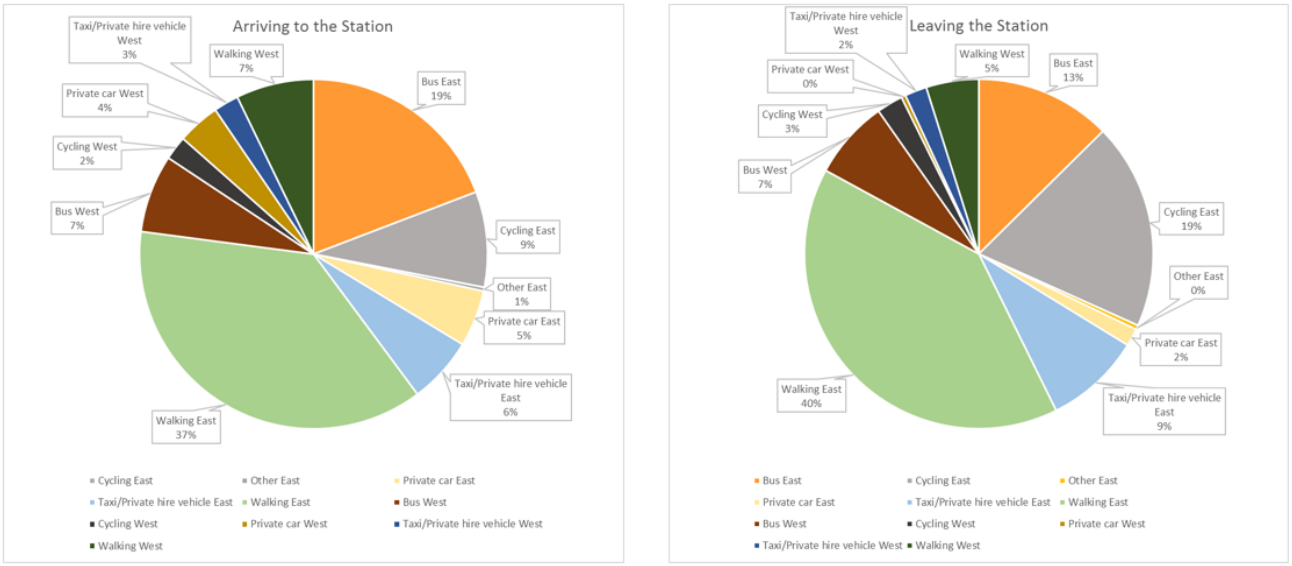


Figure 7: Breakdown by mode of transport and origin or destination. Full sized versions available in Appendix A.

C.04.03 ORCS (up to 2050)

For the 2050 model, most of the assumptions remain from previous models with regards to interchangers and final destinations. However, in this model there is access to both east and west through the connected subway, so the majority of alighting passengers use the subway, except for Platform 1, where all alighters for the east use the secondary gateline.

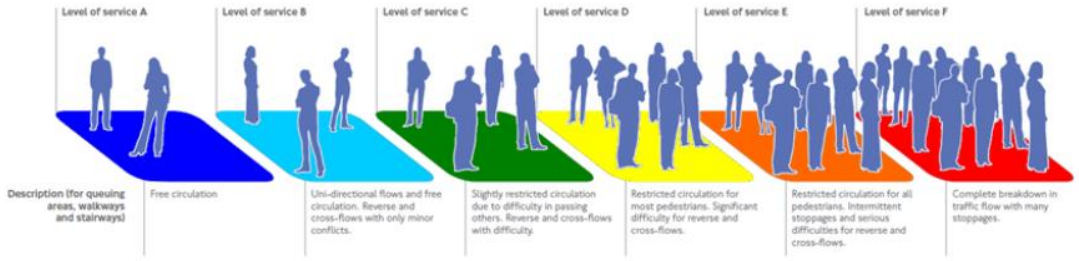
This would mean that the usage of the bridge would be low, limited only to the interchangers. To account for the fact that some of the east-bound passengers will inevitably take advantage of this quieter alternative route, 10% of alighters from the half of the train near the footbridge are assumed to use this route. This statement applies to platforms 2+3 and 4+5 islands.

1 ‘in’ and 1 ‘out’ WAG were maintained for each gateline. The main gateline is operated as 7 ‘out’ ATGs and 3 ‘in’ ATGs in the AM peak, with 5 ‘in’ and ‘out’ ATGs in the PM peak. The secondary gateline is always operated as 1 ‘in’ ATG and 3 ‘out’ ATGs. The western gateline remains the same as in previous models, ie 1 ‘in’ and 3 ‘out’ ATG’s..

Part D: **Analysis**

For the analysis section of this paper, references will be made to the Station Capacity Planning Guidance, and all maps shown are drawn using Fruin’s mean levels of service over a 15-minute period. These are detailed in figure 8 below.

Figure 1.1 Fruin levels of service and the planning criteria for stations



Planning criteria for various operating conditions

Station Area	Normal Ops		Perturbation		Evacuation		Construction		Special Events	
	LoS	Quantitative measure	LoS	Quantitative measure	LoS	Quantitative measure	LoS	Quantitative measure	LoS	Quantitative measure
Passageways – one-way	D	50ppmm	D/E	65ppmm	E/F	80ppmm	D/E	65ppmm	D/E	65ppmm
Passageways – two-way	C	40ppmm	D	50ppmm			D	50ppmm	D	50ppmm
Stairways – one-way	D	35ppmm	E	43ppmm	F	56ppmm	E	43ppmm	E	43ppmm
Stairways – two-way	C	28ppmm	D	35ppmm			D	35ppmm	D	35ppmm
Concourse dwell areas	B	1.0m² per pax	D	0.45m² per pax			C	0.8m² per pax	C	0.8m² per pax
Platforms	B/C	0.93m² per pax	E	0.28m² per pax			D	0.45m² per pax	D	0.45m² per pax
Ticket gates		25ppm/gate		25ppm/gate		50ppm/gate		25ppm/gate		25ppm/gate
Escalators		100ppm		110ppm		120ppm		110ppm		110ppm

Nb: The unit of measurement for passenger flow-rate is ppmm (passengers per minute per metre width) and is applicable to passageways and staircases. The unit of measurement for passenger flow that is used for escalators and ticket gates is ppm (passenger per minute per unit).

In case of ramps with a gradient less than 1 in 20, the passageway planning criteria should be applied. For gradients steeper than 1 in 20, a 10% reduction in flow capacity should be assumed.

Figure 8: Fruin’s level of service and Station Capacity Planning Guidance. For two-way passageways and stairways the target will be Level of Service C (green) or better (blue). Additionally, these values are used to calculate platform clearance times, which should be kept under 2 minutes where possible, and strictly under 4 minutes.

D.01 Survey Footage (2020)

Looking at the survey footage, the area of the station which experiences the most crowding is the bottom of the footbridge stairs on P4 following a large alighting load. This is shown in the photo below and figure 9, alongside the Station Capacity Planning Guidance (SCPG) level for the stairs, shown as a pink horizontal line on the graph. With the busiest alighting loads, the guidance is sometimes exceeded for a single minute, which is indicative of busy trains but no queueing. With the COVID-19 adjustments applied to the data, it is possible that a few more trains would exceed the guidance, but queueing would not exceed two minutes. The yellow horizontal line shows the SCPG level for the bridge span.

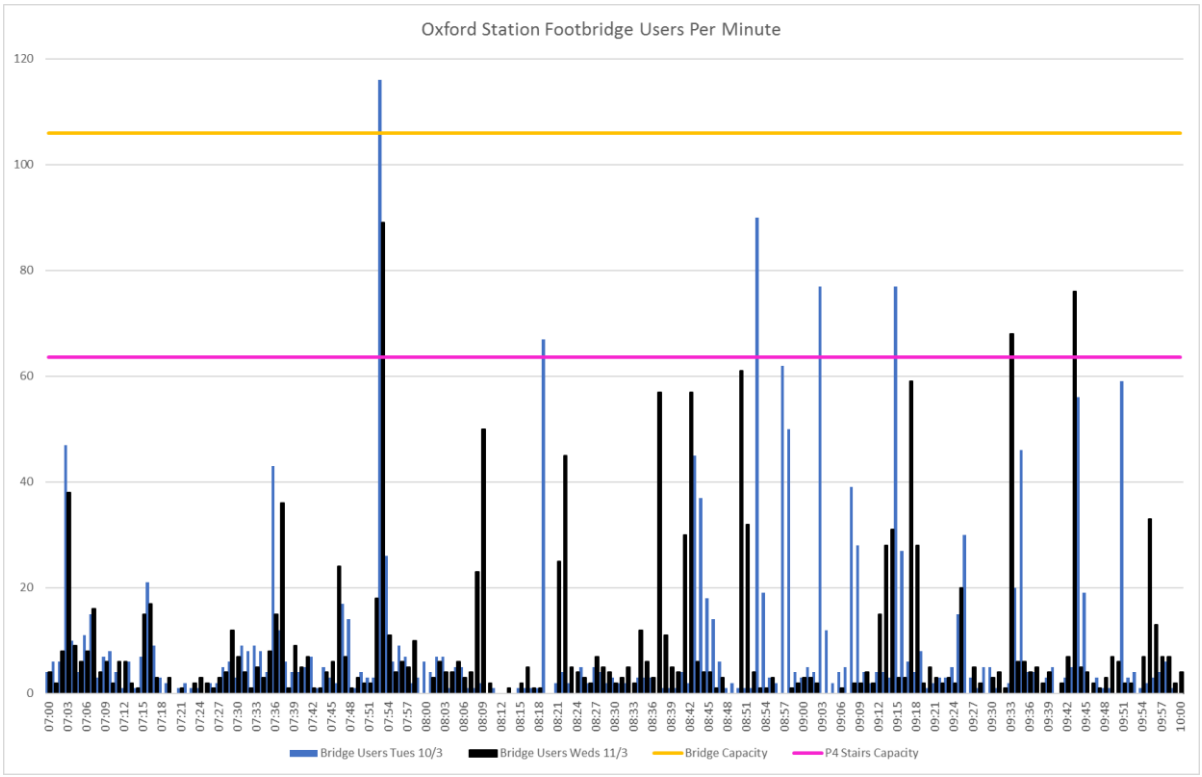


Figure 9: Camera footage and analysis of P4 stair.

The other area of concern at the station is along Platform 3, where benches and boarding passengers can clash with alighting loads plus customers walking between the main gateline and the footbridge stairs. While the benches do actually seal off a lane for movement when the trains are less busy (figure 10, left), passengers can be forced to walk inside the platform edge yellow warning line due to the space used up by the obstructions when larger alighting loads are experienced (figure 10, right).

Figure 10: Alighters generally stay away from the platform (left), but some are forced to cross the yellow line, especially with larger alighting loads (right), which will increase in the future.

The main gateline also has queues for it, particularly after busy trains on P1-3 where passengers are not constrained by the stairways. Figure 11 shows that these queues sometimes extend beyond the main station building and on to the platform. This is due to the short run-off on the paid side of the doors and the platform.

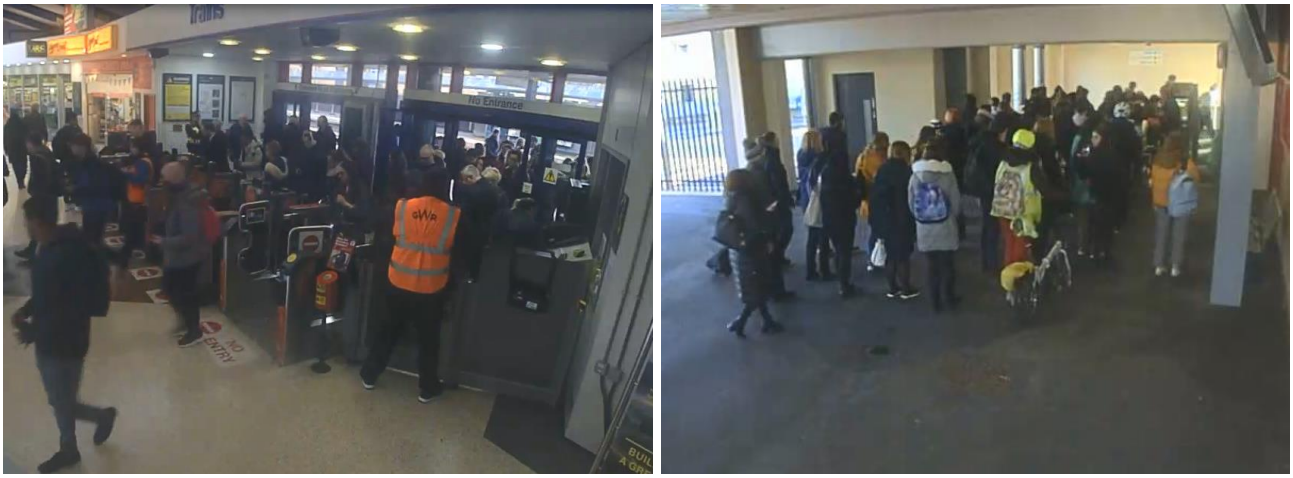


Figure 11: Main gateline queues following a busy train arrival back up onto the platform (left) while the side gateline can have queues at times too (right).

D.02 Base (up to 2024)

As previously mentioned, the base model includes the current layout with growth to 2024. As there is minimal difference between the two provided growth scenarios (WebTAG and OPGS), they will be referred to together as the 2024 scenario, and maps shown are from the larger growth rate prediction, which is OPGS.

D.02.01 Gatelines

In the AM peak, there is minimal queueing at the main gateline following busy arrivals on P1-3. Arrivals on P4 are controlled by the stair flow rates and do not cause queueing. This is shown in figure 12 and is consistent with what is seen in the survey footage (D.01).

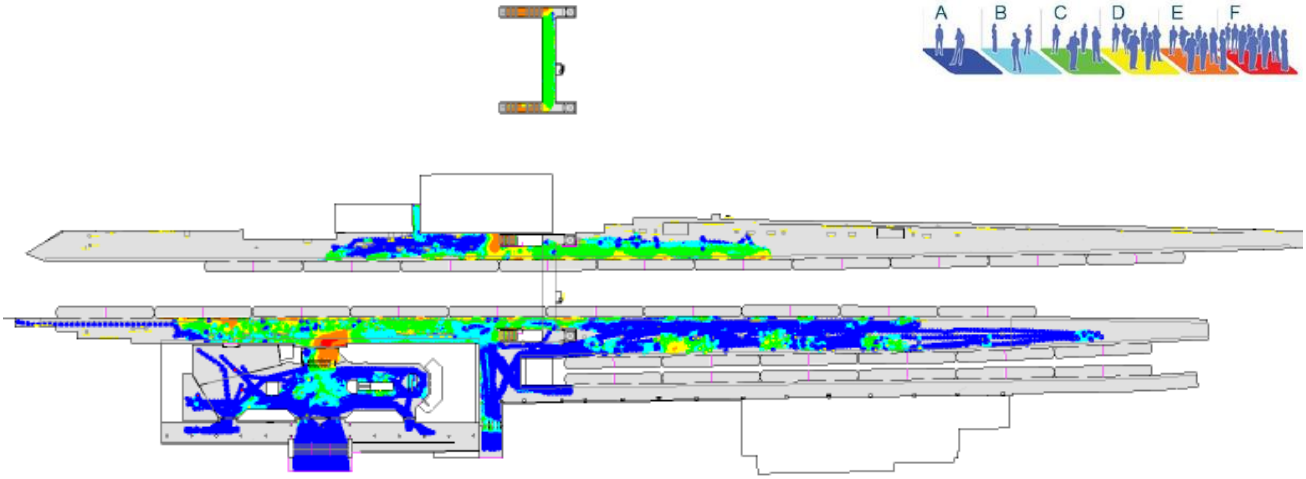


Figure 12: 15 Minute Mean Level of Service Map for 08:00 (2024 OPGS).

There is very limited queueing on the unpaid side of the main gateline in the PM peak, likely due to an increase in the size of boarding loads. This is demonstrated in figure 13.

The secondary gateline is more heavily utilised during the PM peak, when there are still large alighting loads, particularly from London services, but the main gateline is prioritised for boarders. Queues are seen at the secondary gateline, as shown below (figure 13).

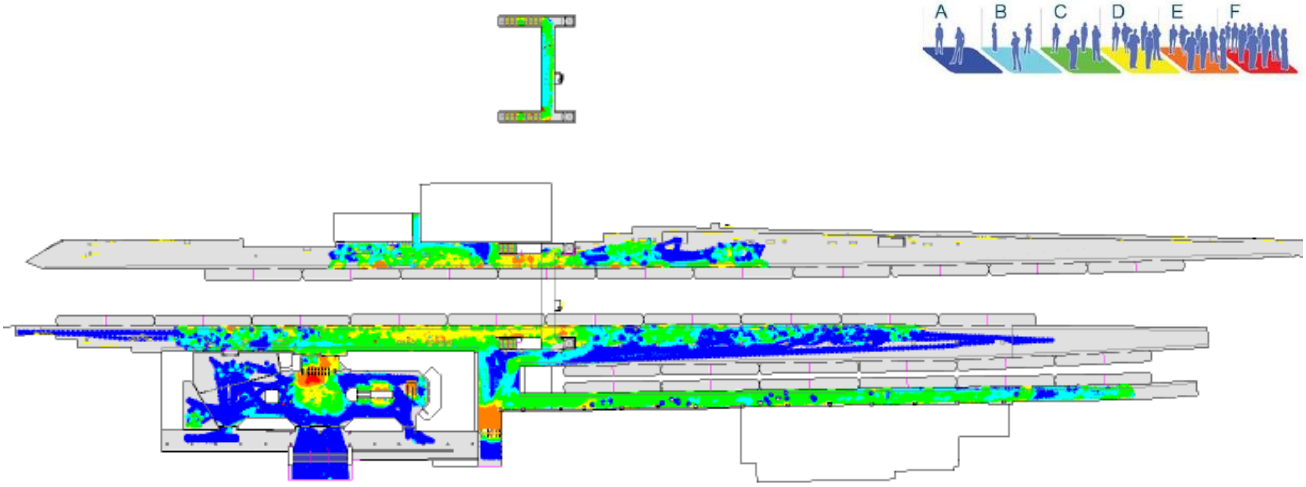


Figure 13: 15 Minute Mean Level of Service Map for 17:30 (2024 OPGS).

D.02.02 Stairs

The only stair which experiences any level of queueing in the 2024 model is the stair to the overbridge from P4. With the growth applied, queues can be seen to reach the platform edge following the busiest alighting trains. This is seen in figure 14.

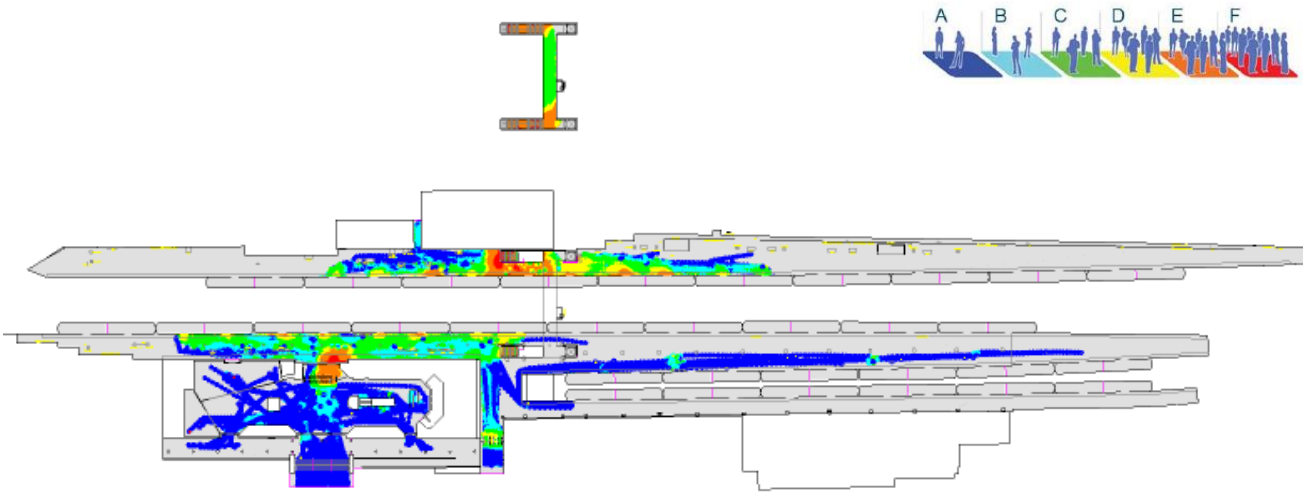


Figure 14: 15 Minute Mean Level of Service Map for 08:45 (2024 OPGS).

D.02.03 Platforms

Particularly shown in figure 13, platforms 2 and 3 are constrained by the benches and columns, as seen in the survey footage. The pinch points between the lifts and the platform edges are also seen to cause minor congestion.

D.03 Phase 2 (up to 2033)

For Phase 2, both growth scenarios were modelled separately, but figures from the larger scenario (OPGS) are included here. Full maps for both scenarios can be found in Appendix B.

D.03.01 Gatelines

The main gateline sees increased queueing by 2033 due to the larger alighting loads, although this is seen less frequently as more alighters from P4/5 services use the new western exit. Figure 15 shows the extent of this queueing. It is probable that passengers would notice this congestion and change their route to the secondary gateline.

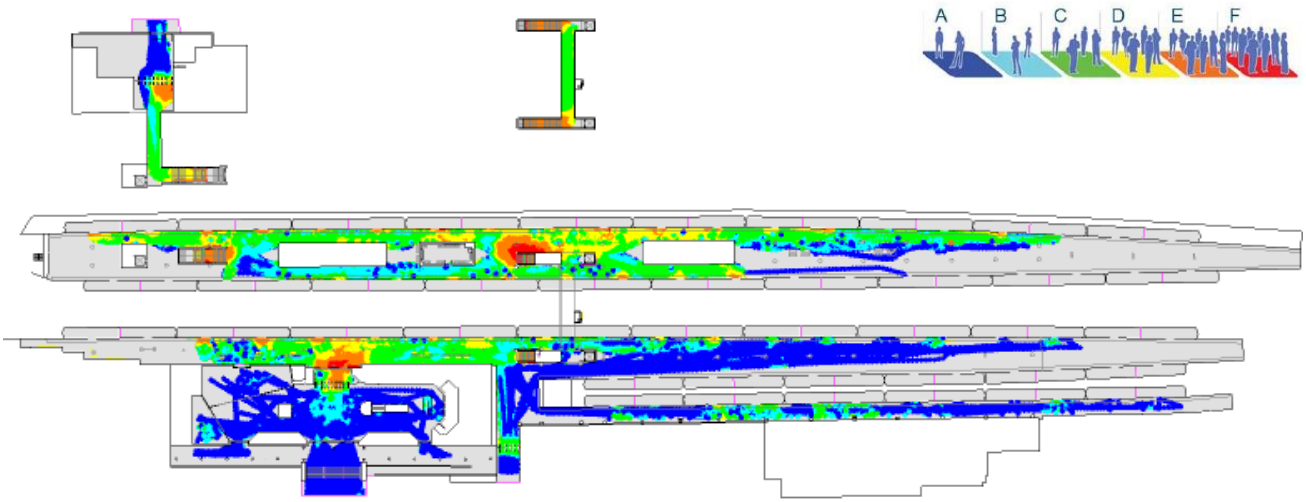


Figure 15: 15 Minute Mean Level of Service Map for 08:00 (2033 Phase 2 OPGS).

Due to the growth in alighters and the assumptions about routing, the secondary gateline begins to develop significant queues in the PM peak. This is shown in figure 16. However, it is once again possible that some passengers would change their routing based on these queues.

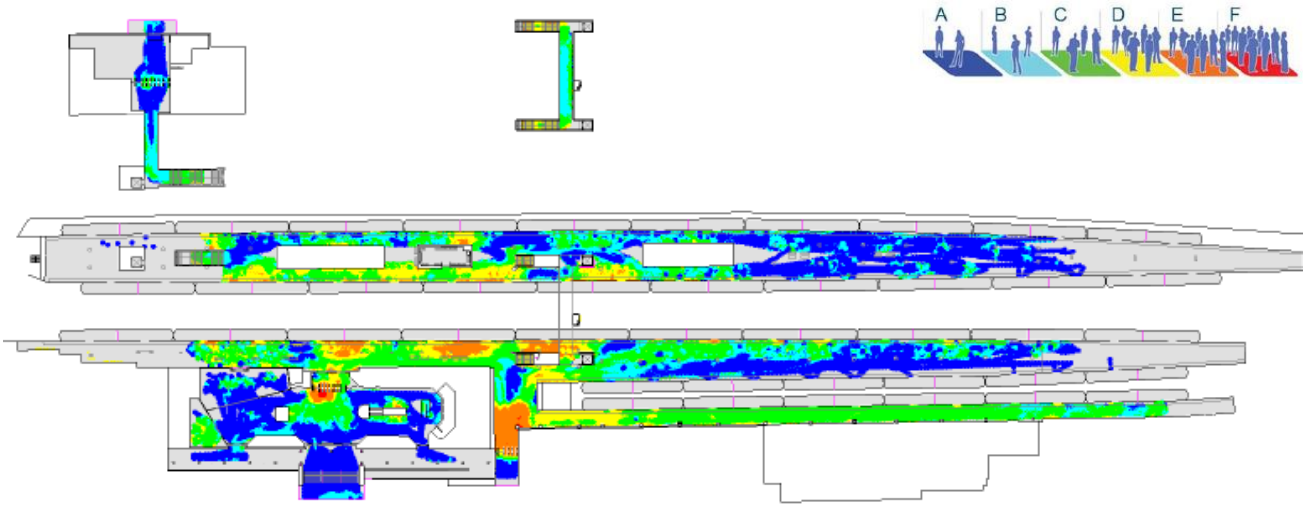


Figure 16: 15 Minute Mean Level of Service Map for 17:30 (2033 Phase 2 OPGS).

The western gateline generally experiences comfortable levels of service, but queues can build up for approximately two minutes after large alighting loads from P4/5. While the crowding is significant (figure 17), it is not present for enough time for it to be considered an issue.

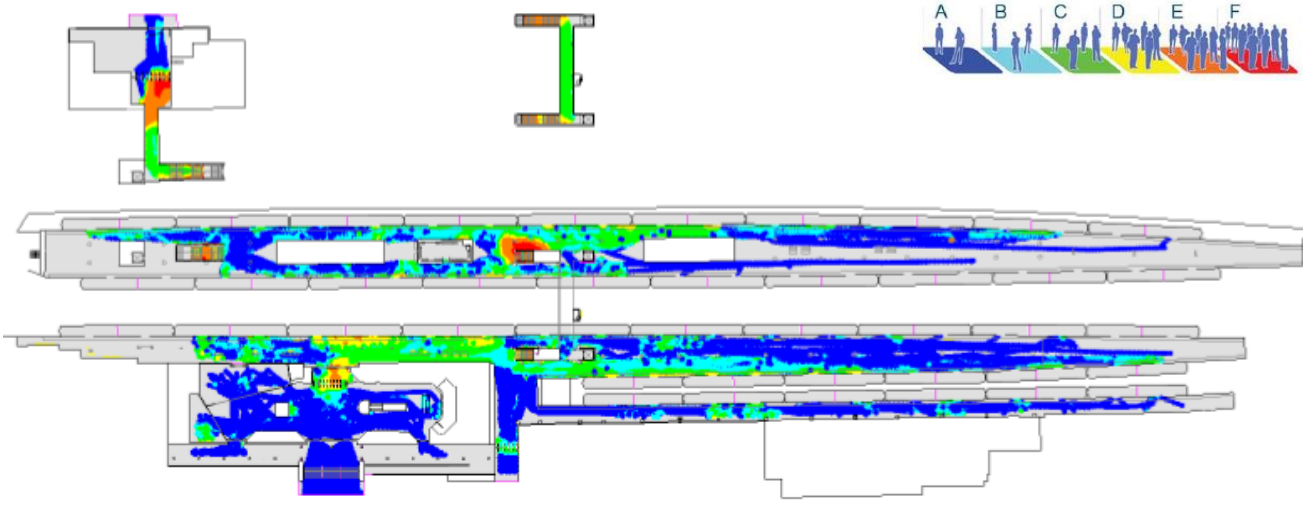


Figure 17: 15 Minute Mean Level of Service Map for 08:15 (2033 Phase 2 OPGS).

D.03.02 Stairs

As shown in figure 15, the queues for the stairs on P4/5 remain but are no longer at the platform edge. This is because additional passengers are taking the new route to exit the station via the west and because routes around both sides of the footbridge are now available (with increased width on platform 5 side). Due to the low percentage of passengers who have a final destination to the west of the station, there is no crowding seen at the top of the newly built subway stairs.

D.03.03 Platforms

As demonstrated in figure 16, the benches and obstructions on P3 are causing significant crowding, particularly when trains on the platform have both large boarding and alighting numbers in the PM peak. Also seen in figure 16 are the initial indications of pinch points created either side of the central building on P4/5

D.04 ORCS (up to 2050)

For the ORCS scenario, the larger of the two growth scenarios (OPGS) has been modelled to allow for the identification of any areas of concern. Full LOS maps for each time period are available in the appendices.

D.04.01 Gatelines

The main gateline starts to experience some queueing by 2050 with the proposed layout, but the queues do not last longer than 2 minutes for any individual. As shown in figure 18, these queues do not extend to the narrow passageways or the bottom of stairs.

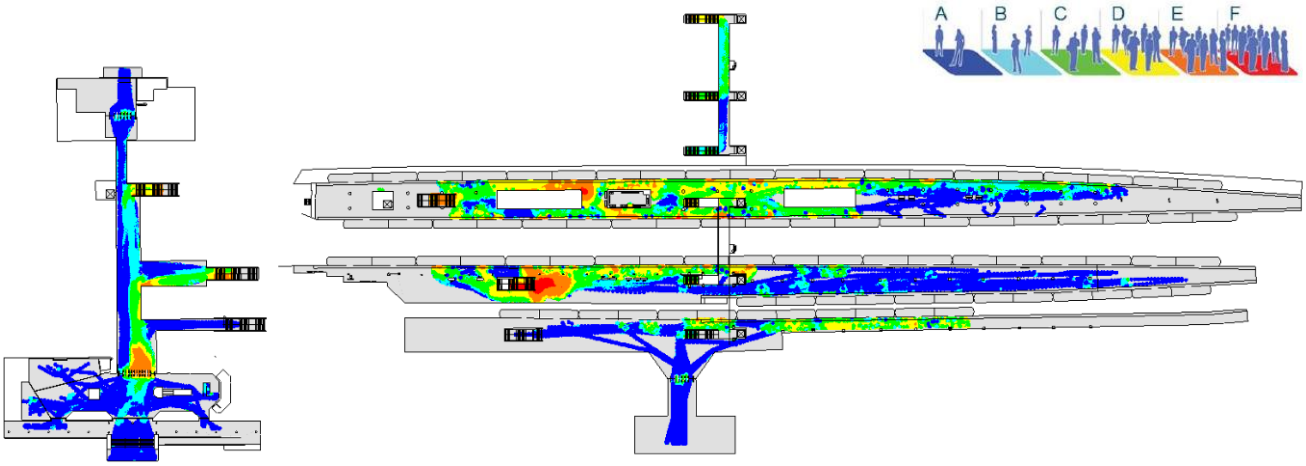


Figure 18: 15 Minute Mean Level of Service Map for 08:45 (2050 ORCS OPGS).

The secondary gateline does experience mild queues after large alighting services on P1. This is to be expected, as access to the gateline is not constrained by stairs. This is shown in figure 19. With the design as proposed, this queue does not reach the runoff area of the stairs, obstruct entering passengers or take more than 2 minutes to clear, so is acceptable.

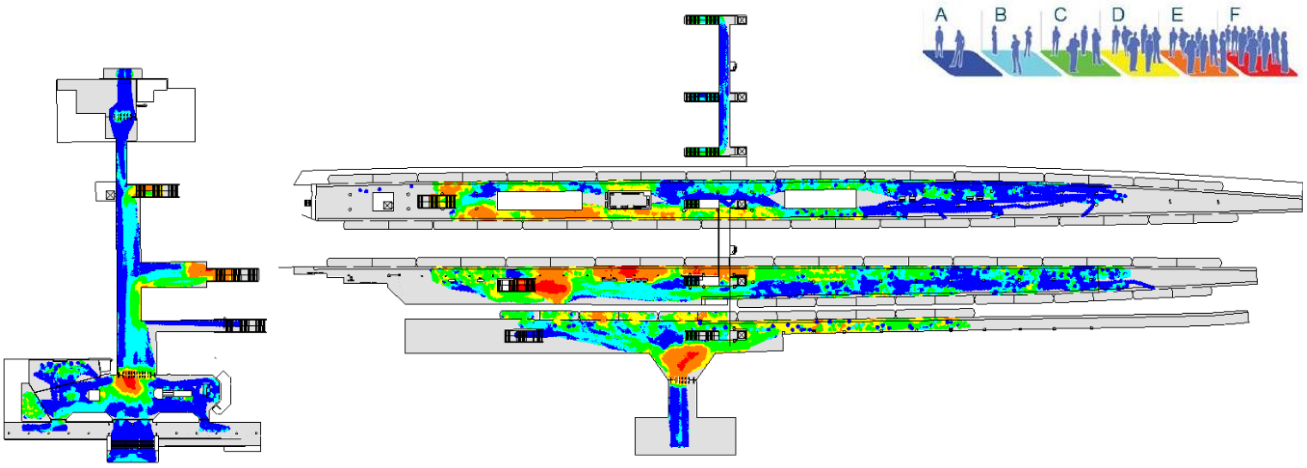


Figure 19: 15 Minute Mean Level of Service Map for 16:15 (2050 ORCS OPGS).

The western gateline no longer experiences any significant queues. This is due to the fact that the majority of passengers have final destinations to the east of the station, and with the subway offering this connectivity there is limited use of the western gateline.

D.04.02 Stairs

For both the AM and the PM models, the single set of stairs accessing the subway saw significant congestion. In the AM, this is mainly limited to the queues at the top of the stairs, which regularly take more than 4 minutes to clear. This is most clearly demonstrated in figure 20 on P2/3, but the platform clearance time suffers similarly on P4/5. While the platform pinch points and obstructions which are covered in **D.04.3** limit the queues seen on the top of the stairs, these would form if the flows were unconstrained.

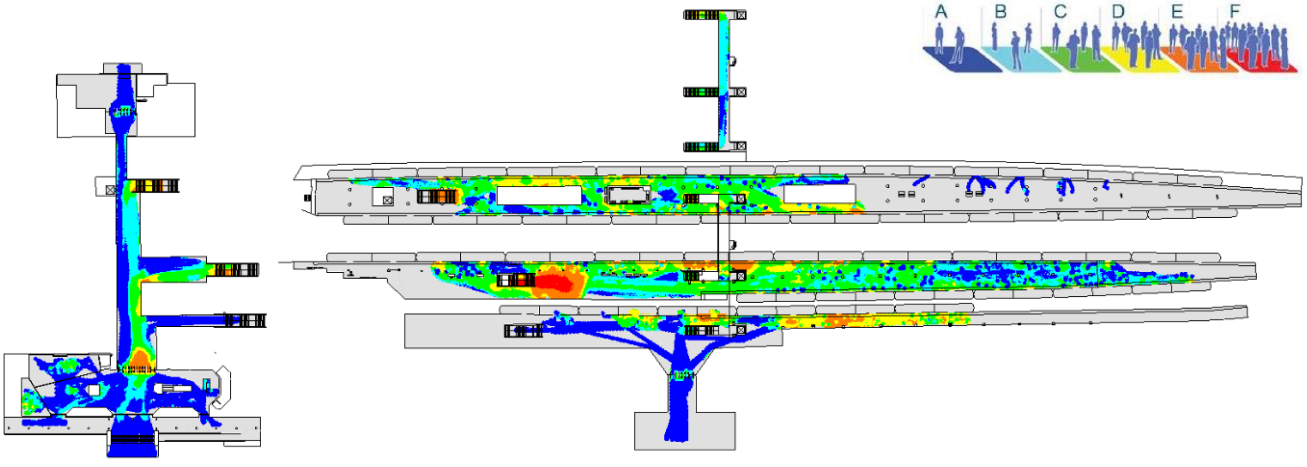


Figure 20: 15 Minute Mean Level of Service Map for 09:00 (2050 ORCS OPGS).

In the PM peak, the clash of boarding and alighting flows results in queueing at both the top and bottom of the stairs, necessitating the widening of the passageway seen at the bottom of the P2/3 stairs. This is seen by the crowding at either end of the P2/3 stairs in figure 21.

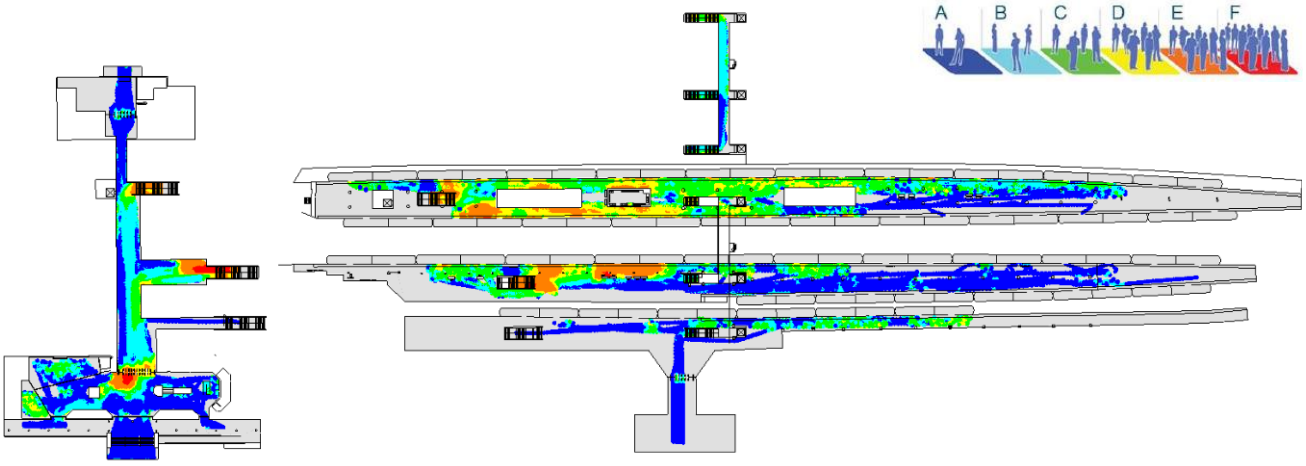


Figure 21: 15 Minute Mean Level of Service Map for 17:45 (2050 ORCS OPGS).

D.04.03 Platforms

Pinch points along the platforms caused by buildings and vertical transport result in congestion and clashes between boarding and alighting passengers. This is demonstrated in figure 19 for P4, figures 20 and 21 for P3, and figure 22 for P5. This is due both to the geometry of the station and the fact that a large majority of passengers have to pass along the full length of the platform to exit via the subway.

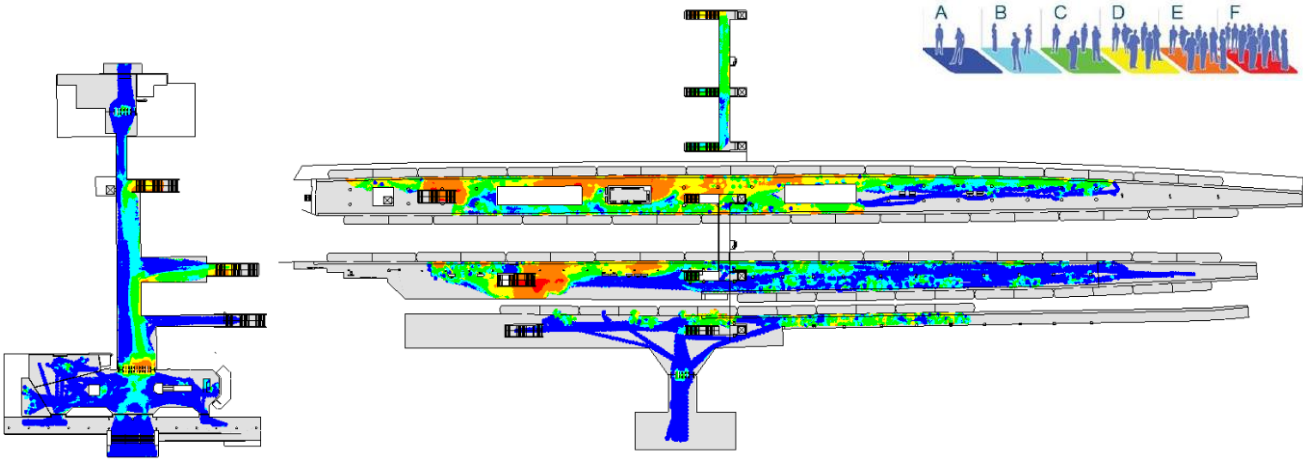


Figure 22: 15 Minute Mean Level of Service Map for 08:00 (2050 ORCS OPGS).

D.04.04 Concourse

In previous models, there was nothing to note about the concourse. However, with the extensive growth up to 2050, combined with the completion of the subway meaning the 90% of total passengers arriving from the east all use the concourse area, crowding begins to occur on the unpaid side of the gateline. In figure 19 this is clearly demonstrated, with queues extending into the concourse and waiting areas.

Part E: **Conclusions and Recommendations**

E.01 Survey Footage (2020)

Based on the survey footage, it is clear that the main issues at the station currently are the stairs up from P4, the 'paid' side of the main gateline and the platform furniture on P3.

E.01.01 The stairs from P4 have moderate queueing. Solutions for the station's future should include alternative methods of egress from the platform to allow for platforms to clear quickly and comfortably, as proposed by phase 2 (western entrance).

E.01.02 The peak hours gate on P4 should be opened in the evening from 16:00, as demand is seen to rise from that time.

E.01.03 The secondary gateline should be operated in an 'out only' direction in order to minimise queueing.

E.01.04 The main gateline experiences queues which can back up onto the platform edge. Station interventions should consider removing the sliding doors on the paid side of the gateline to allow all gates to be easily accessed (but problem as the building is heated), providing additional gateline capacity (which is structurally very difficult to achieve), moving the gateline further away from the platform edge (again difficult to achieve) or encouraging more alighters to use the secondary gateline (which would seem easy to achieve with floor arrows, signage and if necessary staff on platform 3 near the footbridge stairs at key times). The key recommendation is to make the secondary gateline 'exit only' to assist with dissipation of the surges from alighting trains.

E.01.05 The platform furniture on P3 does protect a route for alighters, but as services get busier it forces passengers to move along the platform edge. Future plans for the station should include decluttering this area for a quick win in terms of pedestrian flow. This could be achieved by replacing the benches with a barrier fence to separate footbridge to main concourse flows (closest to the wall) from flows in the opposite direction (near the canopy columns). The benches removed can be replaced south of the main gateline on platform 3, north of the footbridge on platform 3 and tight to the back of concourse wall in the area behind platform 1+2 stopblocks.

E.02 Base (up to 2024)

The base model includes the same layout as today with the survey demand grown. For this reason, the conclusions and recommendations are very similar.

E.02.01 By 2024, queueing on P4 will reach the platform edge. It is once again advised to provide an alternative route off the platform.

E.02.02 The main gateline queues continue to back up further onto the platform. At this time, interventions to increase the gateline capacity or encourage more alighters to use the secondary gateline are recommended. This should also include the secondary gateline being operated as exit only in both peak periods.

E.02.03 The platform furniture on P3 continues to cause increased congestion, particularly in the PM peak when the churn is high at the station. This area of the station should be decluttered by this time to avoid a safety risk with passengers being forced to walk over the yellow line.

E.03 Phase 2 (up to 2033)

In Phase 2, the new P5 is brought into service, offering an alternative route off the now island platform. This reduces passengers both from the main gateline and the footbridge stairs, resulting in improved results.

E.03.01 The crowding at the bottom of the P4/5 stairs is slightly reduced, even though passenger growth has been applied, due to the alternative means of egress provided.

E.03.02 The queueing at the main gateline is slightly reduced despite passenger growth. If possible, an effort should be made in the AM peak to direct more passengers to the secondary gateline, which experiences less queueing.

E.03.03 As all P3 and P2 passengers still exit via the east of the station, there is increased congestion at the narrower locations along the platform after alighting services in this part of the station. A benefit would be gained at this stage through an additional stair to the overbridge to reduce the pressure on these pinch points

E.03.04 Another benefit of this design is that the evacuation time of the station is considerably improved through the addition of the Western exit. The existing Western gate is locked at peak times, so is not included in evacuation modelling. Compared to the existing route via the footbridge, 1478 additional people can now be cleared in the 8-minute evacuation time, based on an evacuation speed of 56 people/metre/minute.

E.04 ORCS (up to 2050)

No design has yet commenced for the 2050 infrastructure, but a model scenario was created. The modelled layout for 2050 resulted in significant crowding, and this option would not be recommended to be taken forward for future consideration. It is analysed here without refinement with a view to finding an improved solution (**E.05**).

E.04.01 The stairs to the subway from both P2/3 and P4/5 suffer significant congestion at the top in the AM peak, and at top/bottom in the PM peak, with platform clearance times exceeding 4 minutes on occasions. The bridge is used solely for interchangers and a few passengers taking an alternate route. Options for beyond Phase 2 should include multiple equally attractive routes of egress, preferably to the same means of transfer (whether that is a widened bridge or a subway). In addition, future designs should ensure a protected route of access to the platforms in the PM peak, possibly with a one-way system in place for this time period.

E.04.02 Narrow points along each of the platforms result in crowding. Primarily, the majority of passengers are required to pass through the narrower points from each alighting service. This results in congestion and lengthened platform clearance times. Solutions which place the main point of egress at the end of the platform should be careful to maximise available width along the platform, while solutions which do not require the passage of all alighters along the platform are encouraged.

E.04.03 The main gateline to the east of the subway is by far the most attractive way to exit the station. A gateline as provided of 10 ATGs and 2 WAGs is sufficient to deal with demand. The queues on the unpaid side of the main gateline did infringe on the assumed waiting areas, but the size of this potential gateline and its configuration should be looked at in more detail in future studies.

E.04.04 The secondary gateline was originally maintained in place, but with the addition of the overbridge stairs onto P1, the gateline was moved back to ensure the queue does not infringe on the stair run-off. To cope with demand, an additional ATG and WAG were added to this gateline. As this will be the point of egress for 90% of P1 alighters, it is possible that this gateline should be further extended, and its layout and configuration should be looked at in more detail in future studies.

E.04.05 The western gateline has a reduction in demand at this time. When the subway is connected through, this means passengers from P4/5 are able to choose their preferred direction, which is east for 90% of users, and the reduction in overall congestion means that most city bound users will follow the shortest route (subway to main concourse).

E.05 Other Possible Options for 2050

Taking into account the observations of the 2050 ORCS scenario, three possible options have been created which could solve the issues posed based on the current station layout. Phase 2 is assumed to go ahead as modelled in this paper in all three options. With these wider options, a capacious feeling within the station is created, with opportunities to open more retail units and provide a better experience for interchangers.

Note that the sketches provided do not include analysis on providing and locating lifts, which will have to be taken into consideration in further design work. Any lift waiting areas and run-offs will need to be accounted for in addition to the specified widths.

At this stage, to enable these ORCS options, it is recommended to maximise the width of the P4 and P5 stairs within reason (possibly to 3.8m through the rationalisation of canopy columns), although the widening of these stairs will not be a singular solution to the problem. For this reason, the following options are suggested.

E.05.01 Option A: Two subway access points from each platform

In this option, which is detailed in figure 23, there are two stairs to the subway from both P2/3 and P4/5. One stair remains as modelled at 3.3m width, with an additional stair further up the platform which is 2m wide. In the AM peak, both stairs would operate as bidirectional, and in the PM peak the smaller stair would become a protected route for boarders, resulting in a one-way system. There is only a single stair to the subway from P1, which is used only by alighters who wish to exit to the west of the station and those from the south end of the train.

The western gateline and eastern gateline are maintained as they were modelled, and the subway widths, which are specified in figure 23, are calculated using the maximum throughputs of each stair. This option assumes that the footbridge remains on the platform for interchangers only.

This option is expensive and difficult to construct, with the passage to the northern set of platform 4 stairs having to be built as part of phase 2 (additional works with no funding stream) with deep excavations in an area that is currently operational platform. Platform 5 would have to be commissioned into use first and then the currently proposed 1 month closure of platform 4 would need to be extended significantly (+4 months?) to carry out this work in a very constrained site and with public/trains on all sides.

In order to have the larger stair on the north side of the platform, where more passengers will encounter it first, it is required to attach to a passageway with 90 degree turns. This could result in lengthened journey times and poor sight lines.

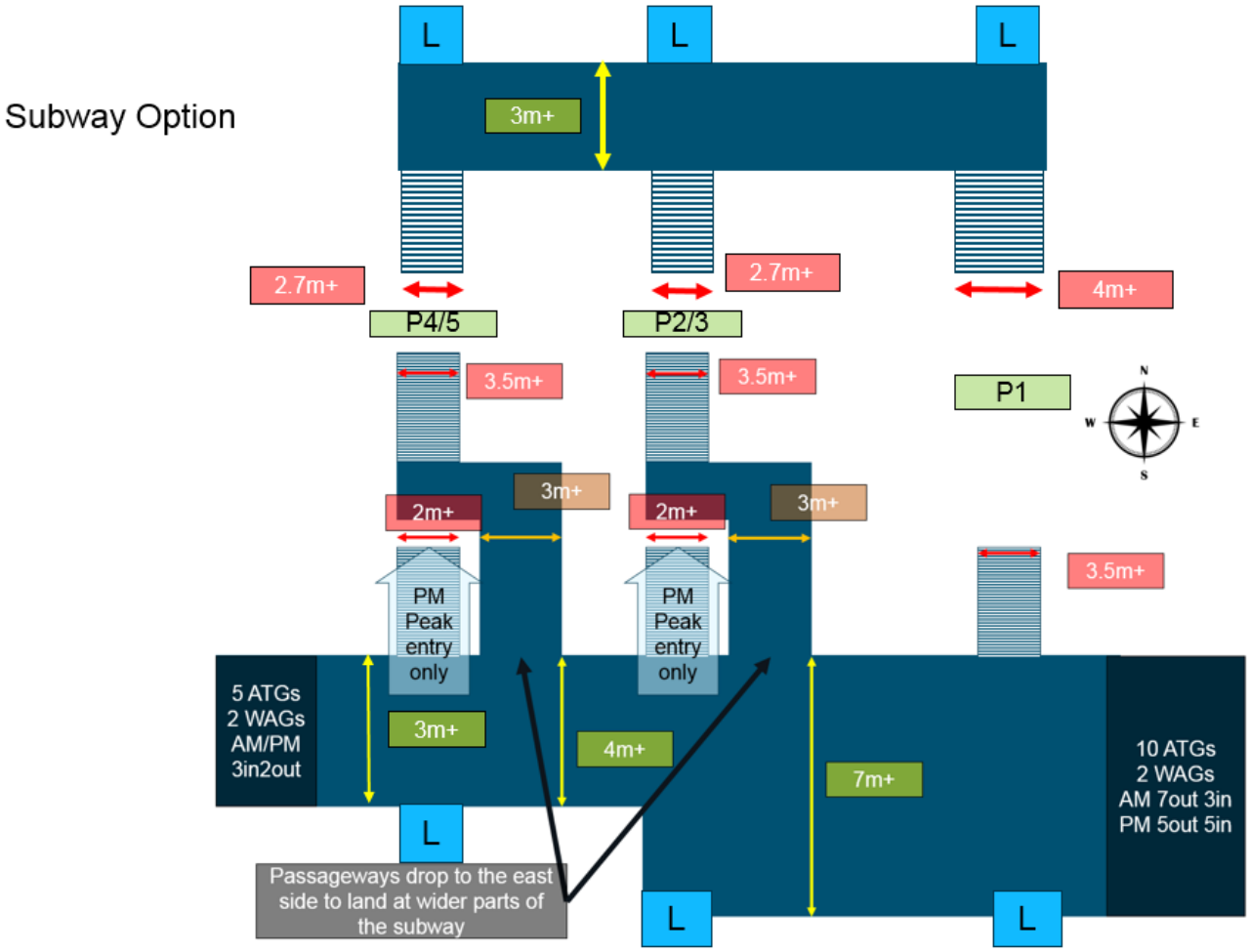


Figure 23: Option A diagrammatic layout with required measurements. Widths are indicative and could be provided in alternative orientations.

E.05.02 Option B: New footbridge and stub subway

In this option, shown in figure 24, the plans for the stairs and widths are similar, with the smaller stair made wider to 3.5m and no longer protected as a boarding route in the PM peak. However, in this version the stub subway remains, and the existing interchange bridge is replaced by a widened overbridge. The stub subway maintains the effect of separating the entry and exit flows out into two groups, with P4/5 passengers, while the additional accesses to the bridge result in a significant platform clearance time improvement. The eastern gateline is maintained as modelled but will be slightly less busy due to the attraction of the stub subway as a quick way out of the station from platforms 4/5.

The option exists to extend a western entrance from the new footbridge, but this offers minimal benefit for passengers looking to go west from P1-3 (the option to go west upon exiting the station main concourse exists), while attracting additional footfall to the bridge. This would also be difficult for land take on Roger Dudman Way (to the west of the footbridge/platform 5 line), would deposit passengers in a ‘back street area’, plus would require even more staff for management of this additional gateline.

Difficulties with this provision include

- Extra vertical travel as compared to a subway (particularly as the station exits are significantly below platform level).
- Significant difficulty in staging the works, with the need to keep the existing footbridge and the existing main concourse (or a temporary arrangement) in place throughout these construction works.
- Space is lost on the platforms for customer and staff facilities. Assuming the wide footbridge is installed around 30-50m south of the current footbridge this will remove most of the space on platforms 3, 4 and 5 for buildings and will force the customer facilities to be built much further north (and therefore in 'user unfriendly' locations). For platform 4/5 this would require the existing agreed phase 2 designs to be significantly altered.
- Lifts would be required in the middle of the footbridge with no through subway, resulting in a much wider footbridge than shown in the diagram

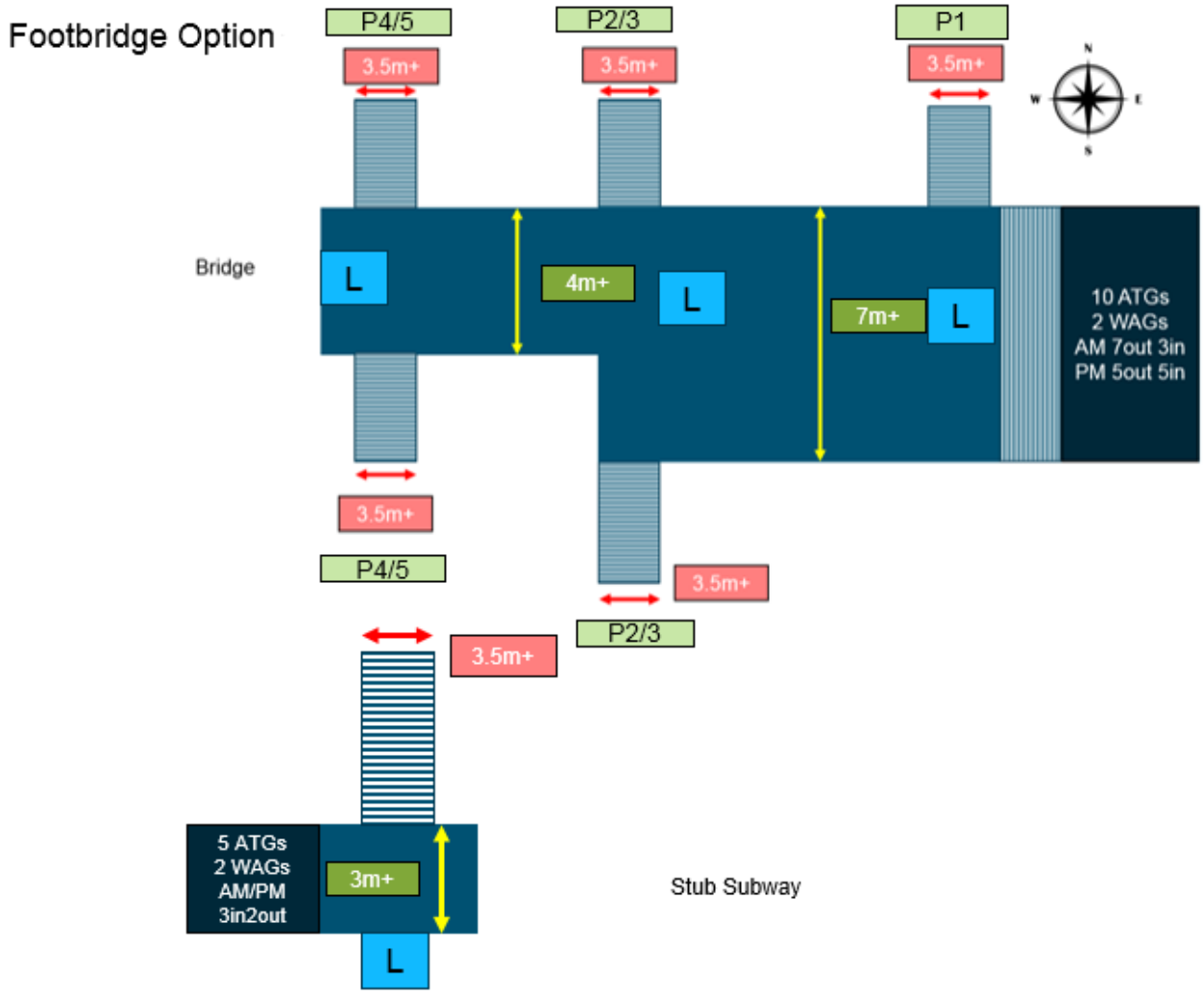


Figure 24: Option B diagrammatic layout with required measurements. Widths are indicative and could be provided in alternative orientations.

E.05.03 Option C: Enhanced footbridge and through subway

As shown in figure 25, Option C includes a combination of both. For this option, the subway is completed through the station with a single stair accessing it from each platform. This provides easier access to the west for all platforms, and passengers who alight from the south end of the trains.

The footbridge is also widened with an additional stair from the north side. This allows for much improved platform clearance time, provided the bridge or subway are not significantly more popular than the alternative. As a part of this option, it is likely that a much larger secondary gateline would need to be provided on platform 1.

This is the preferred solution as it allows:

- Two routes to all destinations, for easier flows and redundancy (lift maintenance and cleaning/repairs in low demand times).
- Encourages some passengers from the north end of long trains to use the footbridge stairs they see in front of them (reducing load on the south end subway stairs).
- Allows construction staging. The subway can be built first and then the lifts can be closed from the existing footbridge and removed. That space can allow new footbridge foundations to be built and main steelwork erected immediately north of the existing footbridge before a shorter period of footbridge closure to allow the new stairs to be added and the bridge opened. The lifts can then be completed.
- It is possible for escalators to be added to the bridge or the subway. Ideally, they would be added to both to minimise platform clearance time and avoid the possibility of having either be significantly more attractive as a route than the other.

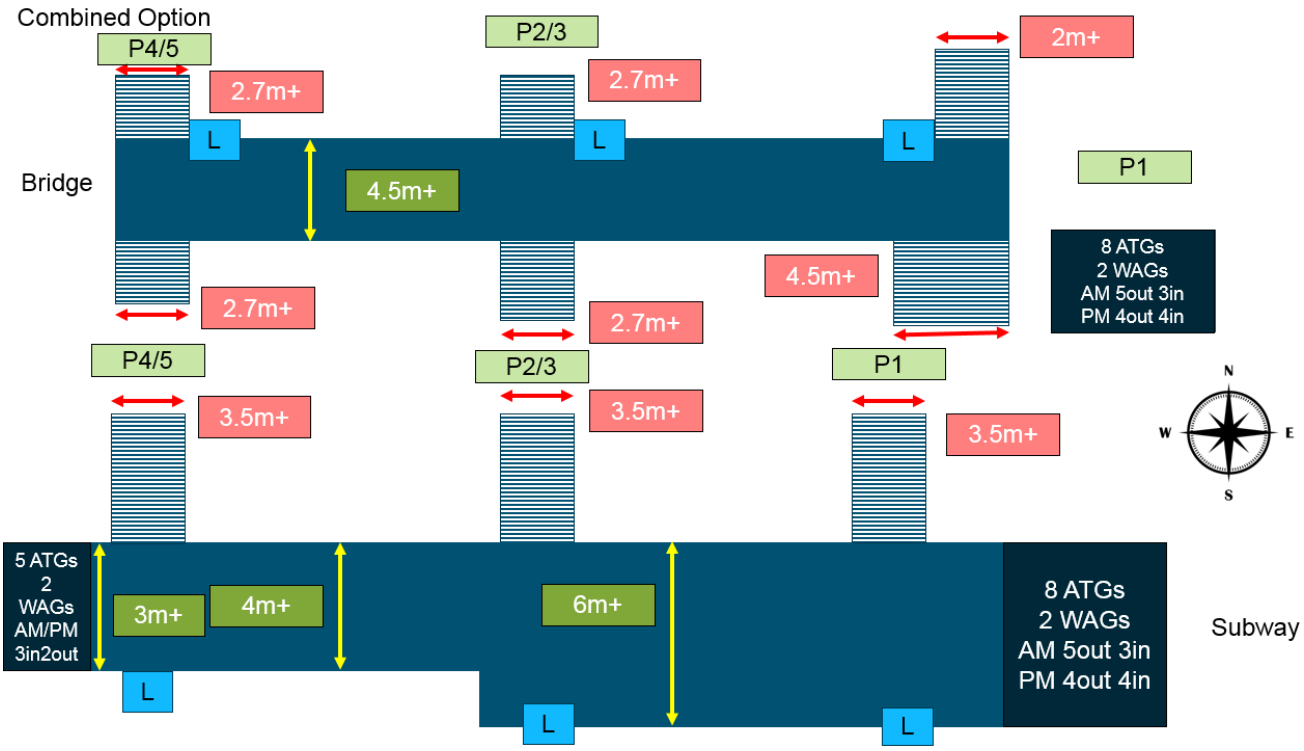


Figure 25: Option C diagrammatic layout with required measurements. Widths are indicative and could be provided in alternative orientations.

Part F: **Appendices**

F.01 Appendix A: Survey Summary

See attachment

F.02 Appendix B: LOS Maps

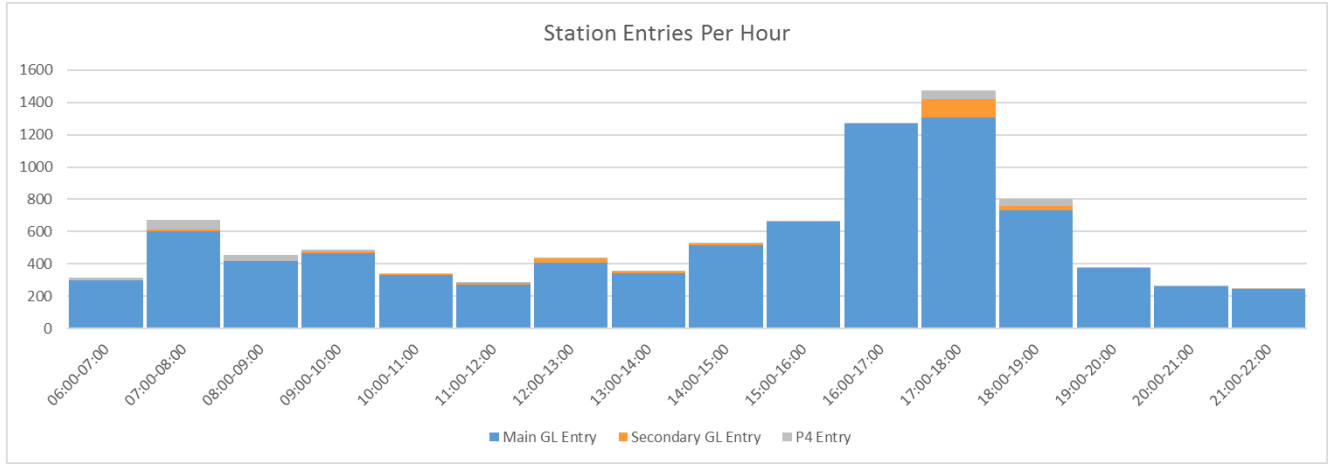
See attachment

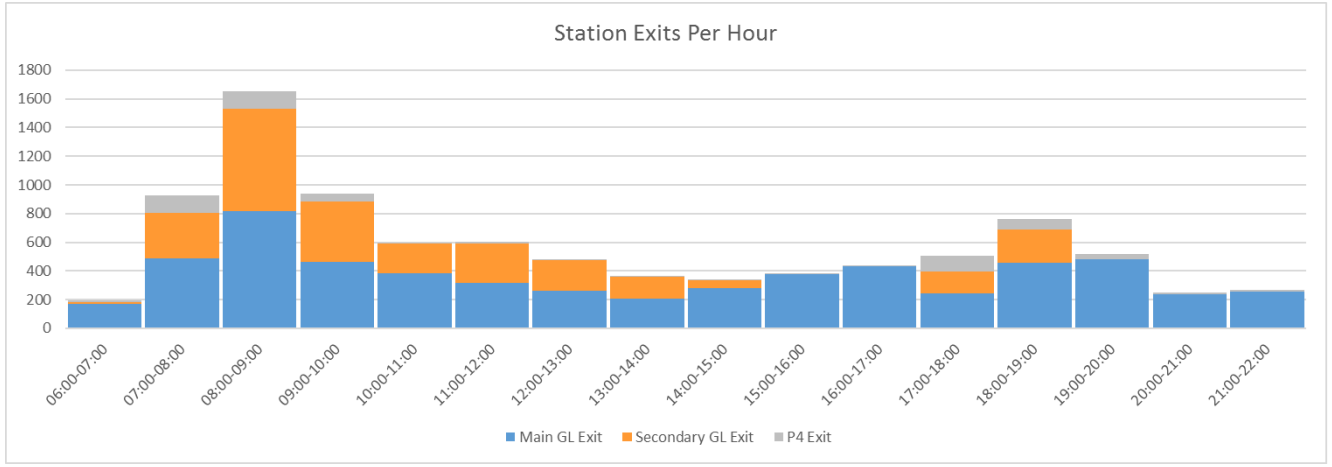
System Operator

Oxford Station Survey Summary

NR Station Capacity Team

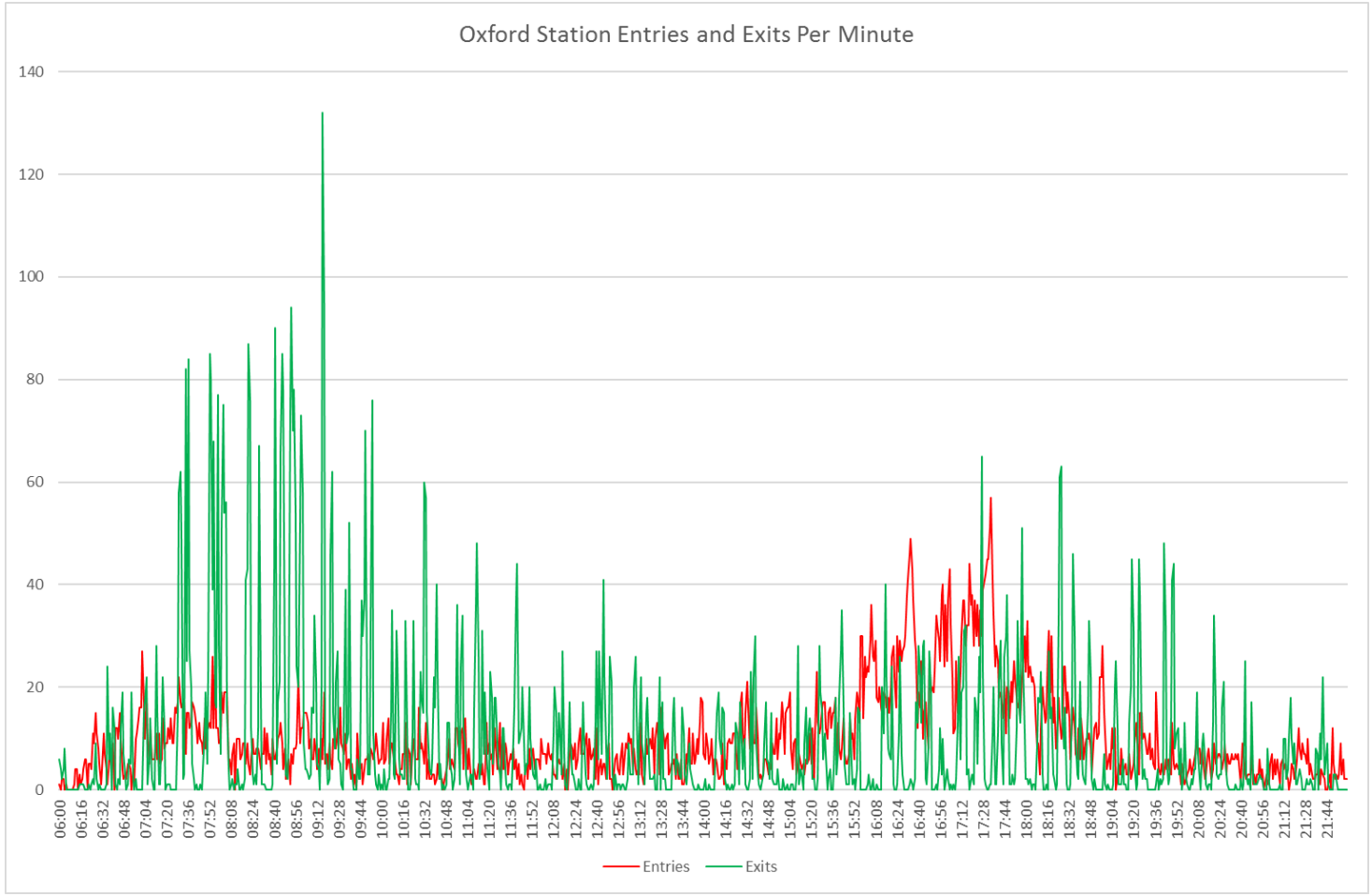
Hour By Hour





Oxford Station shows “peaky” tidal patterns, with more station entries in the PM peak, and more station exits in the AM peak

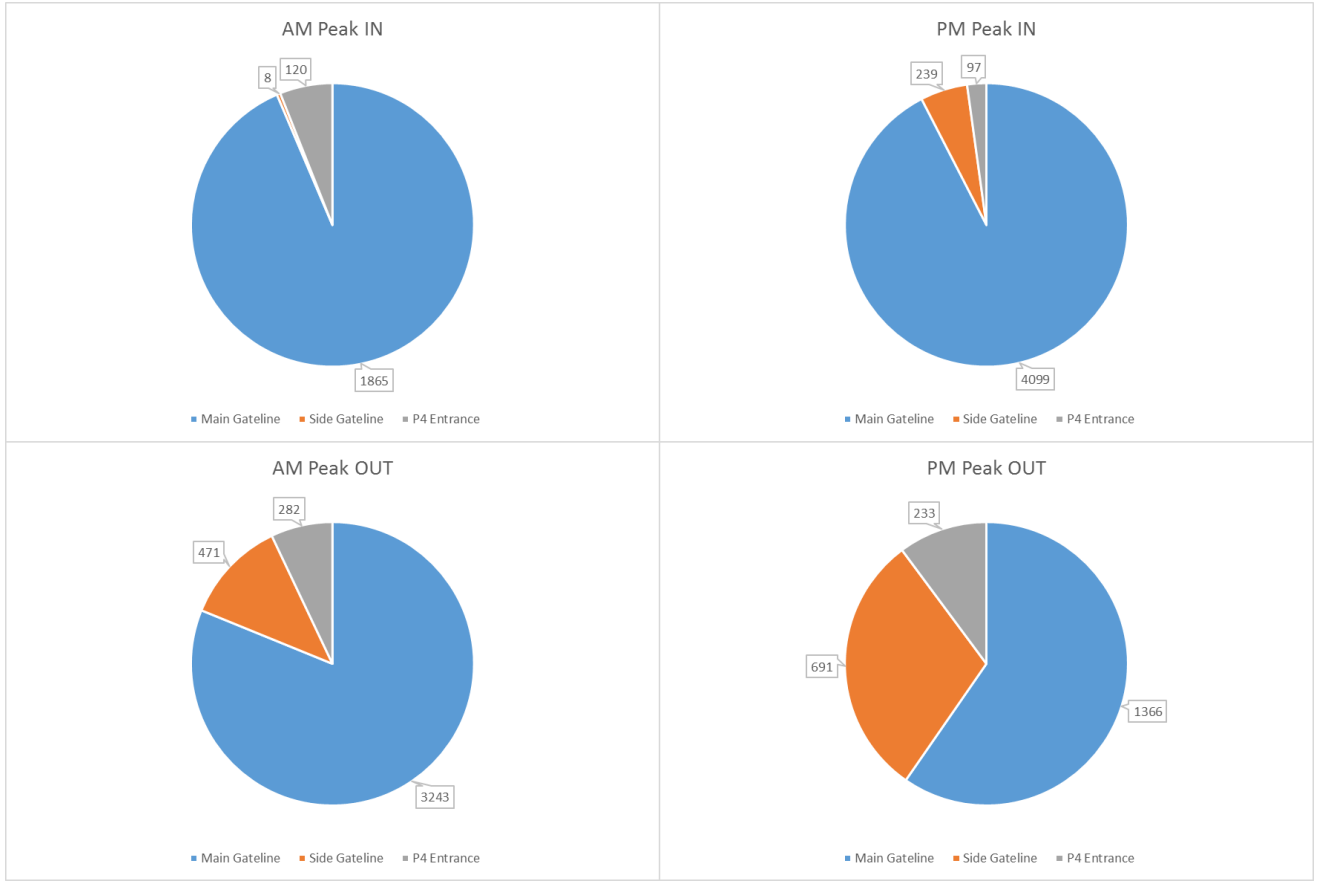
Minute By Minute



As would be expected for a station with large alighting loads, the peak minute for station exits exceeds the peak minute for station entries, with the latter being a more consistent, flat demand.

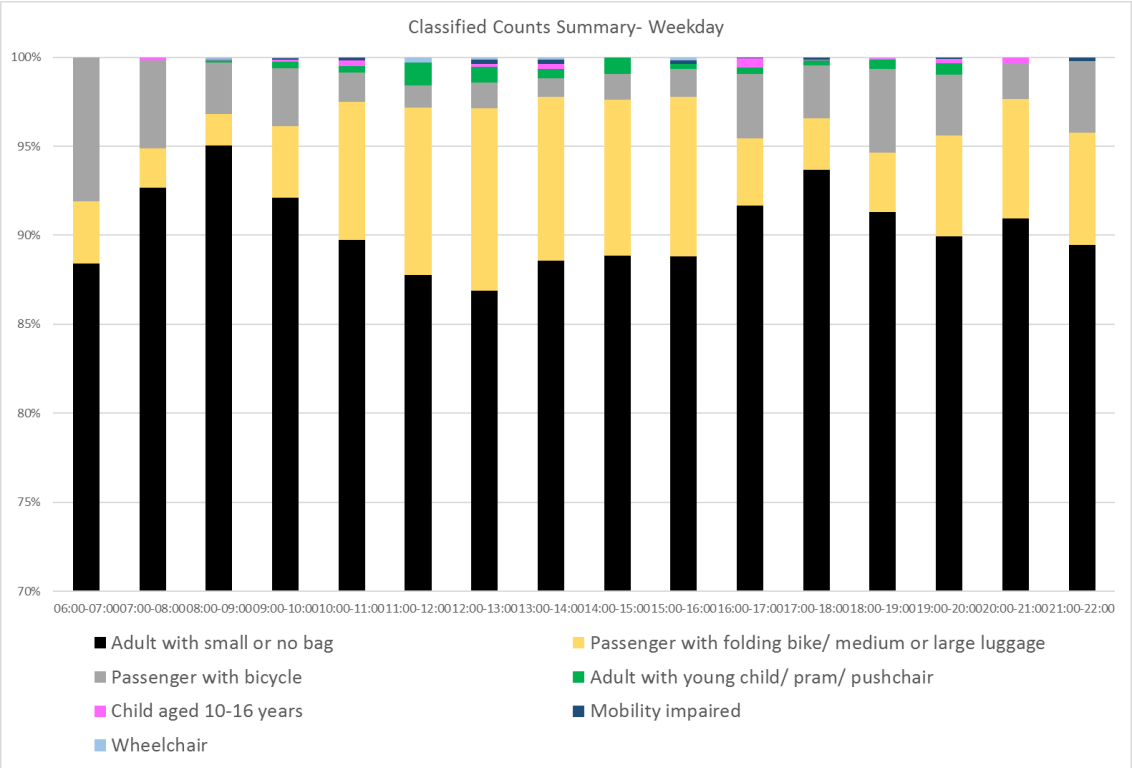
However, the station entries do show peaks at just after the hour and just after half past the hour, suggesting more planned journeys than a “show-up and go” style railway.

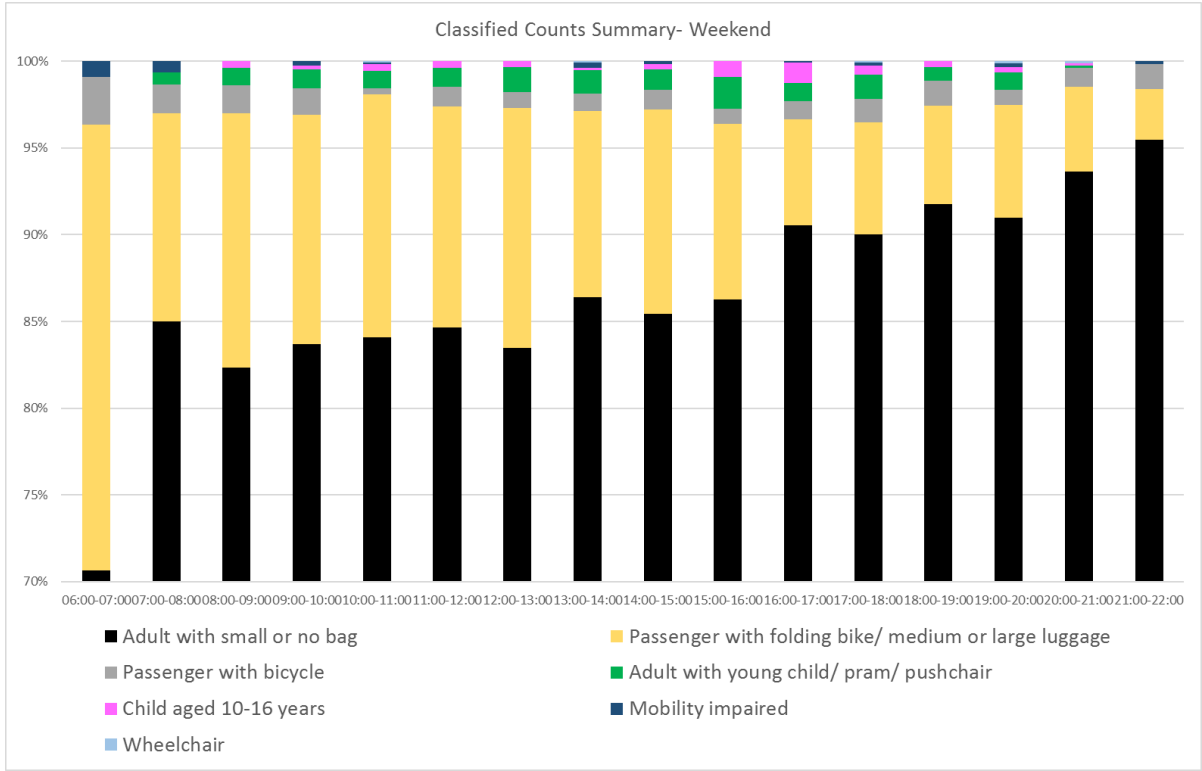
Entrance Splits



- In the AM peak, the secondary gateline is only used to exit the station.
- The small P4 entrance and the secondary gateline are used most heavily in the PM peak, when there are large alighting loads.
- The main gateline is the dominant way of entering the station in both peak periods, and the main way of leaving the station in the AM peak.

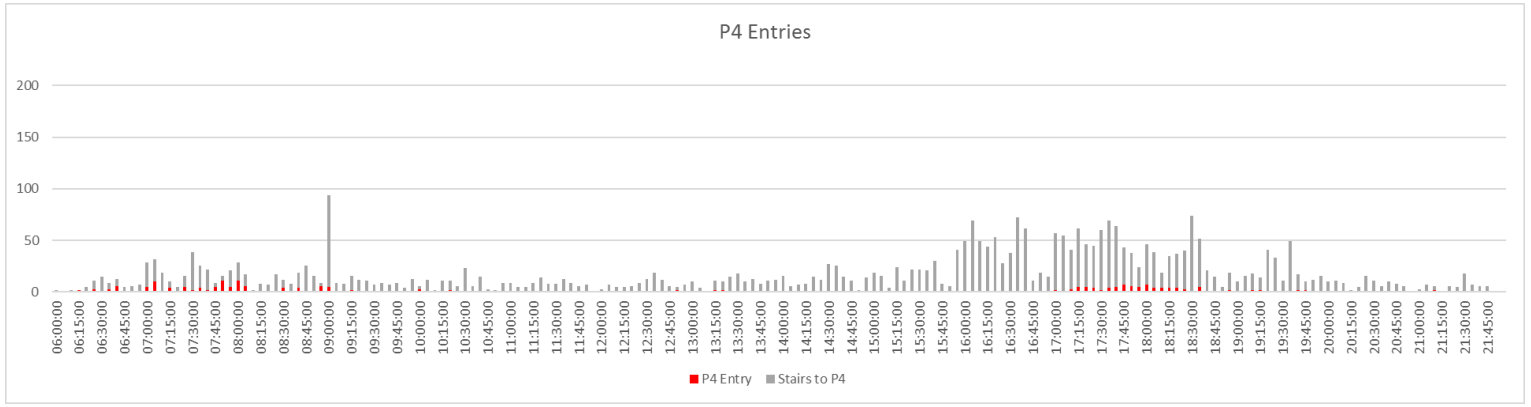
Classified Counts

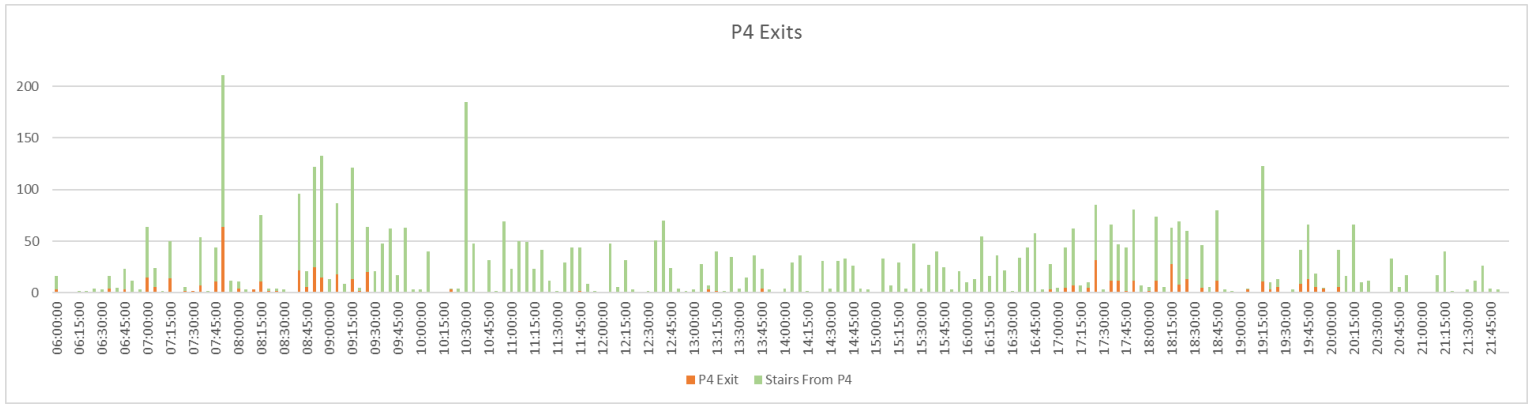




- At any given time, at least 70 % of the passengers at Oxford have no bag or a small bag (note graphs start at 70 %)
- At the high peak during the week, the proportion of PRMs and large luggage drops significantly.
- During the middle of the day and on weekends, a larger proportion of passengers have bags or young children.

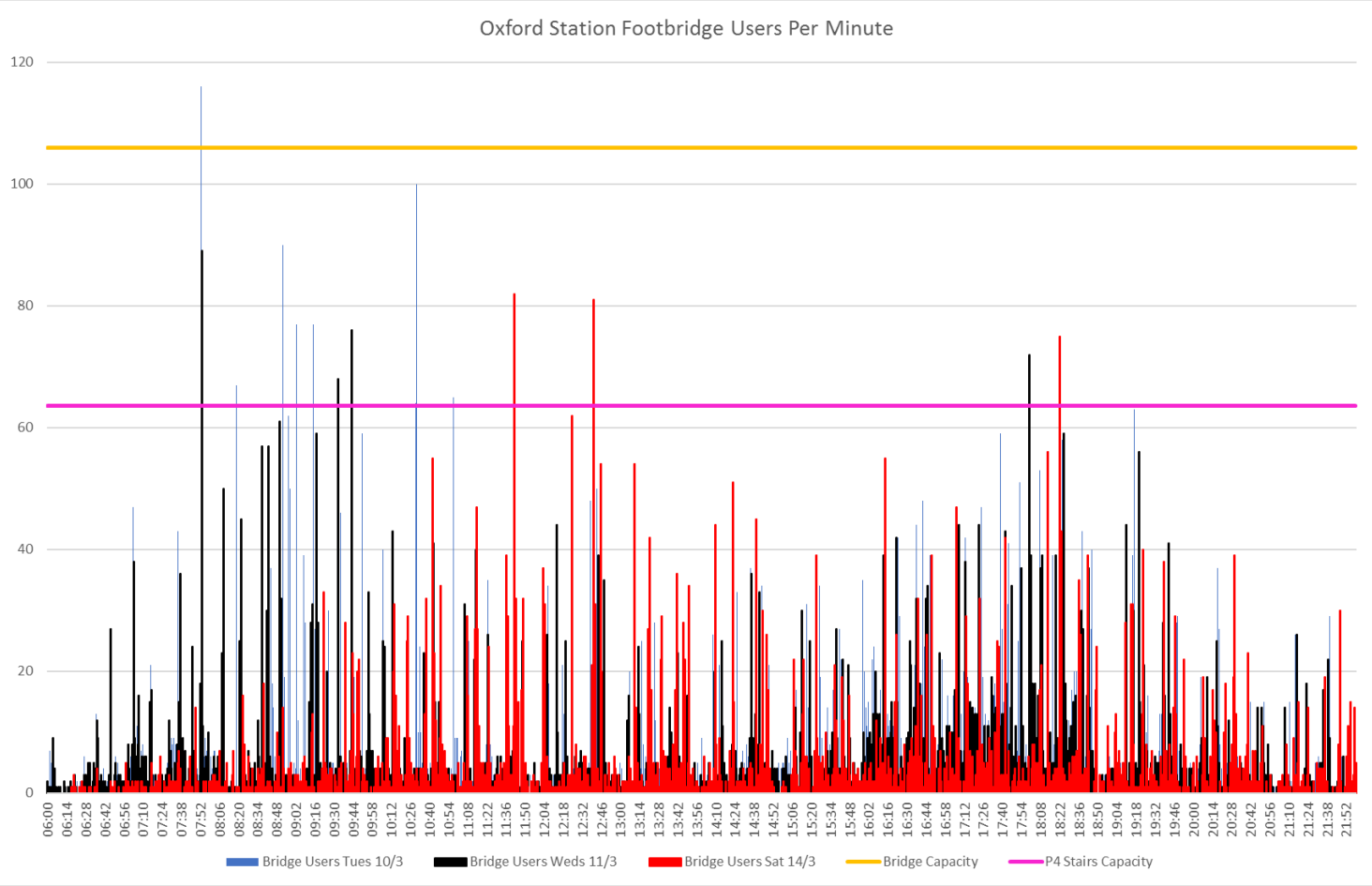
P4 Summary





- Most people enter P4 from the stairs, and therefore access the station from the main and secondary gatelines
- Similarly, most alighters leave P4 via the stairs, except when large alighting loads arrive, when a small proportion of passengers will use the P4 exit.

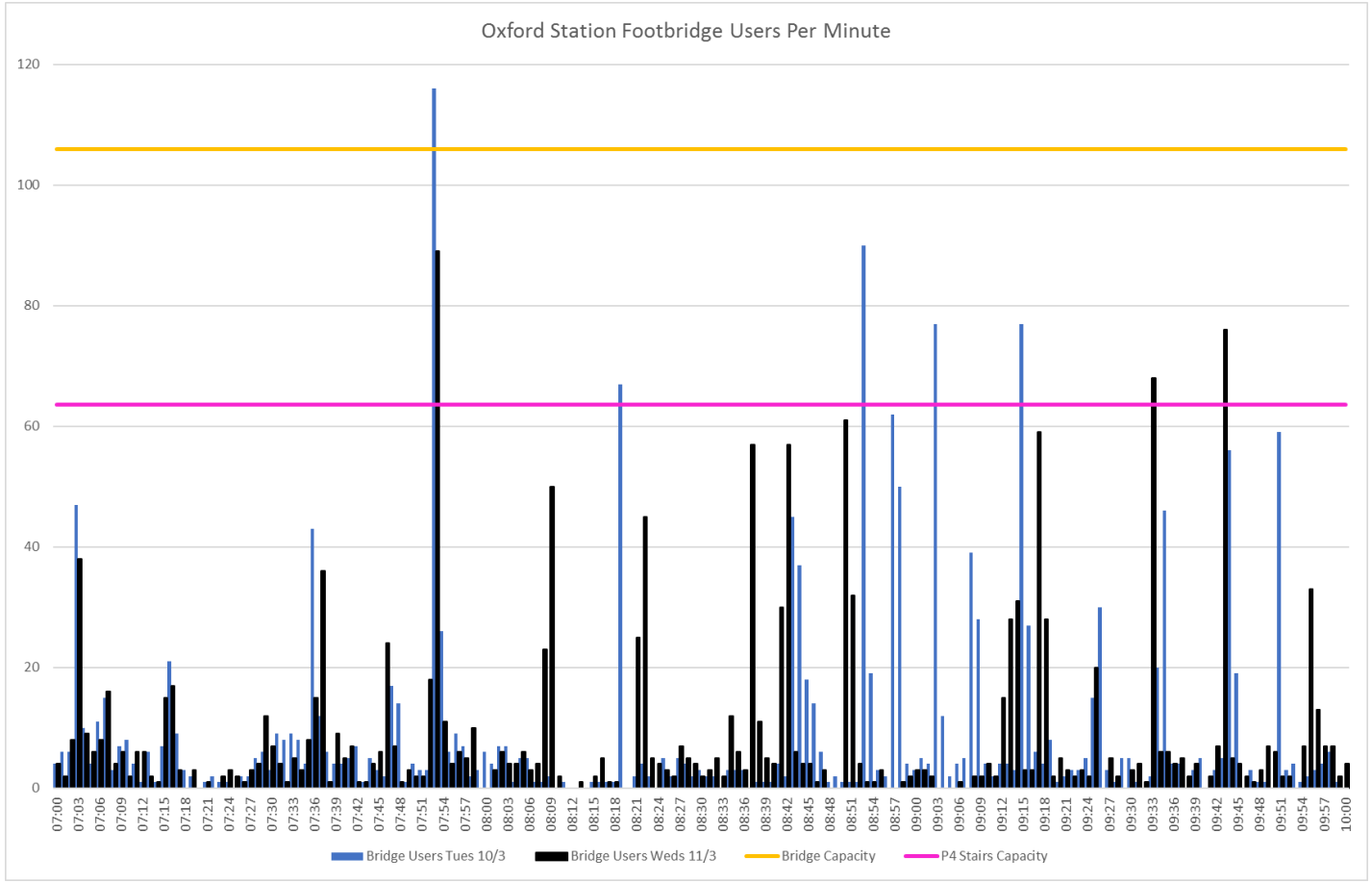
Footbridge Capacity



- Looking at the survey data for the overbridge, the stairs are over capacity for several minutes in the morning peak during the weekdays, and can also be busy in the evenings and during the day on the weekend.
- Station Capacity guidance is rarely exceeded for the bridge itself. This is likely due to the fact that is it only accessed from the lower capacity stairs.
- There is slightly more capacity for the bridge than the stairs in order to ensure the bridge itself is not at stand-still during large alighting loads.

Station Area	Normal Ops	
	LoS	Quantitative measure
Passageways – one-way	D	50ppmm
Passageways – two-way	C	40ppmm
Stairways – one-way	D	35ppmm
Stairways – two-way	C	28ppmm
Concourse dwell areas	B	1.0m² per pax
Platforms	B/C	0.93m² per pax
Ticket gates		25ppm/gate
Escalators		100ppm

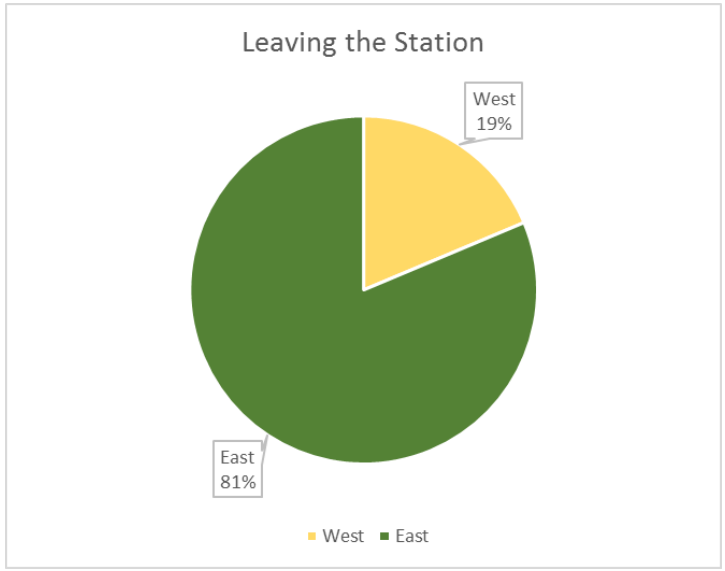
Footbridge Capacity (Weekday AM Peak)

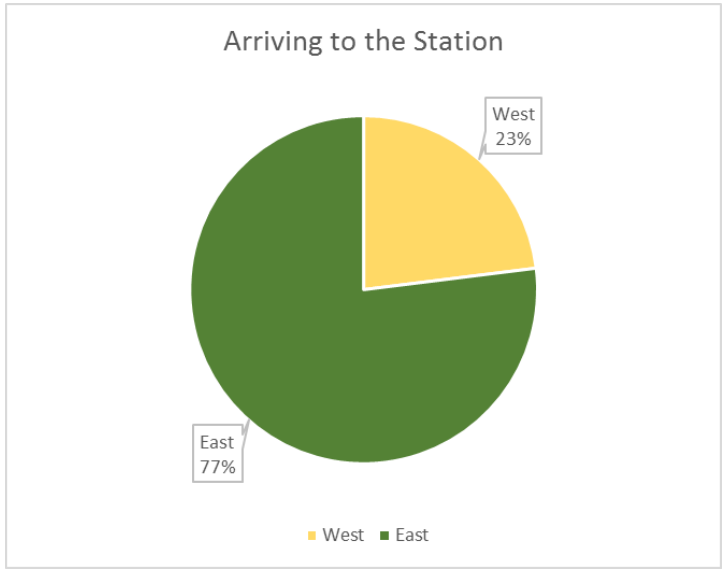


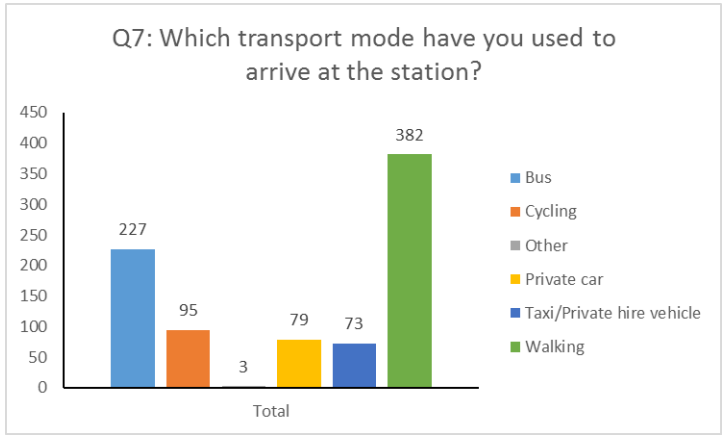
- The peaks in the data likely represent large alighting loads for each weekday in the AM peak.
- The bridge is seen to exceed capacity for a minute after most large alighting loads, but residual queues are limited
- With COVID-19 adjustments applied (addressed later), several more trains will exceed the stair capacity, but not for more than 2 minutes, as seen here

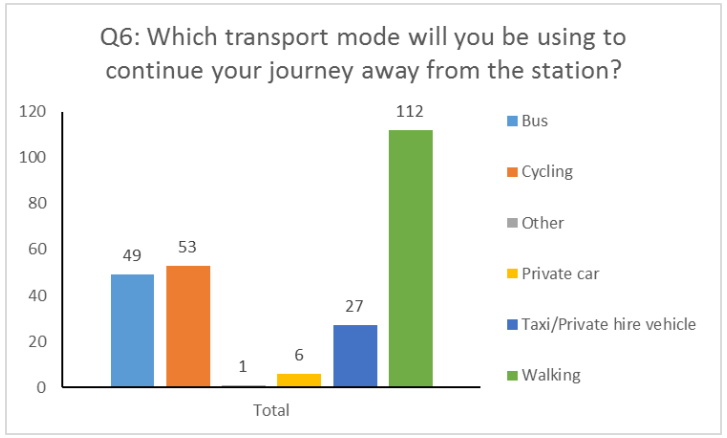
Station Area	Normal Ops	
	LoS	Quantitative measure
Passageways – one-way	D	50ppmm
Passageways – two-way	C	40ppmm
Stairways – one-way	D	35ppmm
Stairways – two-way	C	28ppmm
Concourse dwell areas	B	1.0m² per pax
Platforms	B/C	0.93m² per pax
Ticket gates		25ppm/gate
Escalators		100ppm

Interview Survey Results (weekday)

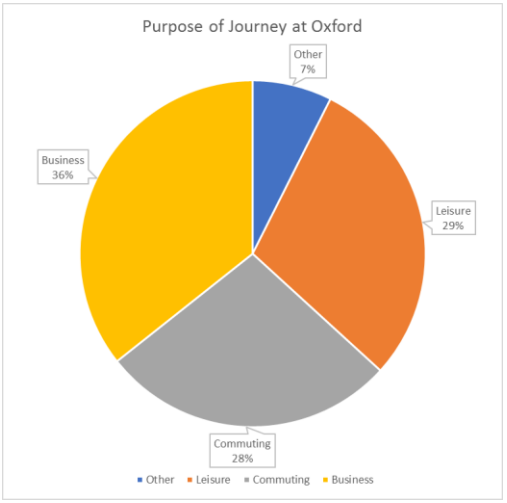






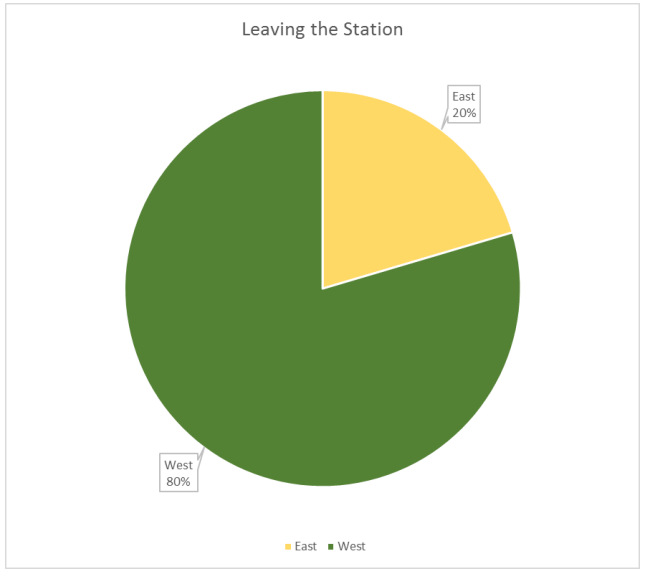


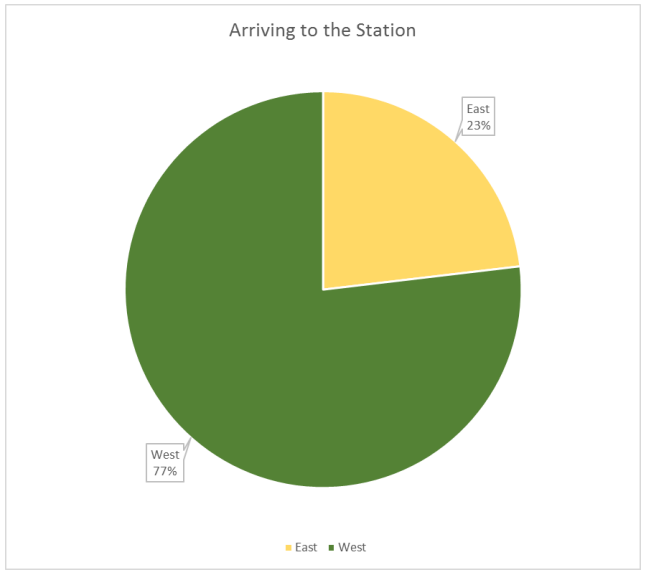
- The interviews were conducted on a weekday from 07:00-19:00
- A total of 1269 people responded to any questions in this survey
- The largest share of onward travel and arrival at Oxford Station is by foot
- Of those who arrive and leave by foot, over 75 % are coming from or going towards the East side of the station.
- Most journeys at Oxford are for the purpose of business or commuting



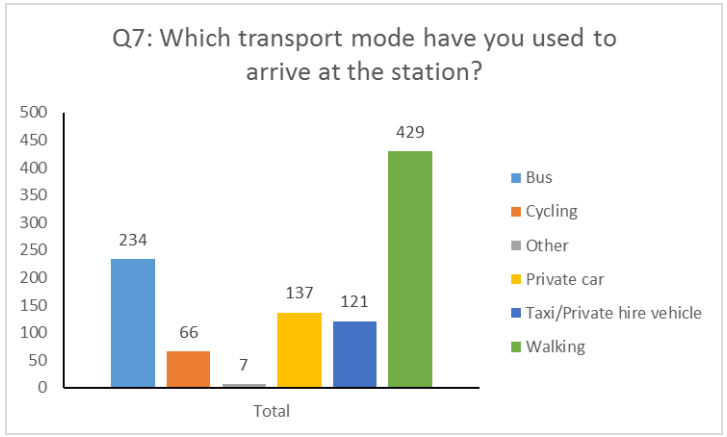
System Operator

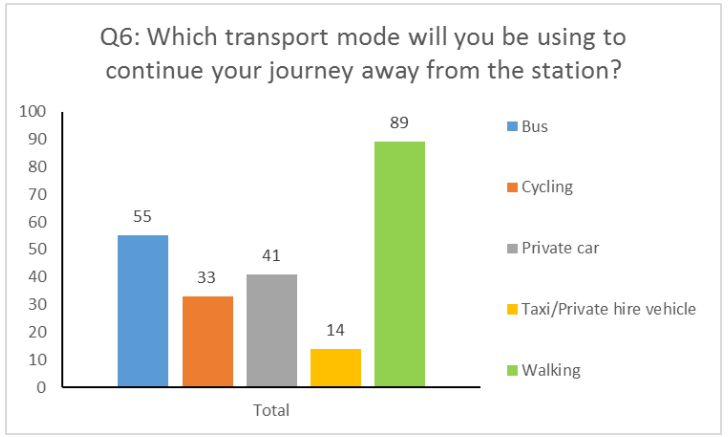
Interview Survey Results (weekend)

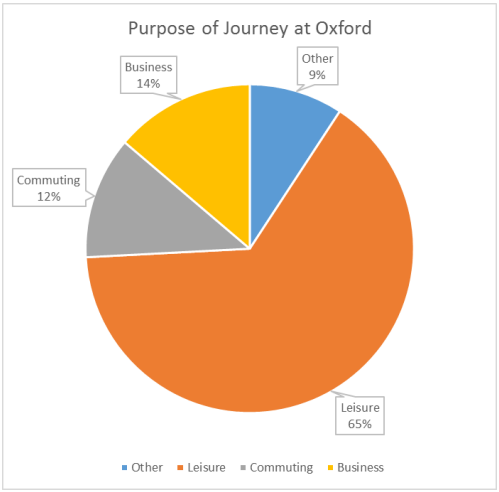




- The interviews were conducted on a weekend from 07:00-19:00
- A total of 1346 people responded to any questions in this survey
- The largest share of onward travel and arrival at Oxford Station is by foot
- Of those who arrive and leave by foot, over 75 % are coming from or going towards the East side of the station.
- Most journeys at Oxford on the weekend are for the purpose of leisure.

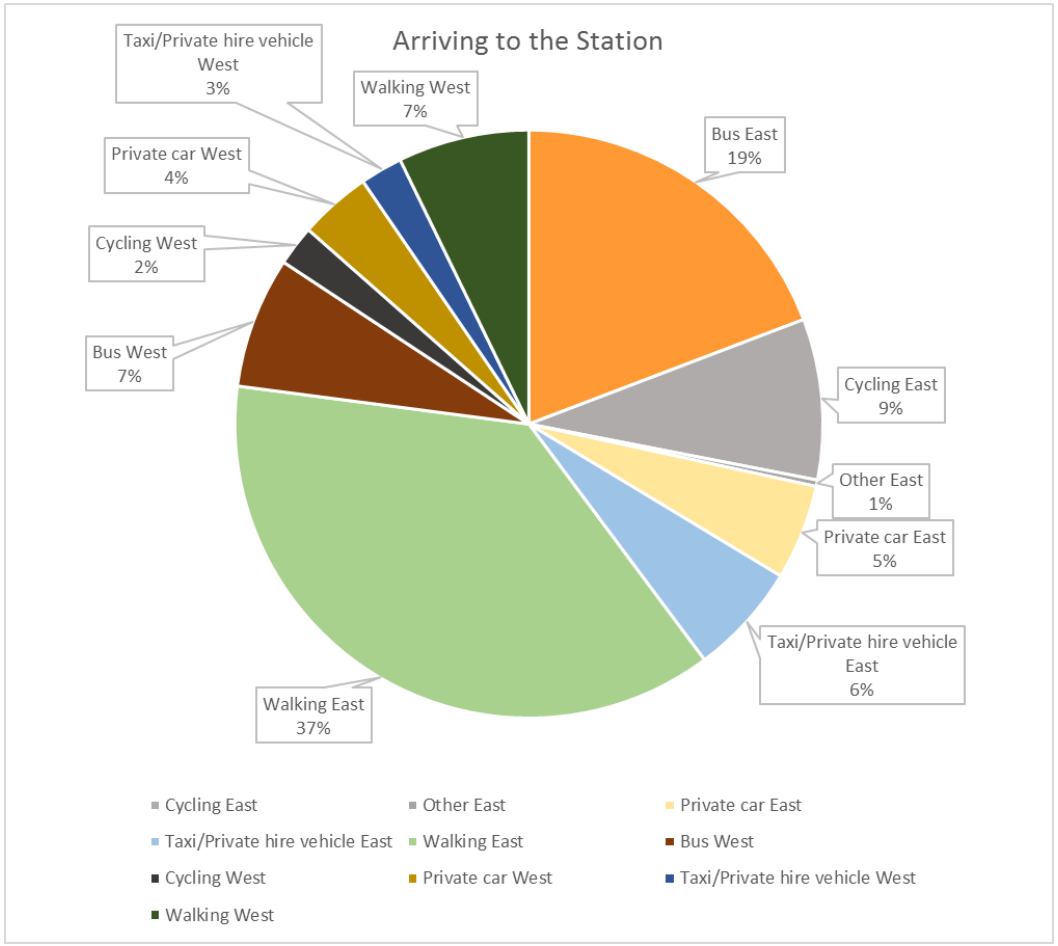


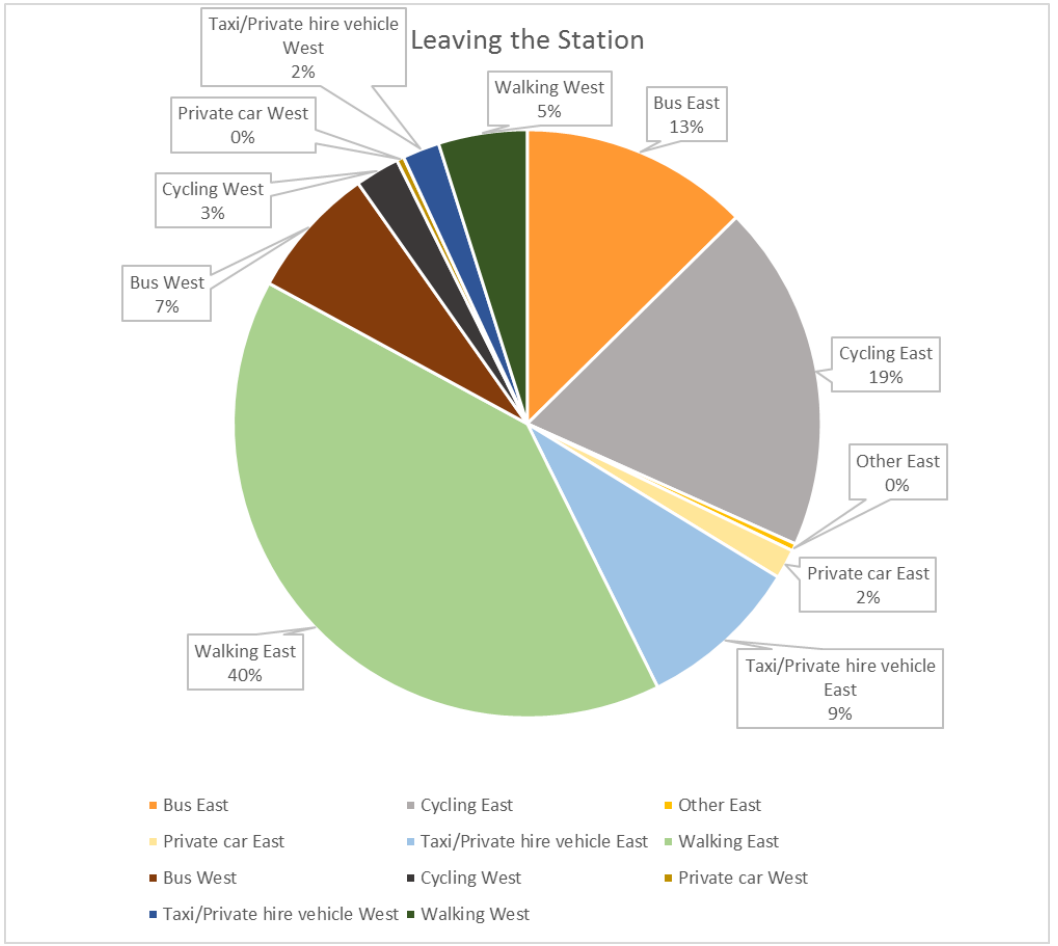




System Operator

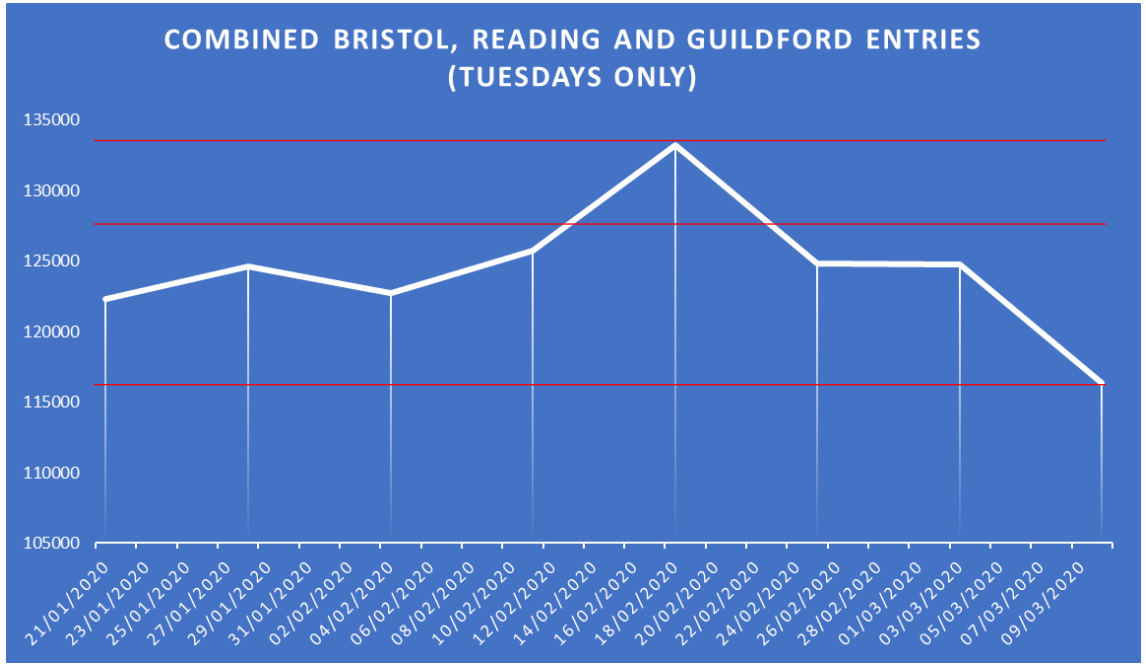
Interview Survey Results (total)





System Operator

Survey Adjustments Required



Scenario	Number	% Drop For 10th March	Factor to Apply
Average Tuesday	125,457.7	7.2%	107.8%
Busiest Tuesday	133,194	12.6%	114.4%
10th March	116,389	0.0%	100.0%

Due to the impact on the surveys of COVID-19 and related travel reductions, Network Rail has assessed three similar managed stations to approximate a drop-off for the survey dates (10th ,11th and 14th March 2020)

In February, the UK government advised self-isolation for any individuals who had been to impacted countries, or who had contact with those who had.

By the 16th of March, all non-essential travel was advised against, and by the 23rd the lockdown was in place.

The statistics show that COVID-19 was responsible for between a 7% and 12% drop in passenger numbers on these days. This means to correct the surveys to "normal" footfall, a factor of somewhere between 107% and 114% should be applied.

The peak seen in this graph appears to be for half term, and a similar increase would be expected at Oxford.

Growth From 2015 (weekday peak)

"Busiest Day" Adjustment Applied		
Scenario	P4 Stairs	Main GL (+secondary GL) Entries
Growth AM Peak	17.64%	6.49%
Growth PM Peak	19.78%	1.16%

"Average Day" Adjustment Applied		
Scenario	P4 Stairs	Main GL (+secondary GL) Entries
Growth AM Peak	10.86%	0.35%
Growth PM Peak	12.87%	-4.68%

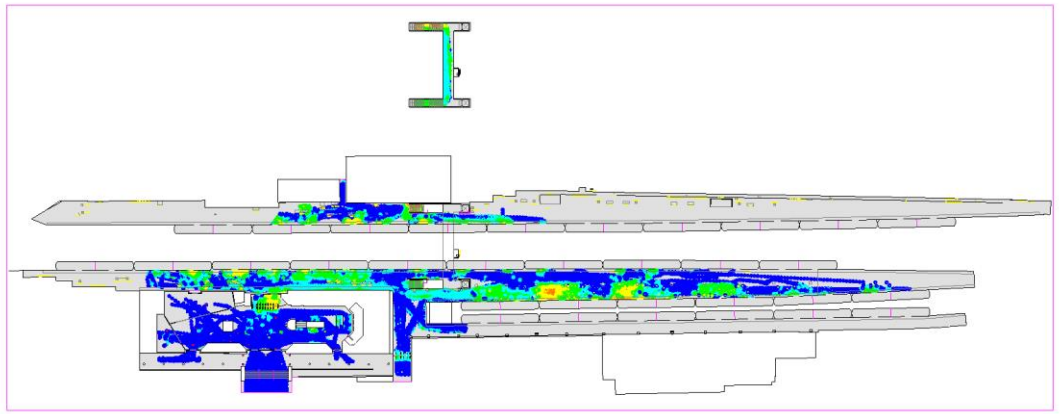
- Due to changes in the station since 2015, the best points of comparison are:
  - Station entries via the main gateline (including the secondary gateline in 2020)
  - P4 stair users
- In order to determine the growth, both values for "Average" and "Busiest" have been tested.
- Based on the average day adjustment, the overall station growth is relatively flat.
- In both scenarios, P4 growth is significant, ranging from 10-20 % up from 2015 levels.
- ORR station usage data shows a ~20 % increase since 2015. This may be accounted for by significant interpeak and weekend growth, but the busiest hours for the station are referenced here.

System Operator

APPENDIX B
LOS Maps

NR Station Capacity Team

2024 Base AM



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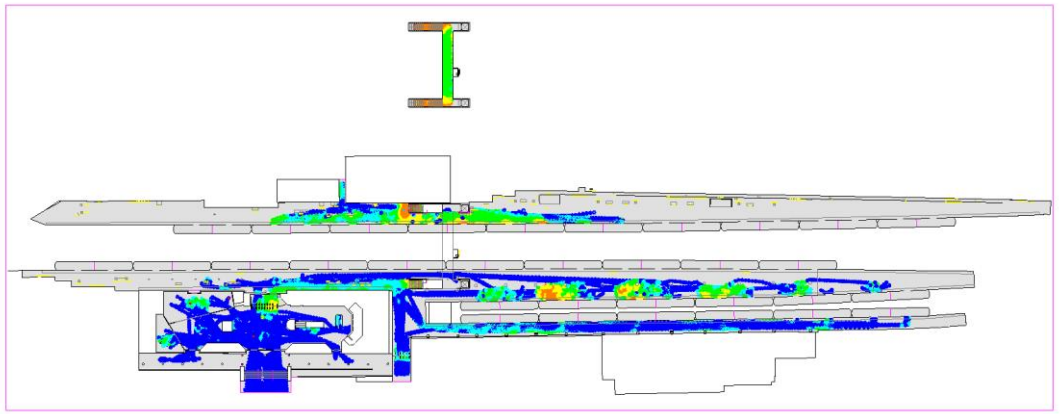

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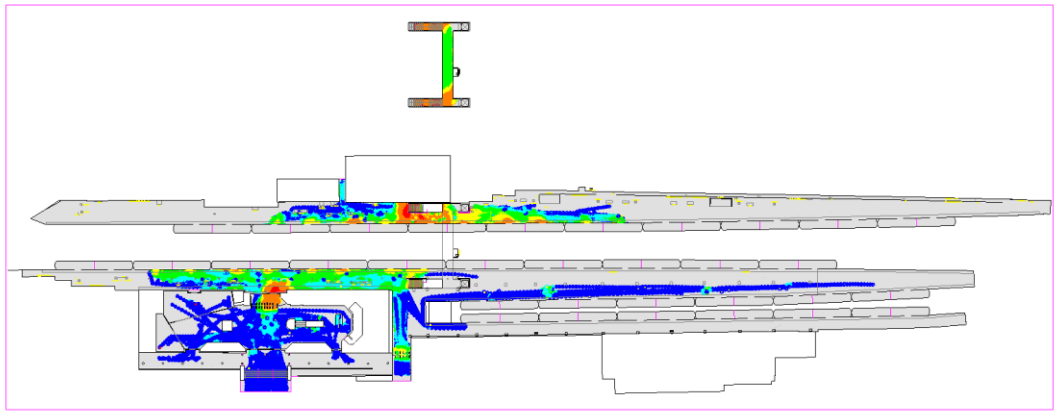

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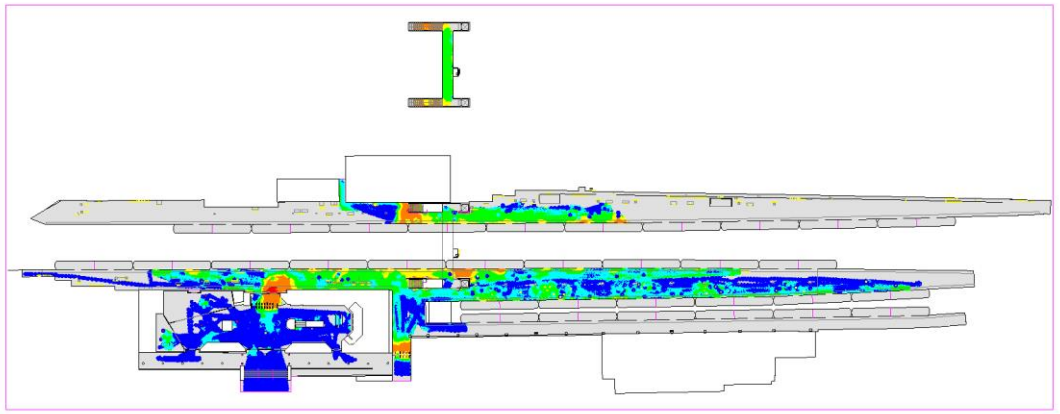

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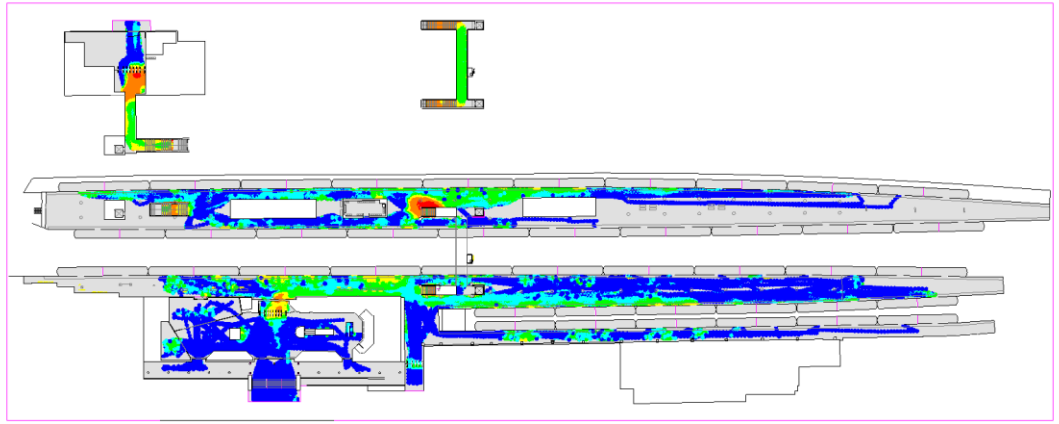
2033 Phase 2 AM (WebTAG)



LEGION SCIENCE IN MOTION

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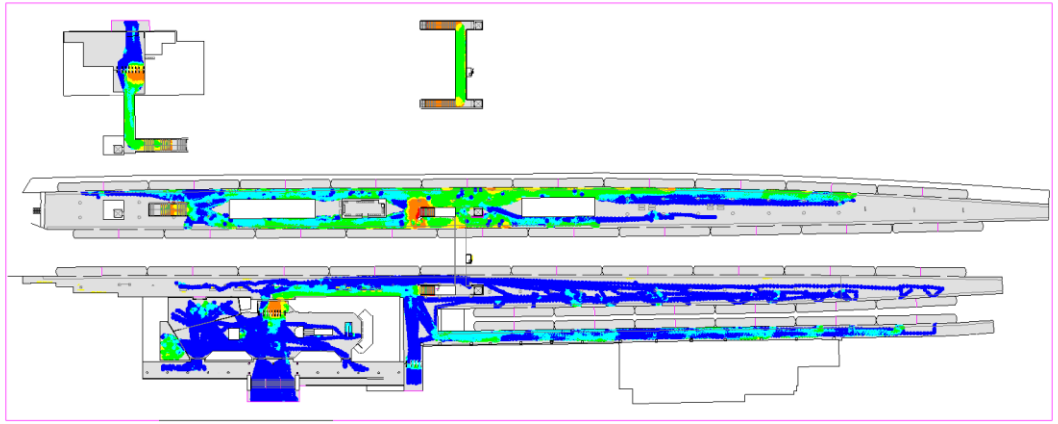

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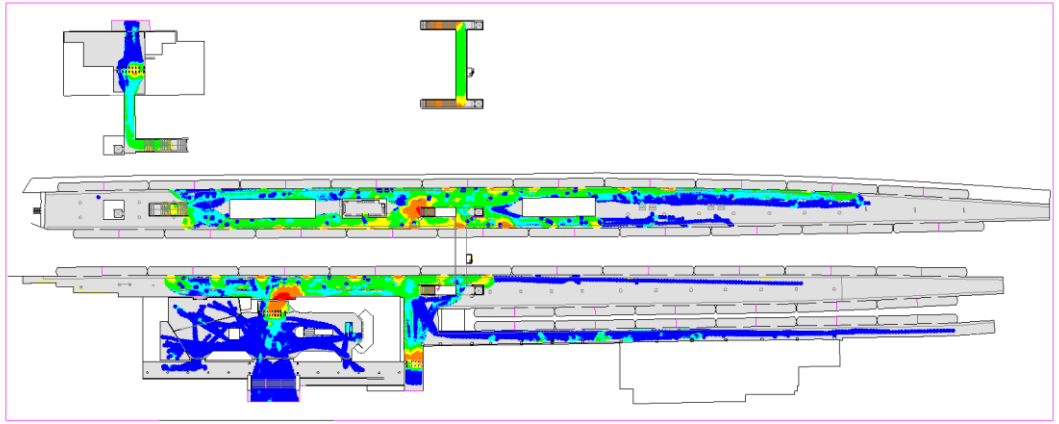

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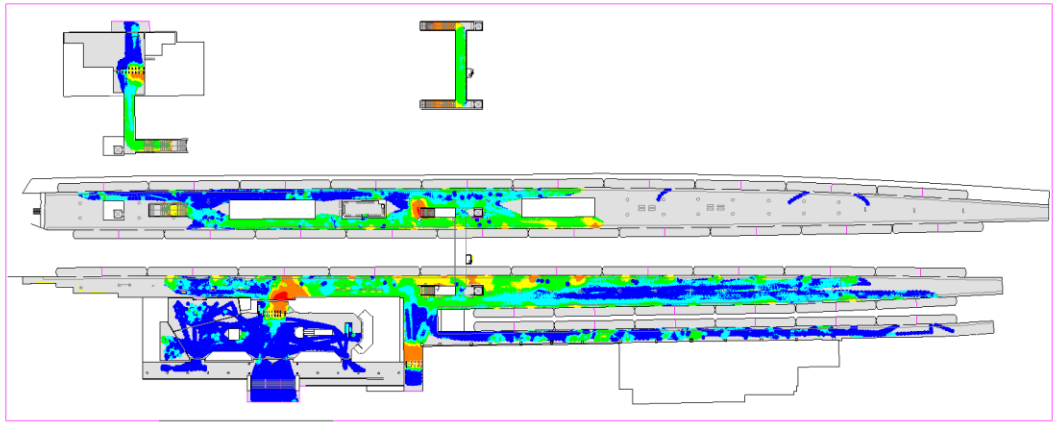

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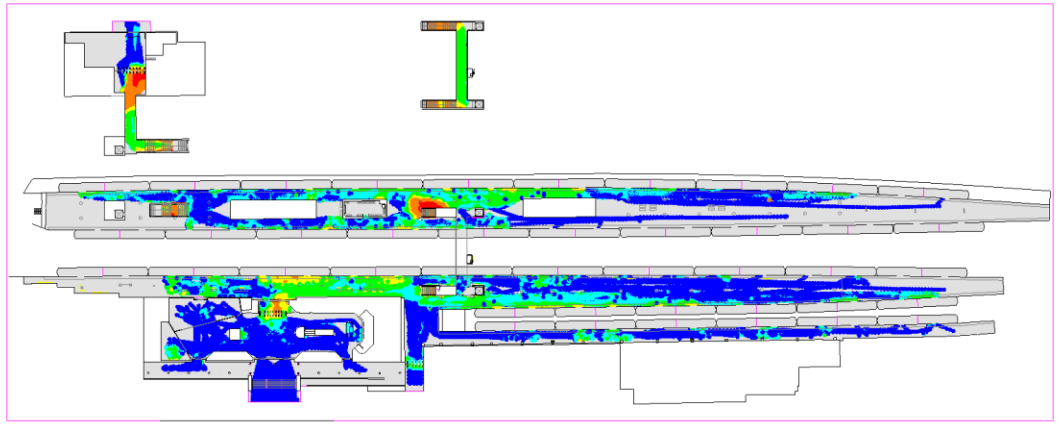

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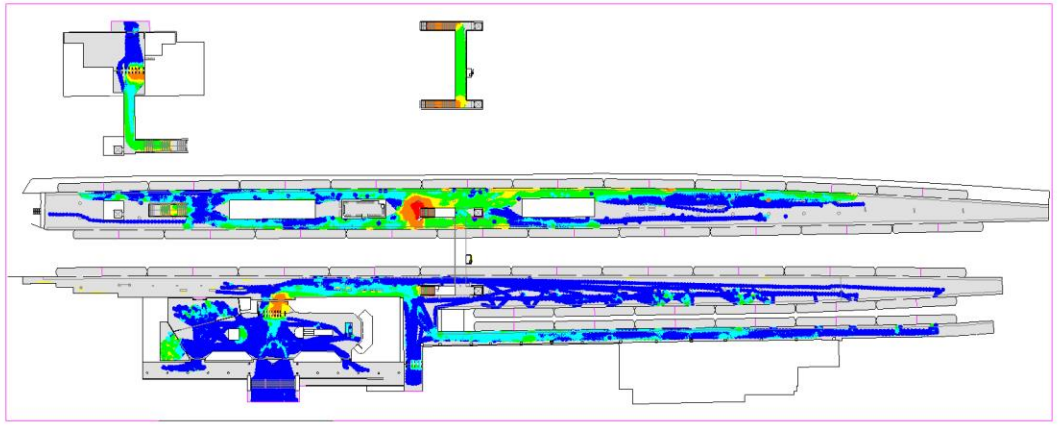

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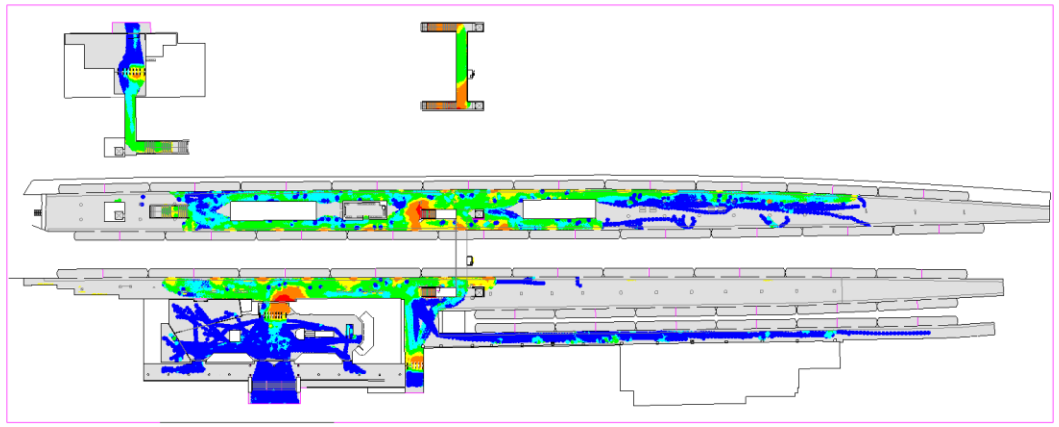

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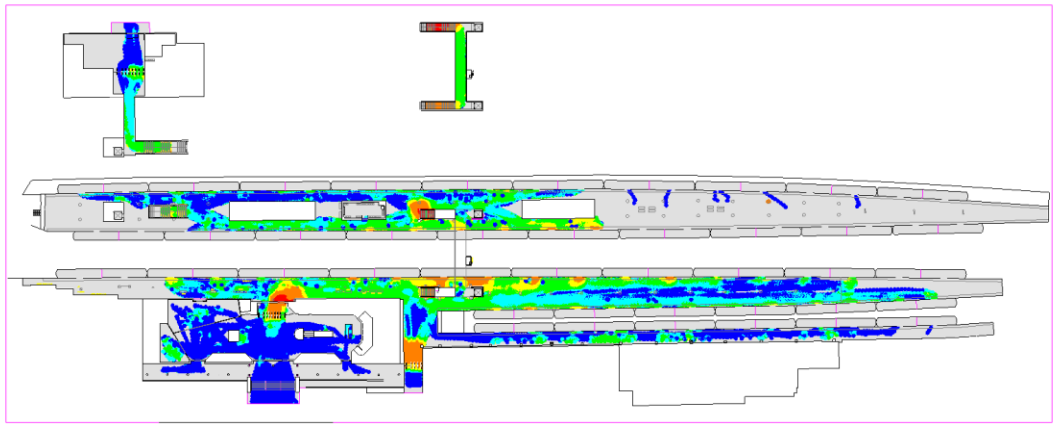

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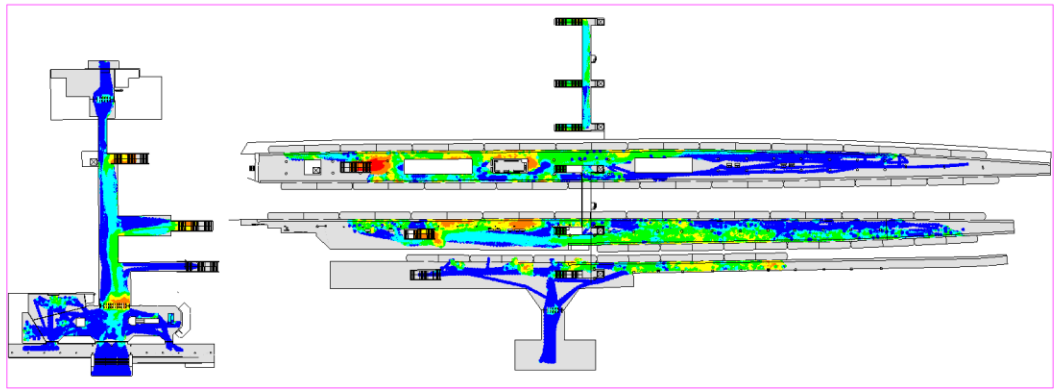
2050 ORCS AM



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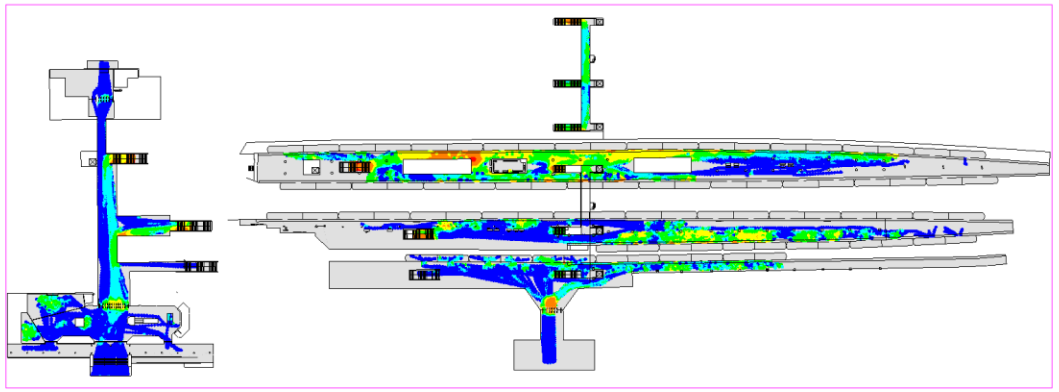

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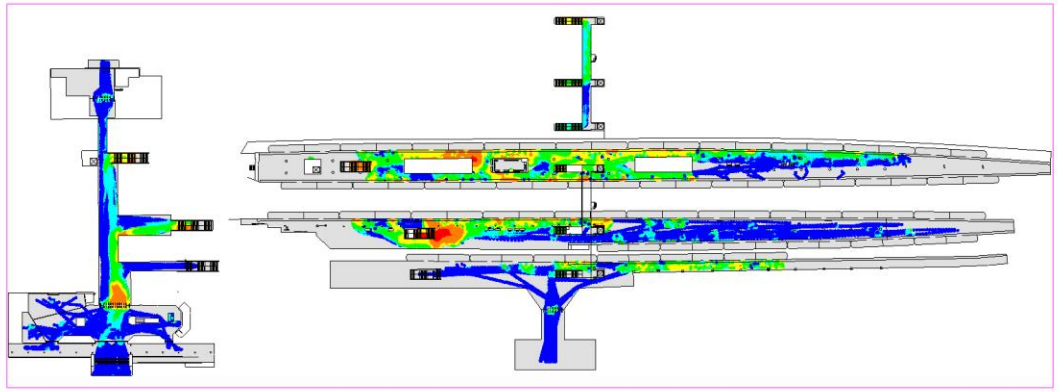

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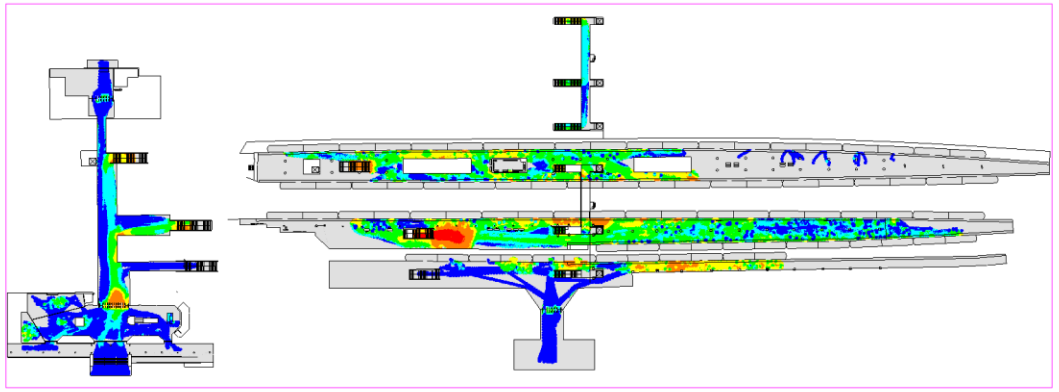

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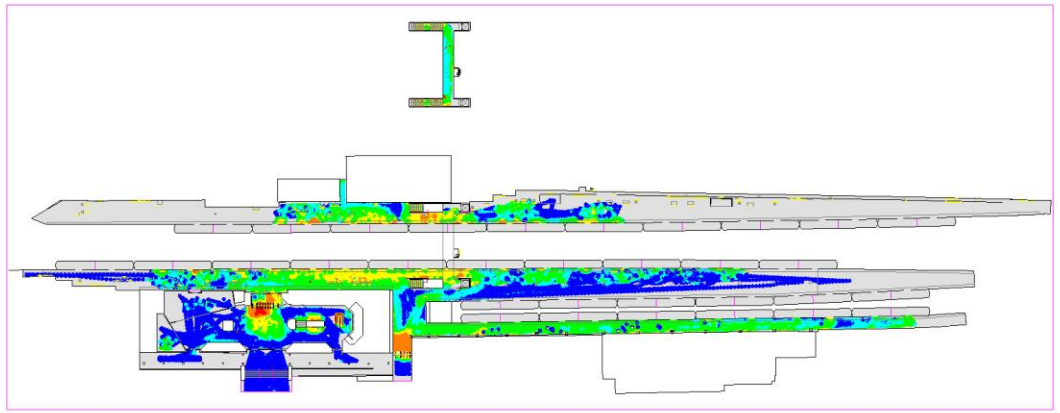
2024 Base PM



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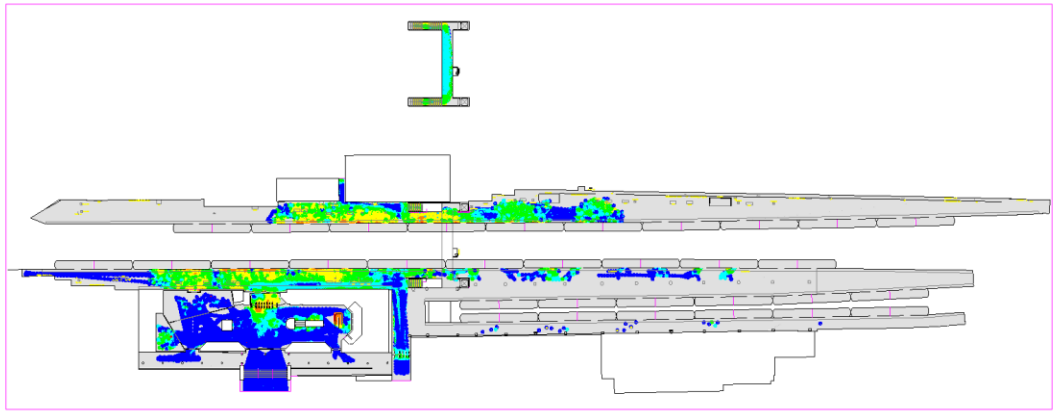

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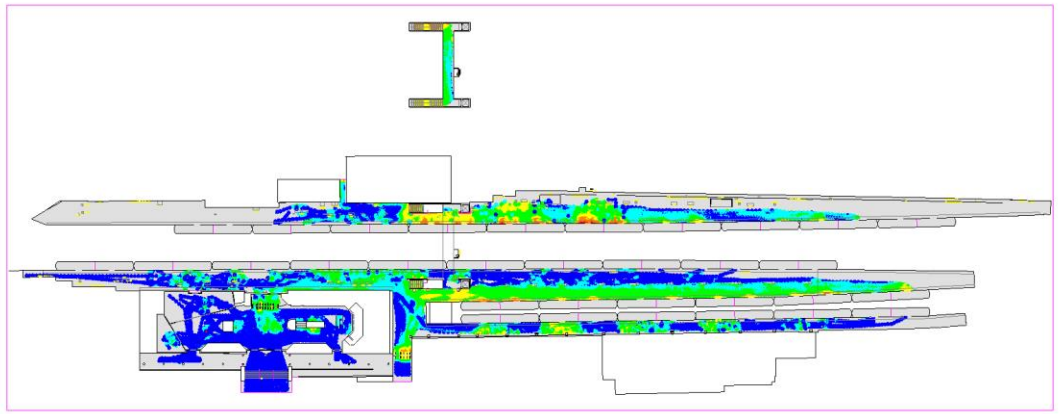

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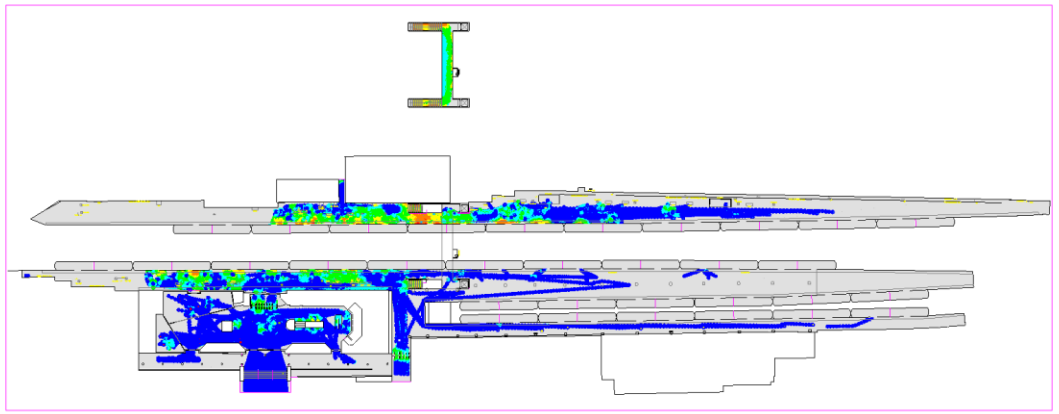

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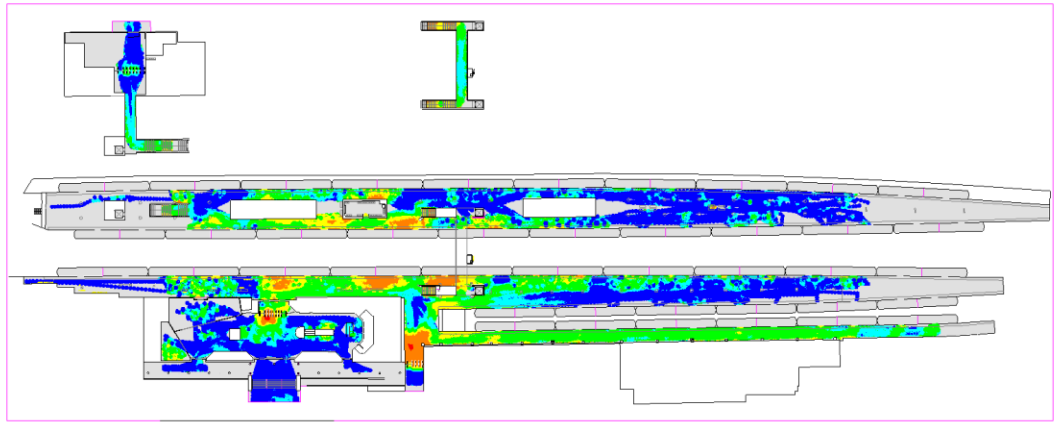

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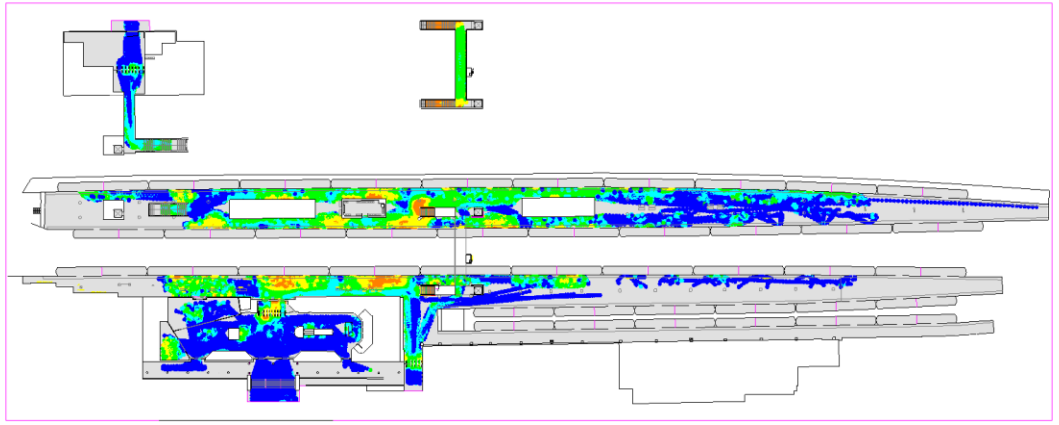

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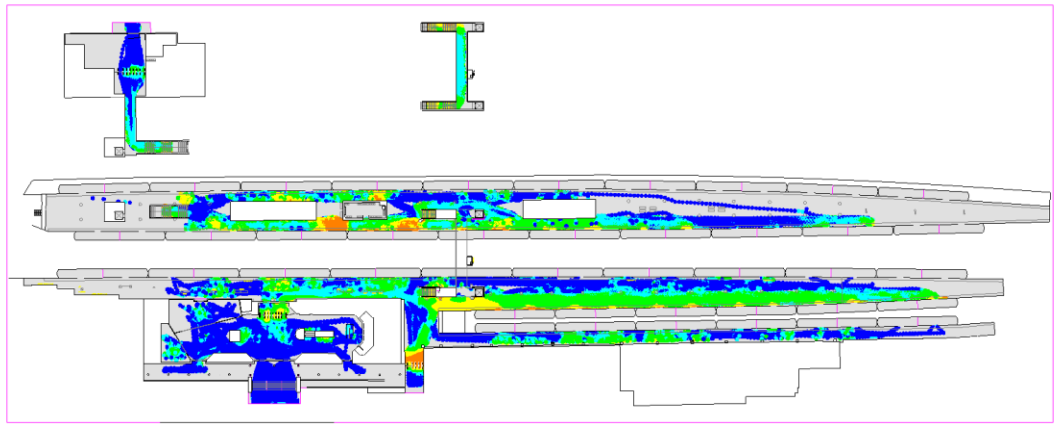

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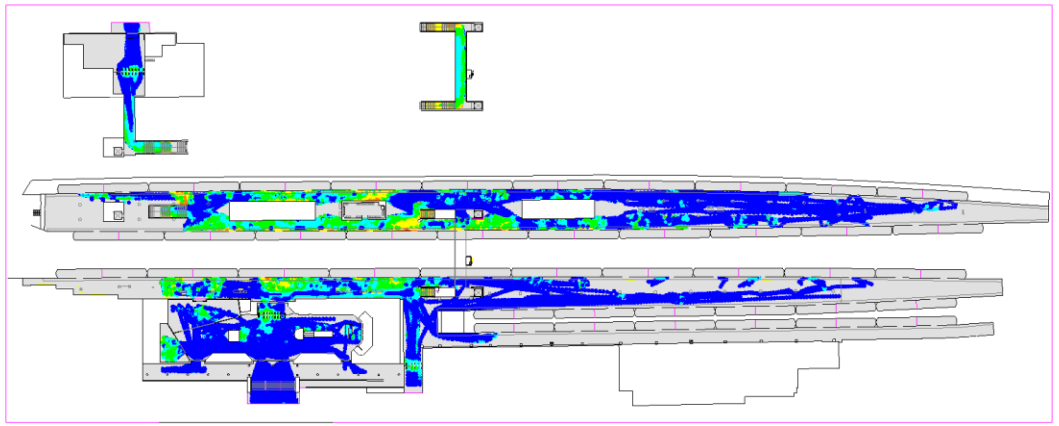

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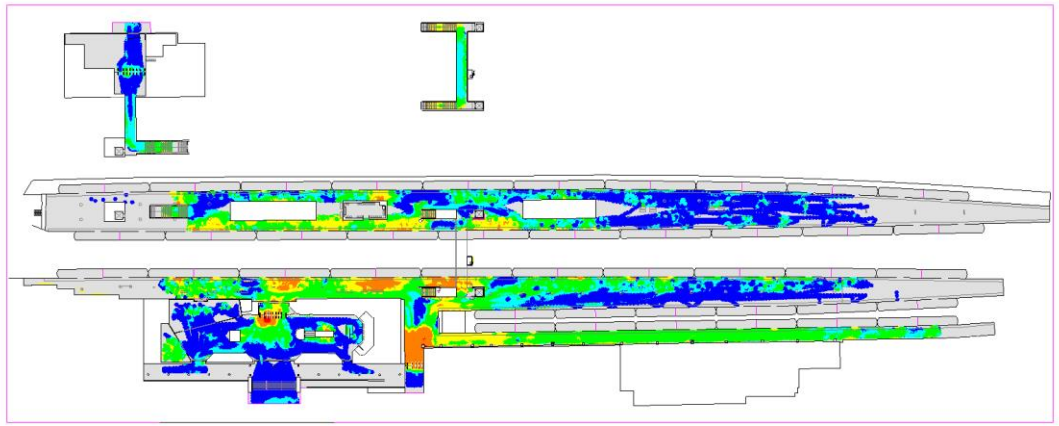

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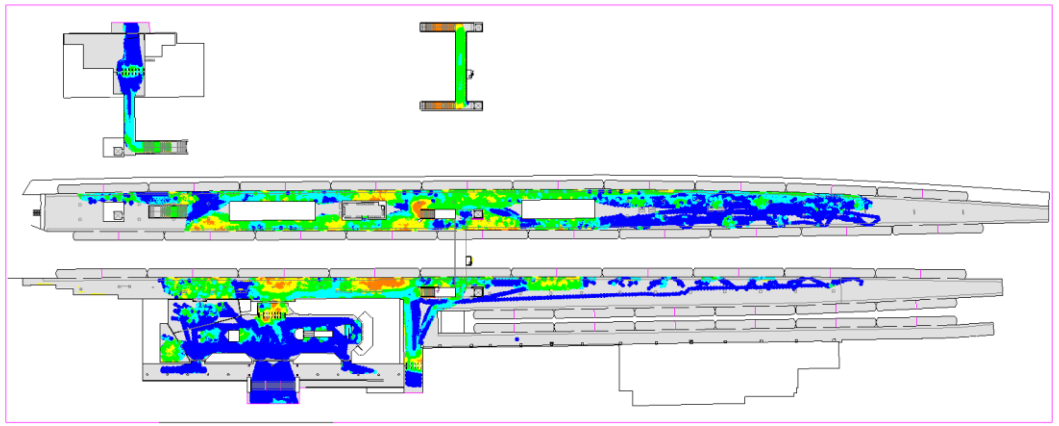

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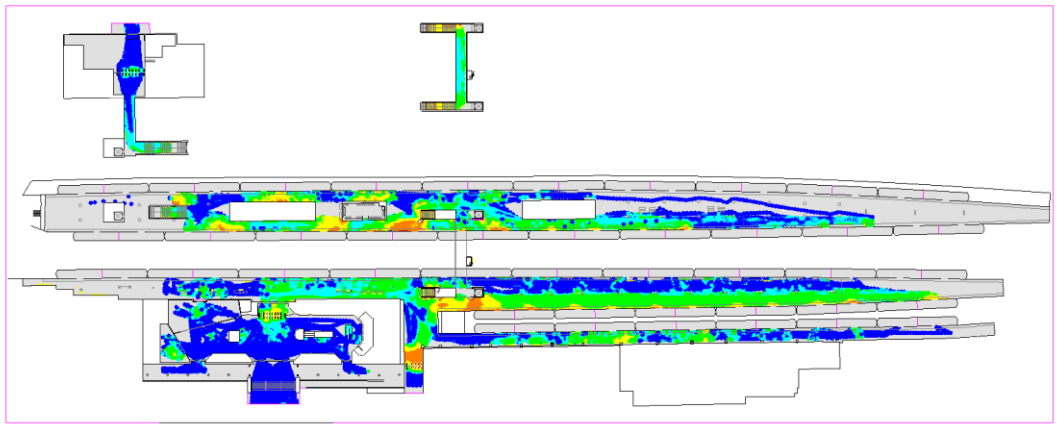

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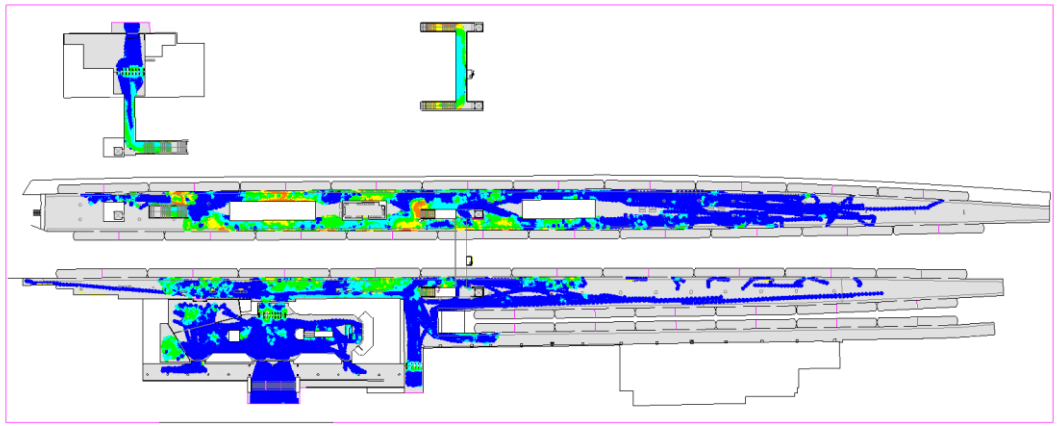

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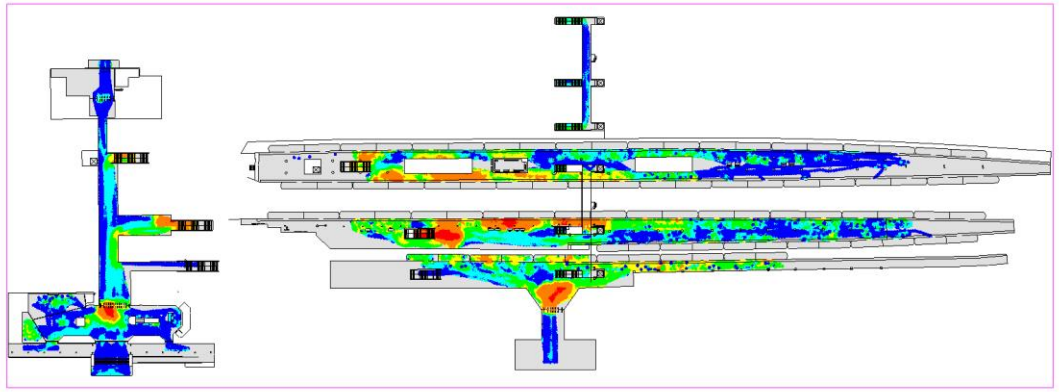

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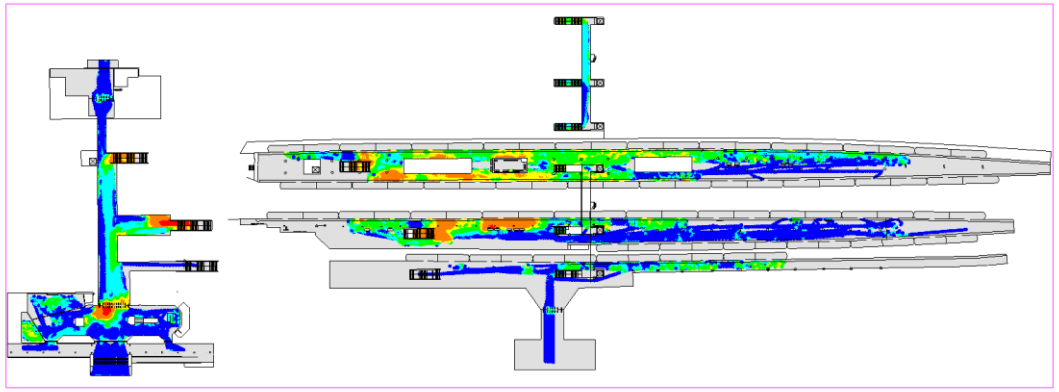

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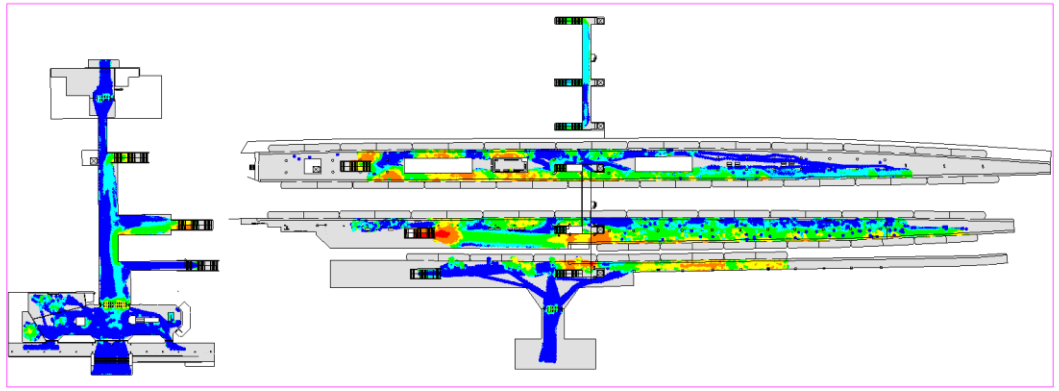

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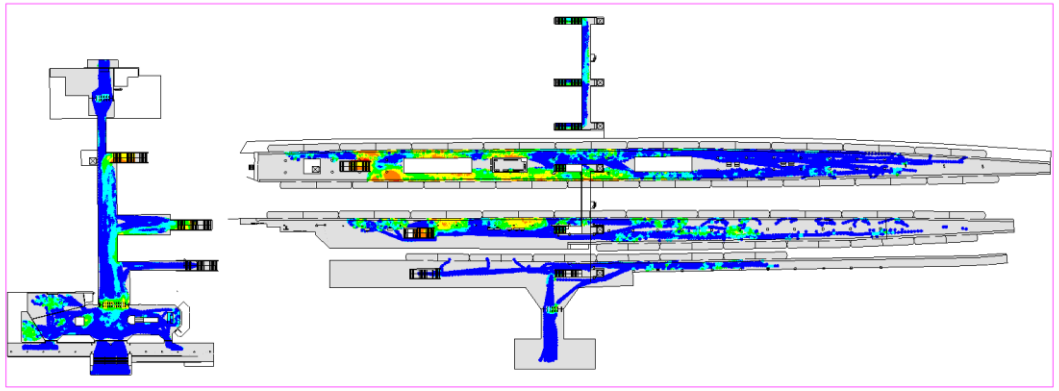

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