Network Rail

King's Cross Station Enhancements

Station Design and Passenger Movements

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Executive Summary

Background

The design of the new Western Concourse has evolved through a series of in depth reviews with various stakeholders involving detail engineering reviews, rail and station operational assessment, and co-ordination with adjacent interchange and development projects.

The existing station concourse sits on the south face of the Grade 1 listed main shed extending up to the public highway of Euston Road. This existing concourse and its facilities are sub standard with passenger facilities and at peak times very congested with poor intermodal connections. This creates an uncomfortable passenger environment. The station also operates as two independent stations with Platforms 1-8 served by the primary southern concourse and the suburban Platforms 9-11 served by a secondary concourse which includes and external waiting area. This arrangement is unsatisfactory resulting in doubling of staffing requirements and inconvenience to passengers.

The Camden planning aims for the station area include revealing the Grade 1 listed southern façade of the station which would complement a new public realm set within the southern square fronting Euston Road. This concept reflecting the ambitions described in the Terry Farrell vision for the Euston Road street scape between Paddington to the west and Kings Cross in the east.

Integrated Transport Hub

With the requirements to demolish the existing southern concourse and retain the Great Northern Hotel, alternative concourse locations have been reviewed. Initial studies explored locating an expanded concourse within the existing main shed. To achieve this major rail track works would be required to set the platform heads back further north. This would require major engineering and signalling works, track realignment to accommodate platforms suitable for longer trains, and also major tunnelling works. In addition to the new southern concourse set within the main shed further works would be required to provide a new improved suburban shed station facility. Hence, the high costs associated with this concept required alternatives to be explored.

The CTRL works at St Pancras, which are due for completion in 2007, include improved London Underground connections and ticket halls. This includes a new Northern Ticket Hall located adjacent to King's Cross Station to the west of the main shed and to the south of the suburban shed. Other CTRL works include a new Western LUL Ticket Hall which has recently opened, and an upgraded of the existing Tube Ticket Hall. These new and upgraded ticket halls will provide a significant improvement for LUL passengers accommodating additional demands due to development growth within London. It has been noted from surveys that some 60% of main line passengers currently use LUL services and therefore direct and easily recognisable connections between main line and underground operations are to be fostered.

The LUL improvements described gave the opportunity to place a new King's Cross station concourse above the new LUL Northern Ticket Hall to provide direct connections with the underground system. This arrangement, whilst not conventional due to its location to the side of the platforms, provides additional operational benefits including:

- A unified concourse serving the main shed (platforms 1-8) and suburban shed (platforms 9-11) with improved passenger facilities centrally located with simplified station management.
- Direct connections for passengers interchanging between the LUL and main line services,
- Close relationship with the St Pancras International and Midland main line stations.
- Close proximity to passenger taxi and private car set down and pick facilities along Pancras Road.
- Direct station connections for the Kings Cross Central development to the north and the new southern public space along Euston Road.
- Direct linkages with bus operations along Pancras Road and Euston Road.

- The LUL station and the main concourse can operate independently therefore maintaining operations of one during closure of the other.

Hence, the provision of a new Western King's Cross Station concourse with its associated good interchange facilities enhances the St Pancras Integrated transport hub.

The station layout and passenger circulation is indicated on the following figure.

Concourse Sizing and Operation

The sizing of the new concourse has been developed from a potential future train timetable with 7 intercity and 12 suburban services during the peak hour. This is an uplift form the current 15 peak hour services to 19 trains services. In addition the opportunity to extend rolling stock has been examined to satisfy Network Rail and Train Operating Company objectives of increasing peak hour capacity to allow for future passenger growth.

The concourse has been designed to accommodate the expected peak passenger accumulation at an average Fruin Level of Service C across the concourse during perturbed conditions. This is when trains are suspended at the station for 15 minutes, however, passenger from other modes and adjacent buildings still continue to arrive. This therefore places the greatest demand on the concourse and its facilities.

The main concourse has two passenger information screens which present full train departures and arrival summary information. These are located to the south and north of the new concourse. Of these areas the busiest is the southern zone which is located closer to the main shed and platforms 1-8. This accumulation area will accommodate intercity passengers who will generally carry more luggage and who are more likely to be infrequent passengers and hence not be so familiar with the station. As a consequence the space per person increases and hence greater area in front of the southern information screen is required. Commuter passengers who use all platforms at the station will be familiar with the station, its operation, and their wait time in the station is significantly shorter than intercity passengers.

Train Departure

Following a train announcement for departure, passengers will move from the concourse through to the platforms. This can take place in the following locations:

- The main southern gate line located within the western range. This gate line accommodates both arriving and departing passengers for platforms 1-8.
- The suburban platform gate line for platforms 9-11.
- A Platform 8 surface connection.
- An upper mezzanine gate line linking to the new overbridge to platforms 1-8.

Of these the main southern (Western Range) gate line and accumulation area would be the busiest and therefore a number of alternative facilities are available which with a range of local passenger information screens distributes passengers to other station facilities. However, as passenger information is maintained throughout the station, with alternative routes to platforms clearly indicated the potential southern congestion area will be relieved whilst maintaining passenger comfort. These elements are explained further.

Within the western concourse a new mezzanine retail/catering facility has been provided. For intercity travel these facilities are important as passengers could arrive some 30-45 minutes before train departure. This area therefore performs a function similar to an airport departure lounge where waiting passengers can sit and relax in comfort away from the busier main concourse areas. During perturbed conditions the use of this area will increase with some 20% of peak hour passengers potentially using this area.

Further studies of passenger movement defined that a new upper level bridge between the mezzanine to a new footbridge could allow passengers to move direct form the mezzanine to

platforms 1-8 without having to return to the southern accumulation area. This bridge link results in simplified passenger movements and better distribution of passenger along the platforms in the main shed. No exit from the platforms is permitted onto the overbridge.

To further relieve passenger pressure at the southern accumulation area and gate line an additional access/egress for Platform 8 is provided. It is expected that this platform will be utilised for commuter services and hence it is expected that the favoured location for the majority of the passengers will be the northern accumulation area where direct access to the platform can be achieved. This Platform 8 gated link will therefore add further relief to the southern accumulation area.

Train Arrivals

Suburban shed passengers have a simple and direct arrival connection with the main concourse which has never been available in the past. This provides direct connections with LUL.

On platform 8 the northern gate allows passengers from the main section of the train to exit early hence improving LUL connections via the northern ticket hall and the Kings Cross development areas to the north.

Passengers arriving on platforms 1-7 are directed to exit the station through the newly opened Southern Façade. This route has direct visual links with the new southern square and connections with the LUL access stairs and bus operations. This performs a dual function:-

- to simplify station operations; and
- to activate public realm.

Firstly, it directs passengers away from the busy western gate line to avoid opposing and conflicting flows. It also allows arriving passengers to pass through the newly opened façade with its extended canopy to animate and maximise the use of the new square. This is a key objective of Camden and English Heritage.

However, with limitations on the distance between platforms and barrier lines careful attention is required on passenger safety in the areas before and after the gate line. With the new gate line in the western range platforms 5-8 have been set back to maximise the passenger flow area and to provide good visual links with the lower number platforms. These platforms can be set back without compromising train lengths. However, platforms 1–4 have to remain as existing to accommodate the expected train lengths. These rail constraints and the station operational requirement to hold departing passengers within the main concourse restricts the southern gate line to exit only. If passengers accumulated at the head of the platforms this would seriously compromise passenger safety and train operations.

After the gate line, station planning standards require a run off length of 6 metres. In this area cross flows are should not happen as this would reduce the operational capacity of the gates and create safety hazards due to passenger flow conflicts and possible trip hazards due to passengers with luggage.

This arrangement where a gate line is so close to the station building boundary is somewhat new to Central London Stations and as a consequence it has attracted operational concerns especially during wet weather conditions.

From detailed studies at Warren Street tube station, where a similar situation exists with the gate line close to the station boundary, it has been observed that passengers tend to slow down after the gates during wet weather often stopping totally to button clothing, lift hoods to cover their heads, or to raise umbrellas. This results in a very obvious reduction in passenger flow and it has been observed to cause tail backs and reduce the capacity of gate lines. As a consequence LUL staff make announcements to passenger in advance of leaving the station to prepare for wet weather and get umbrellas ready. Announcement of this nature are not appropriate for a main line station

because of the number of other announcements being made and the potential to confuse passengers unfamiliar with the layout.

This potential in a reduction in passenger flow during wet weather and the risk of passenger accidents has informed the design of this area to provide an extended canopy along the front of the station beyond the gate line run off. This additional covered area allows passengers to continue their journey in comfort without getting wet through to the southern LUL stair and lift. It also gives passengers the opportunity to make public realm route decisions external to the operational areas of the station in all weather conditions.

Public Realm Connection

The public realm movements have been considered within the design with a separated route for north-south connections along the eastern face of the hotel. With the intervention at ground level a new route is available for street connections to be maintain during peak passenger accumulation within the concourse or when station closure is required.

Summary

The new Western Concourse arrangement has been developed to enhance passenger experience and comfort with operational safety high on the agenda. The station design components which contribute to this include:-

- A unified concourse with an increase in area to accommodate future growth in passenger flows
- Good Intermodal connections.
- Setting back of platforms 5 – 8
- Direct overbridge connections to platforms 1-8 and platform Y
- An extended southern canopy
- Good customer information
- Direct passenger links to platform 8
- Catering and retail facilities where passengers can circulate and relax

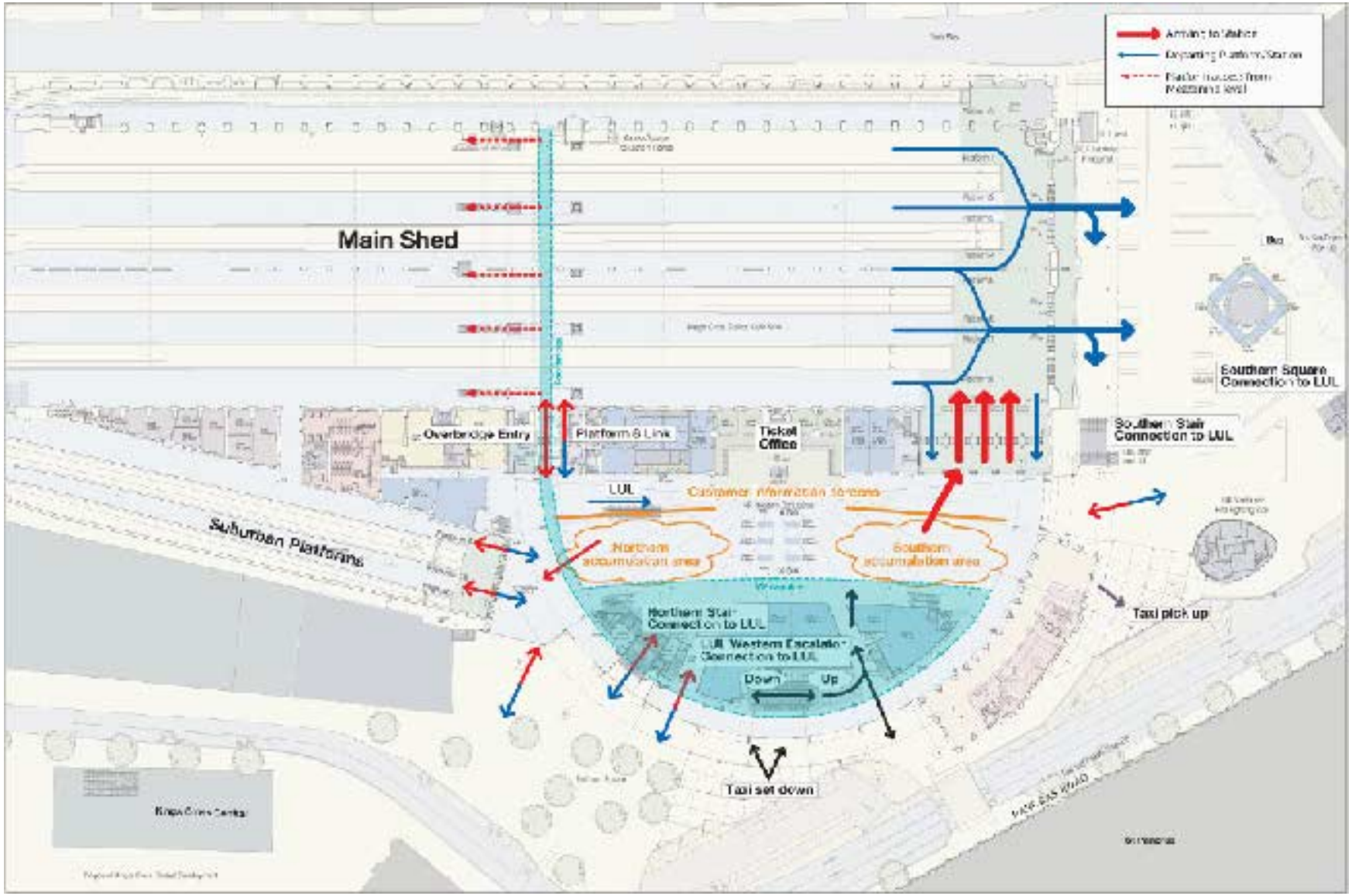
Each of these station attributes combine to perform good station management and circulation. If any one of these is excluded the current design proposal does not provide the objective of an enhanced station at King's Cross.

The circulation patterns for arriving and departing passengers have been planned to give good Intermodal connections and direct links with adjacent public realm. For example at the southern façade and canopy the design has been developed to ensure that the exit route enables passengers to move freely through the barrier lines and exit through the facade with a level of comfort

The extended southern canopy allows passengers' decisions and changes in direction to be made outside of the operational area of the station. This importantly avoids cross-flows within the restricted area between the barrier line and the façade. Without this canopy there would be a potential safety issue caused by passenger cross flows in this confined area.

In conclusion the new King's Cross Station with its western unified concourse and its associated good interchange facilities enhances the St Pancras Integrated transport hub.

King's Cross Station Western Concourse Proposed Layout and Key Movements



1 Introduction

Arup was commissioned by Network Rail in February 2006 to examine passenger exit behaviour at King's Cross and identify issues and risks associated with egress during wet weather conditions.

This report describes the proposed exit strategy for King's Cross station given forecast demand growth, increased train operations and the development of the new Western Concourse areas and connections to onward modes such as LUL.

The report describes the requirement for a new concourse in terms of passenger demand and train operations; connections to platforms and onward modes; and station operations during normal and perturbated conditions.

Passenger behaviour will change during wet weather conditions and this could impact significantly on station operations at key locations such as connections to LUL, gatelines and at the margins of the covered areas. This report examines potential behavioural responses to wet weather and the need to mitigate these through design and management.

2 Proposed Design of King's Cross Station

2.1 Reasons for a Western Concourse

The Western Concourse proposal has been developed in response to a number of key drivers which are summarised as follows:

- The existing Southern Concourse and booking hall facility has only temporary planning consent and Camden Council and English Heritage have a longer term objective to remove this facility in order to expose the Grade 1 listed Cubit façade;
- The existing Southern Concourse and Suburban Concourse are sub-standard in terms of passenger accommodation (according to Network Rail's own design guidance);
- To provide good interchange connections to LUL's Northern Ticket Hall, the International station at St.Pancras and the development lands north of King's Cross.
- The need to offer passengers a greater range of facilities in an enlarged concourse.

2.2 Development of Design Options

Given that there is an objective to remove the existing Southern Concourse and booking hall, options have been developed to provide King's Cross station with appropriate ticket hall and passenger interchange facilities that will accommodate forecast passenger demand.

The options considered are listed in the following sections:

2.2.1 Location of Ticket Hall Facilities Within the Main Shed

Consideration was given to the location of ticket hall and passenger information facilities at the south end of the Main Shed. This would necessitate setting the buffer stops on Platforms 1-8 further north in order to provide sufficient space.

This option would require the Main Shed platforms to be extended northwards in order to accommodate existing train lengths. Significant engineering works would be needed to the track layout and tunnelling north of the Main Shed (the station 'throat') in order to permit train access to the lengthened platforms.

This option has not been progressed due to the prohibitive cost of civil engineering works required.

2.2.2 Provision of a Southern Waiting Area

In addition to a Western Concourse, consideration was given to the provision of a southern holding area where passengers could move from the new concourse and wait before being called through to board trains departing from the main shed.

This option provided no benefits to those waiting for train departures from the Suburban Shed given its remote location. In addition, it did not permit the opening up of the Grade 1 listed façade at the south end of King's Cross station as desired by English Heritage and the London Borough of Camden.

2.2.3 Western Concourse

A Western Concourse was proposed which permitted all train information and passenger facilities to be located in one unified concourse. A Western Concourse located to the immediate west of the Western Range buildings and to the north of the Great Northern Hotel also allows for good connections to the LUL Northern Ticket Hall. It offers good proximity to St.Pancras International and Domestic station and the King's Cross Central development north of the station.

The Western Concourse design option was seen as the proposal best able to accommodate forecast passenger demand increases and provide for all interchange movements to onward modes and destinations, as well as exposing the Grade I listed Cubit façade.

2.3 Summary of Western Concourse Design Proposal

The proposed design for King's Cross station is shown on **Figure 1**.

An arrangement whereby passengers enter the main train shed via a side access is not usual but assessment has shown that there is no overall disbenefit in terms of passenger journey times when compared with the existing Southern Concourse. The Western Concourse offers the best opportunity to unify the ticket hall and passenger information systems for both the Main Shed and the Suburban Shed.

The main features of the Western Concourse design are summarised as follows:

- Removal of the existing Southern Concourse which has temporary planning consent only and is sub-standard in terms of passenger accommodation.
- Removal of smaller Suburban Concourse immediately in front of Platforms 9-11 which is not intended as a primary passenger concourse area and is sub standard in terms of passenger accommodation.
- Development of a new Western Concourse located to the west of the existing Western Range buildings, north of the Great Northern Hotel and to the south of Platforms 9-11.
- Inclusion of a mezzanine level within the Western Concourse with a high level connection through to the Main Shed Platforms 1-8 via a new footbridge.
- Inclusion of new gatelines to the south of Platforms 9-11, at the south end of the Western Range, and in the Southern Façade of the Main Shed.
- New connections to the LUL Northern Ticket Hall via a western set of escalators and stairs, North Western Stair, North Eastern Escalator and Southern Stair.
- Retention of the Great Northern Hotel with intervention at the ground level to form an arcade for through north south pedestrian movements.

The proposed Western Concourse design has been developed in partnership with John MacAslan and Partners architects and Network Rail. Different variants of the design have been proposed and refined in order to respect passenger movements and station operations.

3 Station Operations

This section describes the key passenger movements which occur within the proposed station layout and the operation of the station and concourse in terms of passenger information, ticketing and routes through to the platforms.

3.1 Key Passenger Movements

Figures 1 and 2 describe the key passenger movements at the proposed King's Cross station. The main movements are summarised as:

- Between the mainline platforms (Suburban and Main Sheds) and LUL via the Tube Ticket Hall and the new Northern Ticket Hall;
- Between the mainline platforms and bus and street destinations south of the station and Euston Road;
- Between King's Cross station and taxi set-down and pick-up facilities on Pancras Road;
- Between King's Cross station and St.Pancras station; and
- Between King's Cross station and the King's Cross Central development north of the station.

3.2 Movements to and From the Mainline Platforms

It is proposed that passengers will move to and from the mainline platforms using the following routes as shown on **Figure 1**:

- The Suburban Shed Platforms 9-11 are controlled by one entry and exit gateline located immediately south of the platforms;
- Passengers can enter and exit the Main Shed platforms using a proposed gateline at the south end of the Western Range;
- Passengers can exit the Main Shed platforms using gatelines located in the Southern Façade which provide access to the LUL Southern Stairs and street/bus destinations towards Euston Road; and
- A small gateline is available for entries and exits through the Western Range building to Platform 8 only located at the north end of the proposed Western Concourse.

3.3 Concourse Layout and Operations

The Western Concourse will have two large customer information screens describing train departure information. These information screens will be located in the north and the south parts of the concourse as shown on **Figure 1**. Passengers will accumulate in the areas directly in front of the screens prior to train announcements and these will fill with people particularly during the PM peak.

When departing trains are announced passengers will move through the gatelines to the trains. Given that passengers for long distance services, which operate from Platforms 1-8, are expected to turn up earlier than those for commuter trains, the accumulation of passengers in the southern waiting area is expected to be greater.

Previous passenger modelling studies have shown that these passenger accumulation areas are heavily used during the PM peak. The number of passengers waiting in the concourse reaches a peak when there is disruption to the normal train service.

Figure 3 shows the average passenger levels of service (Service Factors) reported by PEDROUTE for the passenger accumulation areas and surrounding areas for the peak 15

minutes. Blue indicates free flowing conditions with green indicating moderate levels of congestion which may be acceptable during peak periods. Yellow and red indicates high density levels of service, typical of congested conditions. However, in busy mainline station environments where large surge flows of passengers to or from platforms are a feature of normal operations, brief periods of high levels of service may be considered acceptable providing the station continues to operate effectively and average levels of service are within Network Rail guidelines.

The Western Concourse operates effectively there are high levels of service evident in the southern accumulation area and Western Range Gateline. This reflects PM peak accumulation and the surge of movements between the concourse and the Main Shed, and is considered acceptable for brief periods during the peak.

Passenger accumulation builds to a maximum between 1715 and 1730 hours when a number of trains are called. Passengers then move through to the Main Shed platforms and concourse conditions improve. High but temporary levels of service are experienced in the Western Range as passengers move through this area and onto the platforms.

The modelling highlights the critical importance of the southern part of the concourse, the Western Range gateline and the platform heads area to station operations. This area must be free from obstructions of significant movements in the opposite direction in order to accommodate surge movements from the concourse to the platforms.

The Southern Façade gateline operates without any congestion as does the gateline providing access to Platforms 9-11.

The passenger volumes were based on a projected PM peak hour service of 7 Intercity, 8 suburban 8 car service, and 4 suburban 12 car services. The background street flows and distribution to LUL and buses on Euston Road were as per the existing station matrices developed from 2000/2002 survey data.

In the PEDROUTE model Platform Y is not coded although this may be operational in the future.

Figure 1: King's Cross Station Western Concourse Proposed Layout and Key Movements

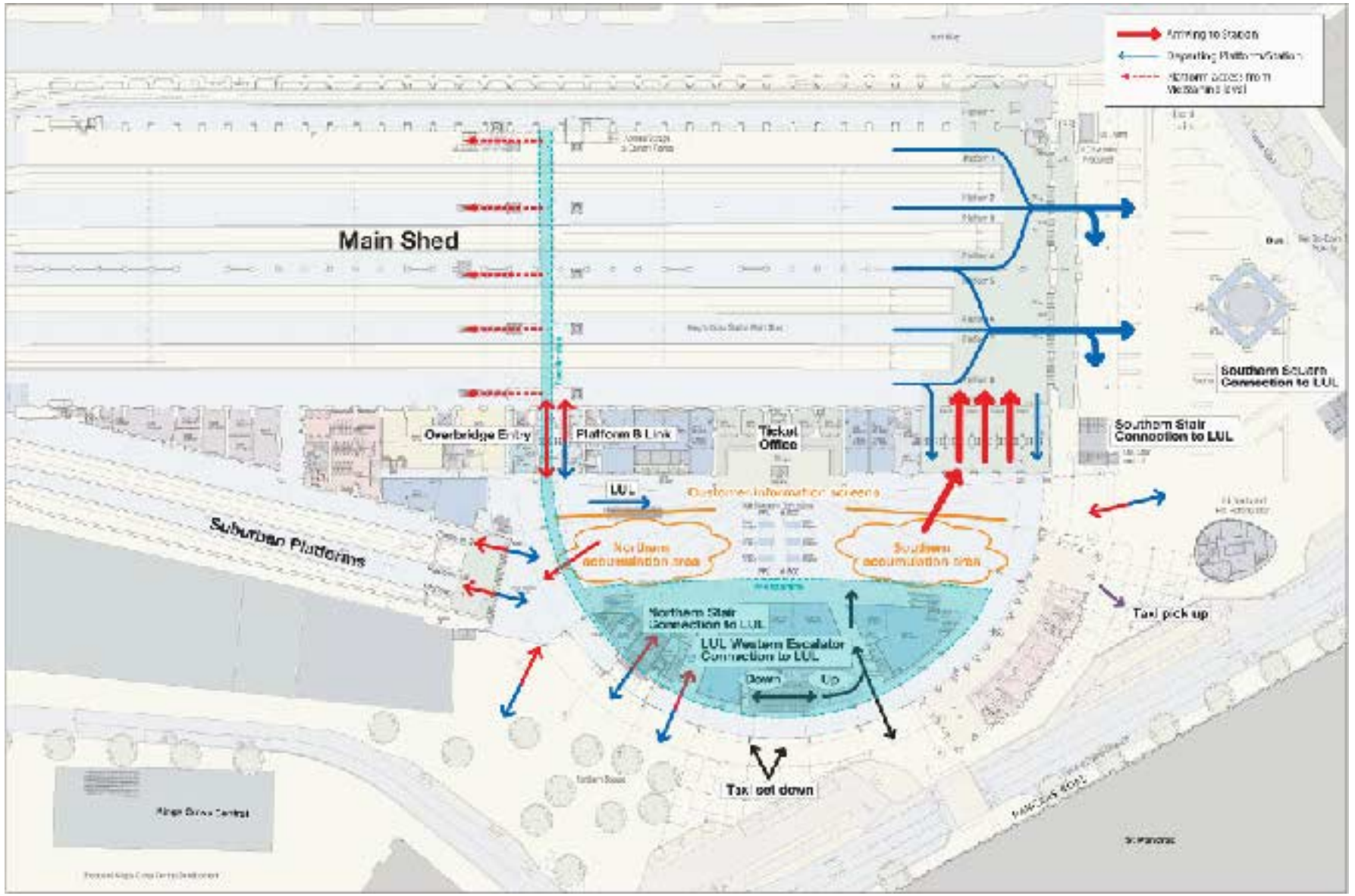


Figure 2: King's Cross Station South End Key Movements (AM 0700-1000 hours)

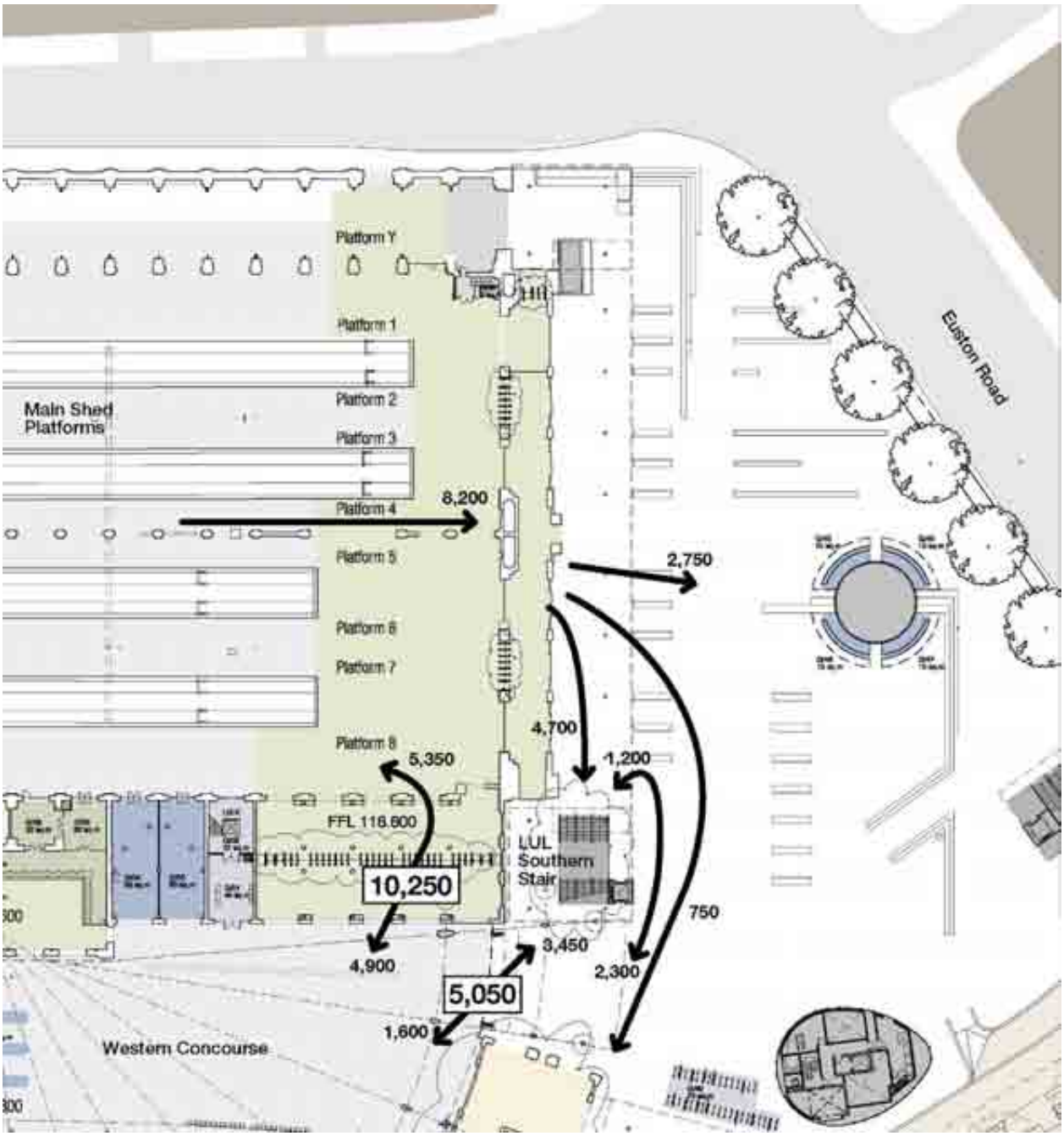
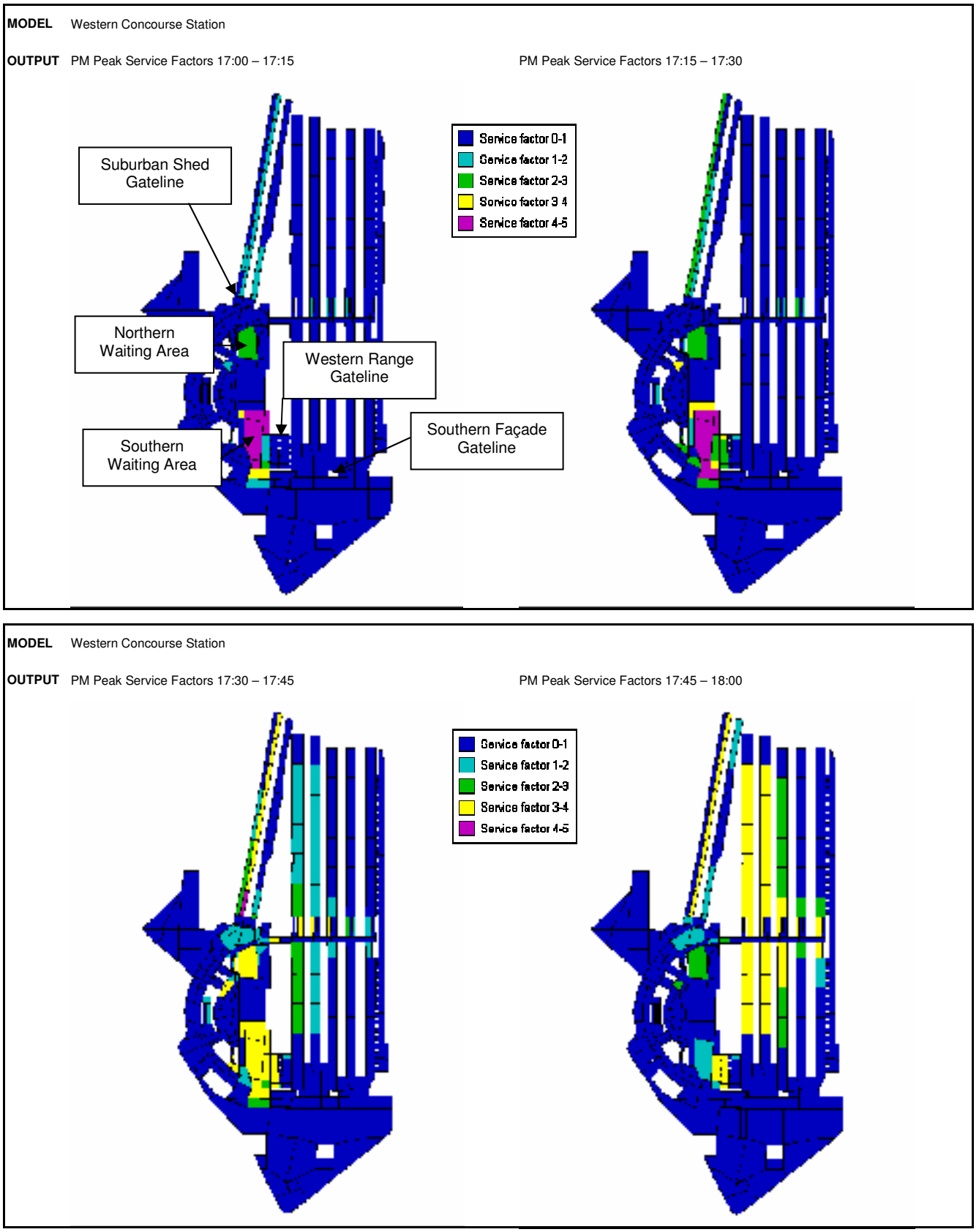


Figure 3: Station Operations 1730-1830 Hours - PEDROUTE Service Factors



3.4 Passenger Circulation Issues

The level of service plots output from PEDROUTE assume dry/typical operations and show a number of passenger circulation issues during the AM and PM peak which will need to be managed. Passenger movements to and from the platforms is described as follows.

3.4.1 Access to Platforms 9-11

- Passengers movements to and from Platforms 9-11 are generally free flowing with no significant congestion or delays;
- The northern passenger accumulation zone does not impact on the gateline accessing Platforms 9-11; and
- Passengers using Platforms 9-11 primarily use the North Western Stair and the North Eastern connection to access the LUL Northern Ticket Hall.

3.4.2 Access to the Main Shed Platforms 1-8

- There is a high level of passenger accumulation in the southern accumulation area particularly during the PM peak;
- When passengers are called through to departing trains there is a surge movement through the Western Range gateline;
- When a train arrives in the Main Shed there is a surge movement through the gatelines;
- If train boarding and alighting occurs simultaneously then temporary congestion is evident in the vicinity of the gateline and management will be required to avoid this;
- Management regimes may encourage passengers exiting the Main Shed to use the Southern Façade gateline during peak times to access LUL's Southern Stairs, buses and street destinations and in order to avoid congestion at the Western Range gateline.

3.4.3 Exits from The Main Shed Through The Southern Façade

- A high proportion of passengers exit the Main Shed through the Southern Façade in order to access LUL via the Southern Stairs and also street destinations and buses on Euston Road; and
- The PEDROUTE models show that the Southern Façade gateline operates without congestion or delays and that passengers move freely through this area and away to their destinations. This assumes dry, free flow conditions.

4 Station Operations During Wet Weather

This section describes how the station operates in wet weather and the issues arising from changes in passenger behaviour during wet weather. Some passenger movements through and around the station will change more than others and this is described as follows.

4.1 Platforms 9-11

The Western Concourse protects passengers moving to and from Platforms 9-11. All main interchange movements to LUL can be made in the dry and passengers moving to or from street are protected for a large part of their journey.

Wet weather does not affect movements to or from these platforms.

4.2 Southern Exits

Given the proximity of the proposed Southern Façade gateline to the open air, passenger behaviour will change during wet weather if no weather protection is provided.

- Passengers will slow before reaching the Southern Façade gateline on the paid side
- When passengers have moved through the Southern Façade gateline a higher proportion is likely to head for the LUL Southern Stair using the covered area on the immediate unpaid side of the gateline.
- Passengers will slow when exiting this covered area as they consider exposure to wet weather.
- There is likely to be some redistribution of passengers egressing the Southern Façade to Western Concourse in order to remain dry.

4.3 Western Range Gateline

Wet weather is likely to cause a re-routing of passengers exiting the Main Shed. A proportion of those that were exiting using the Southern Façade are likely to use the Western Range gateline. The severity of rainfall will affect the proportion of passengers switching to use the Western Range gateline.

There is potential for significant congestion at the Western Range gateline where large train boarding flows meet train alighting flows. The combination of two conflicting surge flows will need to be avoided.

Congestion at this gateline will very quickly begin to impact on passenger flows and delays in the concourse accumulation area and the platform heads area. Congestion in these areas needs to be avoided in order to maintain the smooth operation of the station.

4.4 Changes to Modal Split

The impact of modal shift as a behavioural response to wet weather has been observed at central London stations. During wet weather passengers are less inclined to walk and some modal shift to LUL and taxis does occur. This needs to be managed to avoid congestion and passenger queues will also require weather protection, otherwise they will crowd at the edge of the proposed covered areas, impacting on other flows.

4.5 Observations of Passenger Behaviour in Wet Weather

Arup/Rossmore consultants performed behavioural observations at:

- Euston mainline station
- Victoria mainline station
- King’s Cross mainline station
- Charing Cross mainline station
- Warren Street Underground station

It was planned that video footage of passenger egress at Warren Street Underground Station should be captured in order to document and provide quantitative comparisons of differences between behaviours observed on dry days versus those on wet days*.

Warren Street station was chosen for video footage because it is a busy commuter station with large surge flows of passengers exiting to street. In addition, the proximity of the gateline to the open environment was considered similar to the Southern Façade gateline at King’s Cross.

4.5.1 Dry weather conditions

During dry weather conditions, customers tend to progress through the environment towards the open air at 'normal' pace. This pace is dependent on a number of factors including Level of Service (LOS), Impairments, Familiarity, Way finding etc.

4.5.2 Wet weather conditions

At all studied locations during limited periods of wet weather some customers tend to slow or even stop as they approach the open air. Observed behaviours include:

- Stopping/slowing apparently to assess the propensity of rain;
- Stopping/slowing to locate umbrellas;
- Stopping/Slowing to put up umbrellas;
- Stopping/slowing to fasten coat; and
- Stopping/slowing to orientate themselves to locate dry route to underground and/or taxi links.

The pace of customers during wet weather is dependent on the same factors as those mentioned above in dry conditions with the additional behaviours of slowing and stopping due to the outside weather. The pace will therefore be adversely affected by these behaviours and in times of poorer LOS these behaviours can cause significant crowding issues.

During interviews with the station supervisor at Warren Street underground station it was established that wet weather can cause problems due to the slowing and stopping of customers as they approach the open air. This problem is considered significant enough for LU to have developed a standard mitigation action. The mitigation action is to announce via PA to customers at platform level, and during their ascent up the escalators, that there is wet weather and to prepare themselves for this prior to ascending to concourse level. This is intended to remove the bottlenecks inside and on the edges of the ticket hall that can occur during wet weather.

It is important to note that it was reported that while LUL consider that this mitigation has a positive effect on behaviours, it does not eradicate the problem. It should be noted that system users of Warren Street in the peak times are also normally regular users and are familiar with the station and environment. These users are also likely to be compliant with these types of requests as their experience will have deemed the recommended behaviour to be advisable.

Announcements at King's Cross may confuse passengers who are unfamiliar with the station environment, especially if they occur together with train departure/arrival information. At peak times there may not be sufficient time for wet weather announcements. In addition, a larger proportion of passengers at King's Cross will have suitcases and therefore be unable to put on coats and put up umberellas or slow down even more. It is considered that announcements will not mitigate against this.

Likely causes of blockages at barrier lines and at the edge of station concourse or canopies are presented in **Table 1**.

Table 1: Passenger Behavioural Responses

Description	Location	Possible Drivers	Additional considerations
Stopping/Slowing to locate ticket	Paid side close to gate	e	Luggage could cause additional size of blockage
Stopping / slowing to locate umbrella/fastening coat	Paid side close to gate	a, e	Luggage
Stopping/slowing to put up umbrella	Non-paid side at edge of covered area	a, d	Luggage + Physical space required for umbrellas when put up.
Stopping/slowing to converse with other customers	Paid side close to platform ends	b	Luggage
Stopping/slowing to converse with other customers	Non-paid side at edge of covered area	b	Luggage
Gate line rejection	Paid side at gate	f	Luggage
Orientation and Route choice	Paid/Non-paid side of gates	a, b ,c, d, g	Luggage and cross flows

Key to Behavioural drivers

a. Perceived risk of getting wet
b. Information – Signage
c. Information – PA Announcements
d. Conformative behaviour – Following the crowd
e. Physical abilities
f. Impairments (including luggage)
g. Knowledge and experience of environment

Figures 4 and 5 show examples of typical behavioural responses of passengers to rain and were taken outside Charing Cross station during only light rain.

In **Figure 4** some passengers have stopped or slowed within the dry area to organise coats and umbrellas before moving into the uncovered area. During average flow conditions this does not represent a problem but during heavy flow or surge conditions following train arrivals such behaviour impacts on following passengers and the general flow.

In **Figure 5** the impact of modal shift as a behavioural response to wet weather is illustrated. Additional passengers are queuing for taxis and the queue can be seen to extend across a main egress route from Charing Cross station. During wet weather passengers are less inclined to walk and some modal shift to LUL and taxis does occur. Ideally this needs to be managed to avoid congestion.

Figure 4: Passengers pausing under covered areas during Wet Weather

Figure 5: Additional passengers queueing for taxis during Wet Weather

4.5.3 Quantification of behavioural differences – Warren Street Methodology

Site visits were arranged to Warren Street station to capture video footage on a wet weather day and a dry weather day. Both samples were taken during the AM peak period between the hours of 7:15am and 8:25am and within two weeks of each other. (26/05/2006 – Wet day, 6/6/2006 – Dry day)

It had been noted from previous observations that the most measurable and obvious differences in behaviour were at the perimeter of the station covering (i.e. at the edge of the station) on the non-paid side before the subject actually walked out into the open air. To this end the video camera footage was taken of the exit to the right of the ascending escalators. In this case every person leaving via this exit could be counted and analysed. A similar angle was used on both days of recording.

Results

Wet weather day - 26/5/2006

- Total egress count 7:15 to 8:15 : 422
- Persons stopping for > 2seconds : 73
- Percentage of total: 17%

Dry weather day – 6/6/2006

- Total egress count 7:25 to 8:25 : 956
- Persons stopping for >2 seconds: 2
- Percentage of total: 0.002%

Analysis of results and observations

These results demonstrate a significant difference in behaviours on wet weather days. The main reasons for stopping would appear to be:

- Putting up of umbrellas
- Fastening of coats
- Replacement of tickets into bags/wallets etc
- Contemplation of strategy based on the weather conditions. (i.e. establishing how heavy the rain was falling etc)

The data obtained during this study pertains to pedestrians stopping. It was noted that there also appeared to be a slowing of pedestrians on the paid side of the gate. This was probably due to the contemplation of the weather observed outside.

It should be noted that this behaviour may be differ in the application at King's Cross as the pedestrians will have arrived by an over-ground train so weather conditions may have been assessed on approach to the station.

4.6 Issues Arising from Changes in Passenger Behaviour

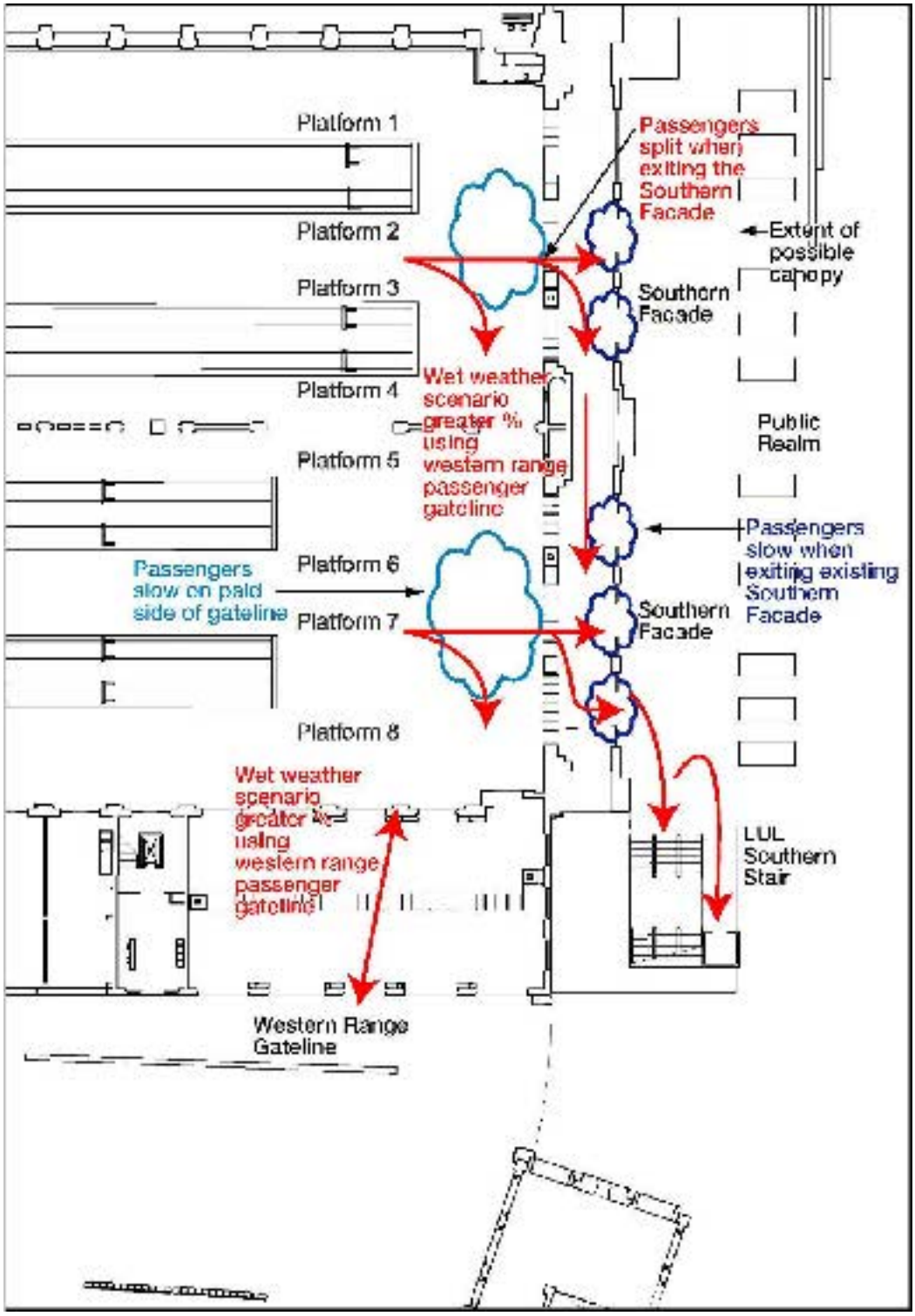
Given the proximity of the Southern Façade exit gates to the open environment, passenger movements through this area are likely to be affected most by wet weather with potential for disruption and congestion to peak period passenger movements.

The operation of the Southern Façade gateline is critical to ensure effective connections to the LUL Southern Stair and street/bus destinations on Euston Road. Effective operation of the Southern Façade will ensure that the Western Range gateline operates without excessive demand placed upon it from simultaneous train boarding and alighting surge flows.

Localised assessment of the Southern Façade area has been undertaken to establish the impacts of wet weather (through modified passenger behaviour) on AM peak egress flows.

Figure 6 shows the possible behavioural responses to wet weather in the Southern Façade area. These responses have been included in the AM passenger egress modelling using the Legion pedestrian simulation software.

Figure 6: Behavioural Responses to Wet Weather at Southern Façade and Gateline



4.7 Pedestrian Simulation Modelling

A Legion model has been constructed of the Southern Façade at King's Cross, to include the Main Shed platform heads, the Western Range gateline, the Southern Façade gateline and egress routes to the LUL Southern Stairs and public realm areas. This model area is shown on **Figure 6**. The model also extends into the Western Concourse and shows the southern accumulation area where passengers wait in front of the customer information screens prior to moving through to Platforms 1 to 8.

Legion is an entity based crowd simulation package which allows the user to see how people use a public space, whether it be a station or public realm. Arup have considerable experience of using Legion at complex stations and interchanges including at King's Cross. Legion is excellent at highlighting layout and operational issues and therefore allows station planners and designers to optimise and validate plans in order to reduce congestion, improve safety, increase economic benefits and to ensure adequate space provision. Legion shows how individuals exit the Main Shed and clearly highlights issues of congestion or design deficiency.

Two Legion wet weather scenarios have been modelled which aim to illustrate the potential passenger flow conflicts and congestion which may result during wet weather, where no extended canopy weather protection is provided on the Southern Façade.

4.7.1 Scenario 1 Assumptions – Wet Weather, No Extended Canopy, Limited Re-Routing

- Without weather protection and assuming wet weather, the passenger distribution when egressing the Main Shed is as normal with people moving freely through the gates and façade. However, there is some limited re-routing and behavioural response to the wet weather described as follows.
- As shown in **Figure 6** passengers slow before reaching the Southern Façade gateline on the paid side
- When passengers have moved through the Southern Façade gateline it is assumed that ⅔ of those heading for the LUL Southern Stair use the covered area on the immediate unpaid side of the gateline (3,150 in peak 3 hours). The remaining ⅓ exit to the uncovered public realm areas (1,550 in peak 3 hours).
- Passengers slow when exiting this covered area as they consider exposure to wet weather.

4.7.2 Scenario 2 Assumptions – Wet Weather, No Extended Canopy, Major Re-Routing

- Passengers exiting through the Southern Façade re-route through the existing covered area as per Scenario 1;
- Redistribution of passengers egressing the Southern Façade to Western Concourse.
- Half of Passengers egressing the Southern Façade and moving to the LUL Southern Stair will now use the Western Range gateline to access LUL via the Western Concourse (2,350 in peak 3 hours).

The passenger volumes were based on a projected peak hour service of 7 Intercity, 8 suburban 8 car service, and 4 suburban 12 car services.

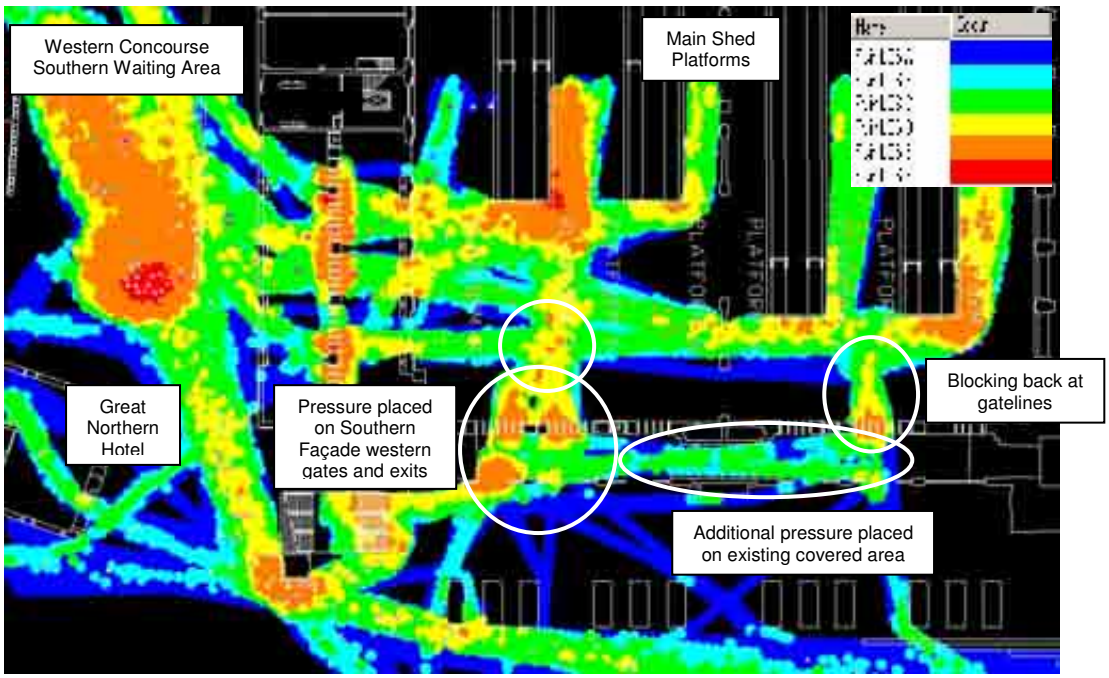
These behavioural assumptions are designed to represent an average change condition between scenarios. It is to be noted that during particularly heavy rain, and if no extended weather proof canopy is fitted, a greater proportion of passengers will stop completely at the Southern Façade or a greater proportion re-route through the Western Range gateline.

4.7.3 Model Results

For Scenario 1 (wet weather, no extended canopy, limited re-routing), **Figure 7** shows the maximum Levels of Service during the peak 15 minutes and indicates the impact of passenger re-routing and the use of the existing Southern Façade covered area and gateline run-offs for cross-flows. High Levels of Service are shown in the vicinity of the western most gateline and the exit route to the LUL Southern Stair. Some blocking back of passengers into the paid side of the gateline is also shown, a consequence of all passengers slowing to consider their responses to the wet weather.

It is noted that the existing covered area in the Southern Façade is now used as a cross passageway and is not preserved as a gateline run-off zone. Best practice station planning advice, as represented by LUL's Station Planning Standards and Guidelines states that a gateline to passageway run-off of 6m should be planned for in order to give passengers time to orientate themselves and move away from the gates.

Figure 7: Scenario 1 (Wet Weather, No Extended Canopy, Limited Re-Routing) Maximum Fruin Levels of Service 0815-0830 Hours

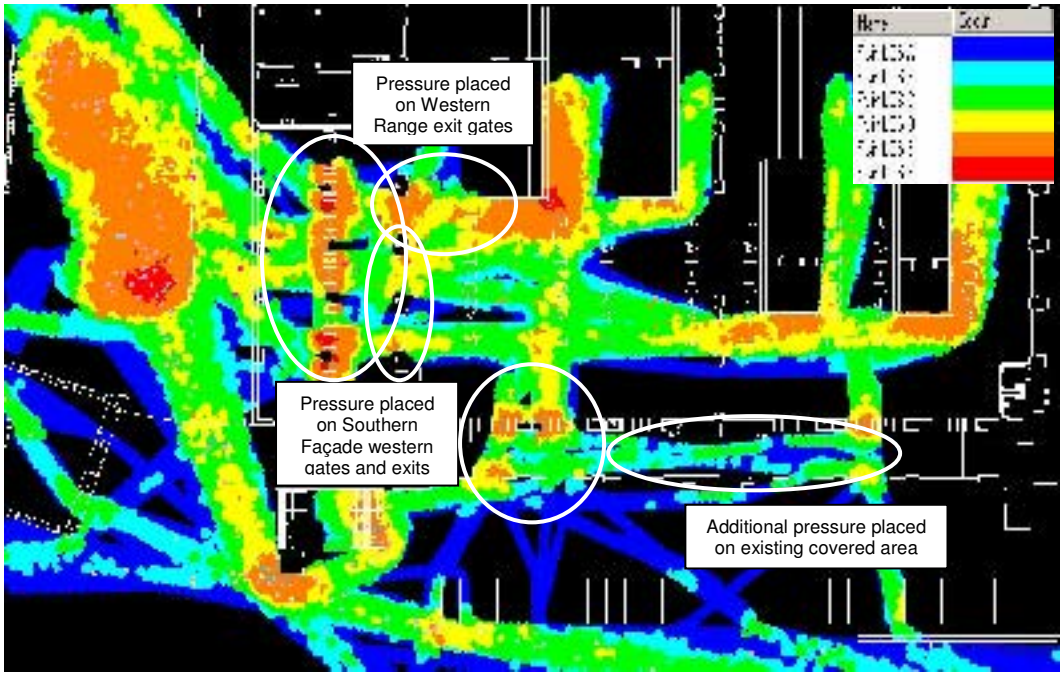


For Scenario 2 (wet weather, no extended canopy, major re-routing), **Figure 8** shows the maximum Fruin Levels of Service during the peak 15 minutes highlighting potential congestion issues which will need to be managed.

The impact of passengers re-routing and the diverting from the Southern Façade to the Western Range gateline is clear. Higher maximum Levels of Service are shown in the vicinity of the Western Range exit gates and there is some blocking back of passengers into the paid side of the gateline during peak egress periods.

Figure 8 also shows that as demand through the Western Range gateline increases, previously localised areas of congestion become linked during surge conditions to form larger barriers and impediments to through movements.

Figure 8: Scenario 2 (Wet Weather, No Extended Canopy, Major Re-Routing) Maximum Fruin Levels of Service 0815-0830 Hours



The issues highlighted by the Legion modelling of the platform and gateline area during wet weather, and assuming no extended weather protective canopy are summarised as follows:

- Additional cross flows in the existing Southern Façade covered area as passengers attempt to stay dry for as long as possible whilst exiting to the LUL Southern Stairs. This is not recommended as this area should be preserved as a run-off zone for the gates.
- Crowding in the platform heads area during train alighting surges where passengers slow down before exiting into the wet weather (this is a potential safety issue given the proximity to train movements and platforms edges).
- Re-routing of passengers from the Southern Façade gateline to the Western Range gateline in order to stay dry and access LUL via the western escalators in the concourse. This results in congestion at the Western Range gateline when two opposite surge flows meet, which has the potential to spread to the platform heads area on the paid side and the southern accumulation area on the unpaid side.
- The efficiency of the Western Range gateline will need to be managed to prevent surge train boarding flows meeting surge train alighting flows at the gateline. If this is not managed extreme delays may be experienced which will impact on train boarding and turnaround times.

5 Southern Exits Wet Weather Mitigation

Peak period passenger exits through the Southern Façade will be impacted by wet weather as described in Section 4. Passengers will slow down, use the existing covered area for cross flows and divert to the Western Range gateline. All this has the potential to seriously disrupt the efficient and safe operation of the Main Shed between the platform heads and the Western Range gateline.

A number of options have been considered to mitigate against the impact of wet weather on movements through the Southern Façade and these are described in the following sections.

5.1 York Way Exit

Provision of a passenger exit to York Way through the south end of the Eastern Range buildings has been considered to facilitate more efficient passenger egress and reduce the numbers using the Southern Façade.

This option was discounted because only a small proportion of passengers wish to exit the Main Shed to the east of the station. Most who exit the Southern Façade are destined for LUL via the Southern Stair, buses on Euston Road or street destinations to the south.

5.2 Additional Gates in the Western Range

Provision of additional gates through the south end of the Western Range would allow greater numbers of passengers to move between the Western Concourse and the Main Shed. However, there are a number of reasons why this is not recommended and these are summarised as follows:

- The Western Range gates are congested during peak periods and are bounded by the main concourse accumulation area in the south of the Western Concourse and the platform heads area, both very busy and critical to the effective operation of the Main Shed;
- Encouraging passengers through Western Range gateline route will compound these already very heavily used areas and potentially result in significant congestion on both the paid and unpaid sides of the gateline;
- Provision of additional gates will not resolve the issues associated with simultaneous train boarding and train alighting surge flows. Opposite surge flows are likely to cause congestion and require management regardless of the number of gates provided. Indeed, provision of additional gates is likely to encourage passengers to use the Western Range route.
- Such congestion is shown in **Figure 8** and is likely to spread to the paid and unpaid sides of the gateline, areas both critical to the operation of the Main Shed. This will delay train boarding and impact on rail operations.

5.3 Passenger Announcements

Passenger announcements can be made in order to influence and manage the pedestrian flow through critical areas such as the Southern Façade. There are two types of announcements that could be made in order to reduce potential wet weather stoppages and congestion at the Southern Façade.

5.3.1 Arrivals Announcements

Announcements to passengers alighting off trains in the Main Shed to inform them of wet weather and that they should prepare themselves by getting coats and umbrellas ready. This would reduce any slowing at the gateline and façade exit and is used by station staff at Warren Street Underground station. However, the problem is only reduced and not eradicated completely. It should be noted that station users at Warren Street are regular commuters who are familiar with the station and local environment. This is not the case at King's Cross.

Announcements at King's Cross may confuse passengers who are unfamiliar with the station environment, especially if they occur together with train departure/arrival information. In addition, a larger proportion of passengers at King's Cross will have suitcases and therefore be unable to put on coats and put up umberellas or slow down even more. Announcements will not mitigate against this.

5.3.2 Departures Announcements

Train information and announcements could be used to manage the progress of passengers between the Western Concourse and the Main Shed. Should a larger proportion of passengers exit the Main Shed via the Western Range gateline effective management would be required to avoid severe congestion at the gateline. Train departure announcements could be timed to prevent surge boarding flows meeting surge alighting flows at the Western Range gateline. However, there are risks associated with this strategy:

- Announcing train departures and platform numbers earlier would encourage passengers through to the train shed and to wait in the platform heads area. This is not recommended given the critical importance of this area to maintaining free access and egress for the Main Shed platforms. Significant accumulation of passengers in the platform heads area would be a safety issues as well given proximity of large numbers of passengers to train movements and open tracks.
- Announcing train departures later would result in passengers rushing the gateline in order not to miss their services. This would create a safety risk as surge flows would be larger and more impatient to move quickly through the gateline and platform heads area.

5.4 Provision of a Canopy

An extended canopy has been proposed for the Southern Façade which would protect passengers exiting to street and to the LUL Southern Stair from wet weather.

5.4.1 Canopy Design and Purpose

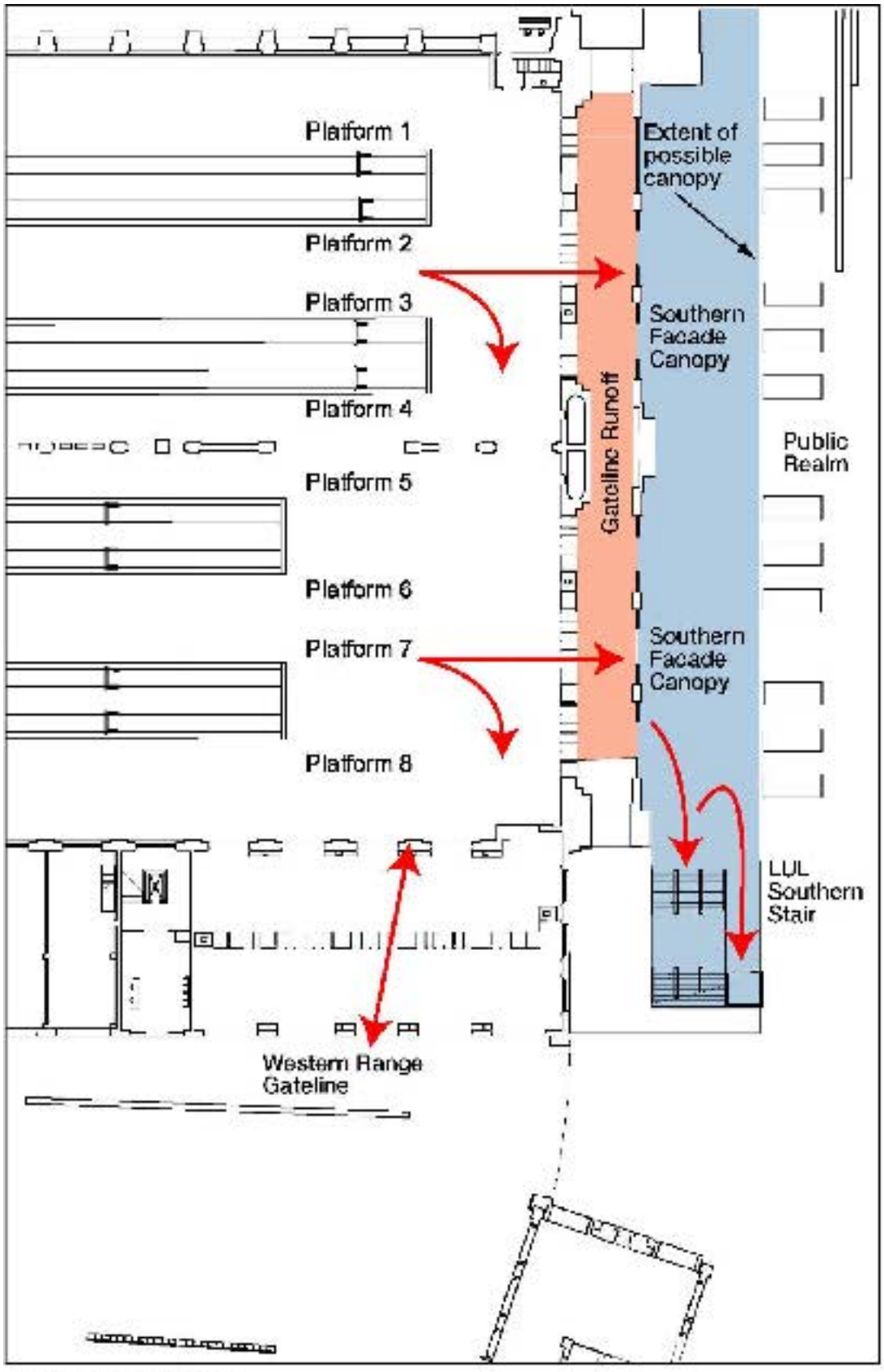
The extended canopy would extend some 5m out from the façade as shown in **Figure 9**.

The objective of providing the canopy would be to enable passengers to move through the gateline and façade in as quick and efficient manner as possible, drawing them out from the façade so that they do not wait around the exit and block flows.

5.4.2 Pedestrian Simulation Modelling

A Legion pedestrian simulation model (Scenario 3) of the Southern Façade, with extended canopy, has been run in order to compare results with the wet weather scenarios reported earlier.

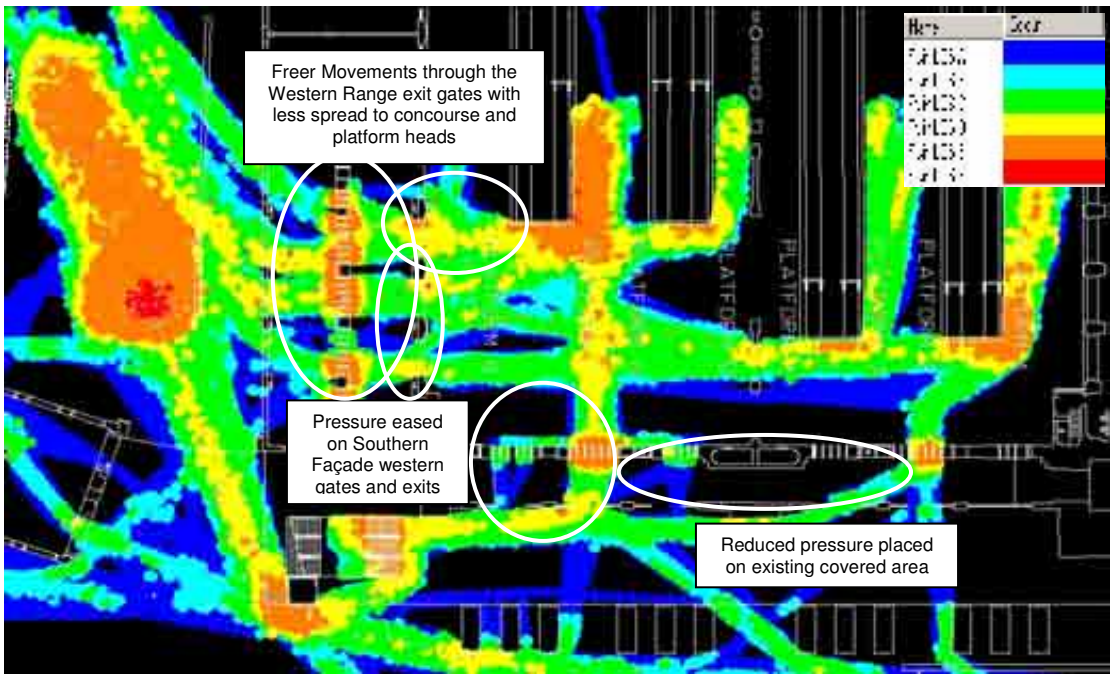
Figure 9: King's Cross Station Legion Model Area and Southern Facade



For the Scenario 3 Legion model (extended canopy) **Figure 10** shows the maximum Fruin Levels of Service for the peak 15 minutes 0815-0830 hours. High levels of service are shown in the southern accumulation area although the concourse as a whole operates effectively.

High Levels of Service are reported in the Western Concourse but this is expected as it is the main accumulation area for passenger information. Other areas showing high levels of service are the Western Range gateline, Southern Façade gateline and the LUL Southern Stair. However, all these areas operate effectively with no significant delays or blocking back of passenger flows.

Figure 10: Maximum Fruin Levels of Service 0815-0830 Hours



The canopy provides a number of benefits to the passenger flow summarised as follows:

- The existing covered area is not used for cross-flows but kept as a gateline run-off area;
- Movements through the Southern façade and gates are more evenly spread with less pressure placed on the western most set of exit gates;
- Congestion at the Western Range gateline is reduced with improved passenger conditions on the concourse and platform heads side of the gates; and
- Better passenger conditions within the paid platform heads area of the Main Shed which reduce safety risks associated with large volumes of passengers surging through confined spaces.

5.4.3 Journey Time Analysis

Egress journey times for passengers moving from the Main Shed platforms to the LUL Southern Stair and into the Western Concourse have been output from the models. These are described in **Table 2** and allow comparison of delays and the general efficiency of movement for the three different scenarios.

Table 2: Comparative Passenger Journey Times for Legion Model Scenarios 1-3

Scenario	Journey Time Route	Free Movement Time (Seconds)	Average Movement Time (Seconds)	95th Percentile Movement Time (Seconds)	Maximum Movement Time (Seconds)
1 (Wet weather - no canopy with Passenger re-routing within the Southern Façade)	Platform 4 & 5 to LUL Southern Stair	45	68	87	126
2 (Wet weather - no canopy with Passenger re-routing within the Southern Façade and through Western Range)		42	63	79	106
3 (Weather protective canopy)		39	57	70	106
1	Platform 8 to LUL Southern Stair	35	74	114	231
2		37	54	67	92
3		33	50	62	88
1	Platform 4 & 5 to Western Concourse	47	65	80	115
2		46	69	98	173
3		47	64	78	91

The journey time analysis shows some significant increases in movement times when no weather protection is provided and passengers slow or stop on at the Southern Façade gateline and exits.

The most significant increases in passenger movement times are experienced when passengers are re-routed via the Western Range gateline (Scenario 2) and subject to significant congestion.

The modelling also shows that the following areas are critical to the operation of the station and must be kept free of unnecessary obstructions with the passenger flow and routing kept as simple as possible:

- Western Range gateline; Southern Façade gateline; Platform heads areas; and
- Concourse accumulation areas in front of information screens.

6 Summary and Recommendations

Arup was commissioned by Network Rail in February 2006 to examine passenger behaviour during wet weather conditions on egress from a main line station and to identify any consequences on passenger flow conditions.

The study reviews station operations and passenger route choice and behaviour to identify what design requirements should be applied to improve intermodal connections and maintain safe station operations. This has been undertaken through passenger observations at stations and pedestrian micro-simulation modelling for the new King's Cross Station.

As part of this assessment benchmarking against station design principles and the facilities provided at other central London stations has also been undertaken.

6.1 Operation of the Western Concourse Station at King's Cross

The proposed Western Concourse layout permits all train information and passenger facilities for both the Main Shed and the Suburban Shed to be accommodated in one unified concourse. It also offers good interchange facilities with LUL and provides good proximity to St.Pancras, the LUL Northern Ticket Hall and the King's Cross development north of the station.

Two large customer information screens are located in the Western Concourse and provide all train information for passengers prior to train boarding. Concourse assessments have shown that during the PM peak there is accumulation in both areas, but with particular pressure placed on the southern waiting area and the unpaid area in front of the Western Range gateline.

Key rail related movements at the station are summarised as follows:

- To/from the Suburban Shed (Platforms 9-11) controlled by one entry and exit gateline located at the north end of the Western Concourse;
- To/from the Main Shed with entry and exit to the Western Concourse via a Western Range gateline; and
- From the Main Shed via the Southern Façade gateline to the LUL Southern Stairs, street and buses on Euston Road.

The modelling also shows that the southern concourse accumulation area, the Western Range gateline, the Southern Façade gateline, and the platform heads area are critical to the operation of the station and must be kept free of unnecessary obstructions with the passenger flow and routing kept as simple as possible.

6.2 Operations During Wet Weather

Wet weather will only impact on passengers exiting the Main Shed through the Southern Façade. The close proximity of the exit gateline to the open environment will mean that passengers will modify their pace and behaviour before exiting the station.

Observations and consultations with station staff at Warren Street LUL station and other central London mainline stations have highlighted some customer behaviour during both dry and wet weather that can block passenger flow. Warren Street station was used as most mainline stations do have weather protection canopies for passengers, because there are surge flows towards the station exits, and also because the gateline is close to the station exit.

The passenger behavioural issues noted at Warren Street are more marked during wet weather and are summarised as follows:

- Passengers slowing on the paid and unpaid side of automatic ticket gatelines to assess the weather conditions, arrange coats and find umbrellas;
- Stopping on the unpaid side of the gatelines to put on coats and get umbrellas out; and
- Stopping at the boundary of the station during particularly heavy rain to wait for a break in the weather and put umberellas up.

The above slowing and stopping during peak period surge flows can cause significant delays to passengers and reduces the efficiency of movement through the station.

In addition, passenger re-routing to other modes such as taxi has been noted during wet weather and the additional queueing at such facilities should be planned for and managed.

6.3 Wet Weather Simulation Modelling

Pedestrian simulation of passenger egress during the AM peak highlights the impacts of passengers slowing as they move through the Southern Façade gateline, stopping on the margins of the covered area, and a proportion of them re-route towards the Western Range gateline.

Without any weather protection wet weather will result in a number of passenger flow and management issues. These can be summarised as follows:

- Passenger flow through the exit gates and the exit routes through the Southern Façade will be less even and concentrated on the western most gates and exit closest to LUL causing unnecessary congestion and the slowing of passenger movements.
- The existing 5.5m deep covered area, which should be preserved as a gateline protected area and run-off, will be used for cross flows and passenger densities will increase, particularly at the western end, and result in congestion during surges following train arrivals.
- Re-routing of LUL passengers during wet weather to use the Western Range gateline and concourse increases flow conflicts through this area, particularly during simultaneous train arrival and departure surges. This will be a more significant issue during the PM when much larger departing train loads are called through from the Western Concourse to Platforms 1 to 8 and should be avoided.
- Passenger journey times through the Southern Façade and the Western Range increase significantly when passengers re-route to stay dry, or pause to prepare clothing for wet weather conditions.
- Crowding in the platform heads area during train alighting surges where passengers slow down before exiting into the wet weather represents a potential safety issue given the proximity to train movements and platform edges.

6.4 Wet Weather Mitigation

A number of measures were considered in order to mitigate against the impacts of wet weather.

- A York Way exit does not serve passenger desire lines and would therefore not benefit those exiting through the Southern Façade;
- Additional gates in the Western Range would encourage use of this critical area to exit the Main Shed, and would not resolve the issues surrounding simultaneous train boarding and alighting surge flows
- Wet weather announcements warning passengers of the weather conditions outside may improve the flow of passengers out into the open environment. However, research

indicates that the problems of passengers slowing and stopping are only reduced and not eliminated. Announcements at King's Cross may confuse passengers who are unfamiliar with the station environment, especially if they occur together with train departure/arrival information. In addition, a larger proportion of passengers at King's Cross will have suitcases and therefore take longer to put on coats and put up umbrellas. Announcements will not mitigate against this.

- Only the provision of an extended canopy beyond the gateline run-off is considered beneficial as this overcomes the issue of passengers slowing and/or taking alternative exit routes which causes other passenger management issues for other areas of the station. Pedestrian Simulation modelling with a canopy shows that passengers move more evenly through the Southern Façade gateline and façade exits and do not use the existing covered area for cross-flows to access the LUL Southern Stair. Better levels of service are shown in the vicinity of the Southern Façade and the Western Range gateline given that there is less diversion to routes through to the concourse. Passenger journey times are significantly improved through the provision of a Southern Facade canopy.

6.5 Benchmarking Against Station Planning Standards

The covered area between the Southern Façade gateline and the edge of the building has been designed as a gateline run-off for passenger orientation and decision making. The LUL Station Planning Standards and Guidelines, on which Network Rail's Major Stations Design Guide is based and which is considered best practice, stipulates a minimum gateline to street distance of 6m for such run-off facilities which includes a 2m protected zone on each side of the gateline.

Use of this run-off area for cross flows contravenes the standard, reduces the general efficiency of the gateline, and results in delays on both the paid and unpaid sides as passengers move more slowly through the cross-flow.

The Southern Façade and Western Range gating proposed at King's Cross has followed these best practice guidelines. In addition, the distance between the end of the platforms and the gateline has been designed to accommodate expected passenger surges to and from mainline trains.

6.6 Other Major Central London Stations

Site visits have confirmed that a large number of major central London terminal stations have weather proof canopies to provide protection to passengers accessing and egressing the concourse areas. These stations include Charing Cross, Waterloo, Marylebone, London Bridge and Victoria where typically a covered area of some 5-6m is provided between station façade and the external environment.

Site visits have also confirmed that the use of weather proof canopies assists in the management of peak surge flows encouraging passengers to move out of the concourse areas and towards other modes and egress routes. This in turn improves passenger circulation and efficiency.

6.7 Risk

The modelling assessment has included a number of assumptions which may vary depending on the severity of weather. The assumptions represent a best estimate of average flow conditions and decision making by passengers. However, there is risk associated with these assumptions summarised as follows:

- With no weather protection, and in extreme weather, there is likely to be an increase in the proportion of passengers using the limited covered route available in the Southern Façade. This will result in additional congestion and delays at the edge of the façade.
- With no weather protection, very wet weather is likely to divert a higher proportion of passengers from the Southern Façade exit through the Western Range exacerbating any congestion issues at the Western Range gateline.
- The combination of heavy rain and no canopy has the potential to create very congested conditions at peak times and will require more active management of train boarding and alighting in order to ensure efficiency.

There is also the very real risk that slips, trips and serious injury will be increased in the Southern Façade area, and at the top of the LUL Southern Stairs, should this area be exposed to wet weather.

6.8 Recommendation

It is recommended that an extended weather proof canopy is fitted to the Southern Façade at King's Cross in order to provide a covered link to LUL and extend the gateline run-off required for passenger orientation and decision making.

Incorporation of an extended canopy reduces potential conflicts in passenger flow both in the vicinity of the Southern Façade (across the face of the gateline), the LUL Southern Stair and the Western Range gateline. There is less potential for delay and with a reduction in passenger flow conflicts there will be less need to employ peak period passenger management strategies which attempt to avoid conflicts and congestion.

A Southern Façade canopy which protects routes out of the Main Shed, and particularly the route to the LUL Southern Stairs will also reduce the risks of slips, trips and serious personal injury associated with large volumes of passengers moving across wet surfaces.