CITY OF CARDIFF COUNCIL
CYNGOR DINAS CAERDYDD

CABINET MEETING: 2 JULY 2015

CARDIFF CENTRAL BUS INTERCHANGE

REPORT OF DIRECTOR CITY OPERATIONS & DIRECTOR OF ECONOMIC DEVELOPMENT

AGENDA ITEM: 10

PORTFOLIO: **TRANSPORT, PLANNING AND SUSTAINABILITY (COUNCILLOR RAMESH PATEL)**

Reason for this Report

1. To provide Cabinet with an update on the Central Square regeneration scheme and the recent progress made with the delivery of a new central bus interchange.

2. To seek Cabinet approval to move forward with the preferred concept design for a new central bus interchange and to work up a detailed scheme in preparation for the submission of a planning application.

3. To seek Cabinet approval to begin an engagement process that will outline the proposals for a new bus interchange to the public and seek views on a number of issues regarding the facilities to be provided.

Background

4. The Council's Corporate Plan 2015-17 sets out what the City of Cardiff Council will do to deliver our vision of becoming Europe's most liveable capital city. One of the four main priorities outlined in the Corporate Plan is s*ustainable economic development,* which will be delivered through two key improvement objectives, namely:

   - Cardiff has more employment opportunities and higher value jobs
   - Cardiff has a high quality city environment that includes attractive public space and good supporting transport infrastructure

5. In order to achieve these objectives the Corporate Plan outlines commitments to:

   - Deliver, with partners, 200,000 square feet of Grade A office as part of a new business district in the vicinity of central station between March 2014 and March 2016

- Work with key partners to design and deliver a new transport interchange - including a new bus station - as part of a high quality gateway into the city by December 2017

6. The Central Square regeneration scheme is the Council's key major project aimed at delivering against these Corporate Plan objectives. The Council has been working in close partnership with Rightacres Property Limited since 2012 on an ambitious masterplan for the area which involves the development of circa 750,000 sq ft of office-led mixed use development.

7. On 17th July 2014 Cabinet provided authority to progress with the delivery of a new headquarters building designed by Foster & Partners on the site of the existing central bus station, on the basis that a new state-of-the-art bus interchange would be re-provisioned in close proximity to the train station. As part of this, authority was also provided to undertake a formal consultation process with the public regarding the preferred location of the new interchange.

8. On the 15th December 2014 a further report was presented to Cabinet outlining the results of the public consultation exercise which showed overwhelming support to build the new bus interchange north of central train station. Authority was provided to develop proposals for a new bus interchange and approval was granted for the proposed interim arrangements and related enabling works to manage bus movements in the city centre for the period that the city will be operating without a bus station.

Issues

9. The regeneration of Central Square is progressing at pace following BBC Cymru Wales' decision to choose Central Square as their preferred location for a new headquarters building (subject to detailed negotiation and contract). In order to facilitate the delivery of this opportunity the Council has agreed to close the existing bus station in advance of the delivery of a new bus interchange, recognising the catalytic effect that a Foster & Partners building would deliver, not only in terms of the regeneration of Central Square, but also to the Cardiff economy as a whole.

10. In May 2015, Rightacres Property Ltd secured planning permission for the new headquarters building. It is anticipated that negotiations regarding the lease for the headquarters building will be concluded in time to enable a start on site in the autumn of this year. In order to provide clarity to bus operators and the public and to minimise disruption caused by the temporary diversion of bus services the Council has announced that it will close the existing bus station on 1st August 2015. August is the quietest time of year in terms of public transport usage and it will enable the temporary arrangements to be embedded before the Rugby World Cup 2015 matches take place at the Millennium Stadium in September. It will also provide time for preliminary works and service

diversions to be undertaken on the headquarters site before development needs to begin later in the year.

11. Once the BBC announced its preference to relocate from Llandaff to Central Square the Council understood that it would need to close the existing bus station before a new bus interchange could be constructed. The Council has therefore been working to ensure its plan for a new bus interchange is released for public consumption before the existing bus station has to close.

Design Competition

12. Following the Cabinet decision in December 2014, Rightacres Property Ltd, working closely with the Council, initiated a design competition with ten leading architect practices to design a concept for a new bus interchange on the Marland House/NCP Car Park site. The brief was to design a multi-layered mixed use building with car parking underground, a bus interchange and ancillary uses (such as retail) at ground floor level with mixed use development above including offices, hotel and residential. Participants were provided with a framework of requirements relating to the Council's transport priorities based on work undertaken by industry experts Steer Davies Gleeve (see **Appendix 1**). The Council also provided aspirations in terms of the required quality of design and place and the need to establish significant integration with Cardiff central train station. The developer provided criteria in terms of ensuring an affordable and deliverable high quality mixed use scheme.

13. Nine of the ten practices submitted initial proposals and following interviews the Council and Rightacres invited five to provide more detail. All five submitted high quality proposals that adequately met the transport requirement including the potential for integration with central train station. Following further interviews three practices were short-listed for the developer to review the proposals in some detail, including a review by construction companies, to ensure they were deliverable and fundable. Rightacres and the Council have subsequently agreed together that the proposal presented by Foster & Partners best meets the aspiration for Central Square and as such has been appointed as the preferred concept scheme for the new bus interchange.

Preferred Concept Scheme

14. The delivery of the new Integrated Transport Hub, of which the new bus interchange forms an integral part, is an important transformational project for Cardiff. It will provide the platform to meet the emerging transport needs of the city, and in addition through the delivery of a high quality urban built environment will significantly contribute towards Cardiff aspirations to become Europe's most liveable capital city. The Council has received numerous high quality submissions and the level of technical detail involved in selecting the preferred solution has made this exercise an extremely difficult challenge to evaluate.

Objectives

15. To ensure Cardiff has a modern Transport Interchange that caters for the projected growth of the Welsh Capital, the Council identified a number of key criteria to assess the shortlisted schemes. These were:

- Maximising the operational effectiveness of the bus station, in terms of capacity, arrangement of access, service user convenience and public safety.
- Expertise and experience of designing and delivering successful high quality transport facilities of similar or increased scale and significance.
- The outstanding architectural and urban design quality of the whole scheme. Ideally the selected proposal should be of high design impact appropriate to a major public building in a European Capital city. Furthermore, we will need a practice that will ensure that the final implemented scheme maintains the same or higher levels of architectural quality to that presented in initial concept stage/planning stage designs.
- To deliver a quality 'international gateway' to the city, interlinking public transport, the surrounding buildings and public spaces and the wider Central Square regeneration area into a single destination in its own right.
- To ensure that the concourse area of the interchange is undercover and fully safety managed (day/night) environment, with 'airport style' seating areas that integrates transport functionality (bilingual signage /ticketing /boarding) with a range of other uses including retail, cafes, and a most importantly a multipurpose 'best in class' 'cycle hub'.
- To ensure that the new interchange is able to successfully integrate in the short and medium terms with the wider Station development as it takes place. Also, that it will create a 'shared' interchange area linking the train station, bus station and Central Square into a multifunctional 'covered' space.

Scheme Selection

16. It has proven to be a very difficult process to review all the schemes in light of the above selection criteria. Each of the schemes has considerable merits and a number of the proposals were considered to meet most of the criteria. However, following careful consideration we recommend that the scheme proposed by Foster + Partners most effectively meets these criteria and that the architect firm become the preferred bidder for this project. A summary of the submission presented by the preferred bidder is attached to this report as **Appendix 2**. The detailed reasons are as follows:

- Efficient Operational Bus Layout: It is considered that this design offers the required transport facilities in terms of waiting environment for passengers and facilities in terms of transport information, along with clear integration with other modes of transport.

- Major Transport Development Experience: As the design practice responsible for a number of the most prestigious transport interchanges in the world, they provide outstanding assurance regarding deliverability and the quality of the final development.
- Scheme Design Quality: The scheme in all its elements is outstanding and original. In particular, we would highlight the following:
    - The bus station layout creates a high quality and generous concourse with an entrance on to Central Square that is striking and provides a real sense of arrival;
    - The Interchange enclosed area between the bus station and future rail station is a real 'destination space' which will allow a range of exciting inside/outside uses, and in some respects becomes the 'centre' of the new scheme;
    - The above ground office and hotel development is a landmark in its own right and will not only complete the development but will also become a landmark in the city as a whole.
- Gateway Quality: Analysis suggests that the relationship between the new bus interchange, the headquarters building and Central Square will become a major international 'gateway' for the city of the highest quality.
- Concourse Opportunity: The concourse offers more generous spaces for entrance, travel functionality and people interactions. Also, there will be significant opportunities for new facilities in terms of a major new cycle hub and opportunities that will emerge from the public engagement exercise.
- Interchange Linkage Area: The scheme very successfully allows Saunders Road to remain an active and attractive pedestrian and cycle area – as some of the schemes used it more for servicing or development. In turn, with the wide covered canopy, this area will become a landmark new 'covered' space in the city with a range of exciting uses for seating, performance, cycle hub spill out, retail and restaurants – effectively linking the new and existing rail and bus interchange areas. The selected proposal really opens up the opportunity for a landmark new 'central interchange covered space'.

17. The Foster and Partners submission represents a comprehensive and convincing vision for the site and provides a strong 21st century vision for the transport interchange, both internally and externally, and which is capable of being integrated with future Network Rail plans.

18. The overarching design reinforces the existing street pattern and desire lines particularly along the three principle pedestrian routes: the Marland House frontage; Saunders Road; and Wood Street. The proposal does however introduce a new form and scale of development which will significantly alter the physical, social and economic function and appearance of the area. In this respect the current transient nature of much of the area around the square will change to become a

sustainable, vibrant quarter of the city centre with a whole range of uses and occupants, helping to form a new community.

19. The built form will represent a modern city scale development which, whilst contrasting with much of the medium/low rise scale of building seen in St Mary Street and parts of Wood Street, will bring a scale which is in keeping with other parts of the area including the Millennium Stadium, Southgate House, Millennium Plaza, and more recently building No 1 Central Square.

20. Network Rail has ambitious plans to redevelop Central Station, encouraging rail users to interchange with greater use of sustainable modes of transport. This design for the new bus station future-proofs these links by ensuring they can be delivered when Network Rail implements their project. The Network Rail planning process for this redevelopment is at an early stage, and will not be brought forward until Control Period 6 (2019-2024) at the earliest.

Bus Station Operational Functionality

21. In terms of the Interchange operational efficiency there are a number of key features. In order to maximise the efficiency of stand use, it is likely that a system of limited Dynamic Stand Allocation will be used to make bus operation and capacity more efficient. Information on Dynamic Stand Allocation is included in Appendix 1. Although the reduced footprint of the facility will preclude long distance coach layover, provision will be made for coach drop-off and pick–up.

22. Whilst the number of bays provided under the proposed design is less than at the current facility, this has to be viewed in the context of the Council's future vision for the city's bus network. The recently completed Bus Network Review envisioned a strategy which would transform the bus network, resulting in a step change in bus use. This would include operating core network services as cross-city rather than radial routes with hub interchange points located outside the city centre, which will reduce the need for terminal points traditionally located at the bus station. This more flexible method of network provision will enable the growth in the use of public transport, which will cater for the increase in population generated by the LDP development sites.

23. In order to facilitate the establishment and reliability of this new type of network, a series of infrastructure changes and improvements will be undertaken by the Council. These would entail junction modifications and improvements to facilitate bus access to, through and around the city centre whilst limiting general traffic to access to city centre car parks and delivery traffic. This will change the way bus services circulate within the city centre and reduce the number of bus movements via Westgate St, which will have a positive impact on air quality. These measures, together with enhanced enforcement of parking restrictions and Moving Traffic Offences will improve bus journey times and reliability and increase the attractiveness of public transport vis-à-vis use of the private car.

Delivery Approach

24. At present the proposals for the new bus interchange have been developed to concept stage and the developer has undertaken high level cost appraisals predominantly relating to the developments that will sit above ground floor level, i.e. above the bus station. Over the next few months the concept will be developed into a detailed scheme in preparation for the submission of a planning application. Once a detailed scheme has been produced a full and detailed appraisal of the costs of all aspects of the scheme can be undertaken.

25. To date the potential costs associated with the new bus interchange have been based on work previously undertaken by the Council and knowledge of recently built facilities across the UK. These indicative costs were presented in the report to Cabinet in December 2014 and ranged from £10m to £20m depending on the scale of development and the facilities provided. It is anticipated that significant economies of scale will be realized through the integration of the new bus interchange into a broader mixed use development. The chosen approach to funding will need to be considered in the context of a detailed cost analysis of the chosen scheme and the approach to funding of the broader development. The Council has land assets in the area which could effectively cover the cost of the new facility. However, there are existing income streams (such as departure charges) and potential new income streams associated with the new bus interchange (such as rental income from retail units) that could potentially cover the costs of the new bus facility aspect of the development. Full details of the funding options and the chosen approach will be presented for consideration by the Council in October.

Public engagement exercise

26. It has always been the Council's intention to carry out Comprehensive public and key stakeholder engagement with additional engagement with specific special interest groups including the Cardiff Council Access Focus Group and 50+ forums once the preferred concept for a new bus interchange was chosen. This will ensure that the public are fully informed on the new proposal, as well as receiving information on the new bus departure points while the bus station is closed. The engagement process will present the scheme in 'conceptual' terms, as there remains a significant amount of work required to produce the detailed scheme. Under the current timeline, a detailed planning application is expected to be submitted towards the end of this year. Feedback from the public including the above mentioned special interest groups will be considered, as the detailed design of the new bus station develops; indeed a separate EqIA (Equality Impact Assessment), will be conducted on the planning application of the new facility. The public can consider the type and location and uses/activities in all the main areas of public realm, concourse, and shared covered spaces. In particular there will be the opportunity to define the nature of the new cycle hub.

27. The public engagement process will include:

- Roadshows - these will involve four public exhibitions led by officers. The new proposals will be presented and feedback forms will be available for the public to give their details and their comments.
- Staff on street giving out information on the new scheme - there will be on street presence of staff working with transport operators to give information on the new bus station, and the interim arrangements that are being put in place to cater for the displacement of services while the bus station is closed.
- Media Coverage and on street advertising - there will be comprehensive local media coverage (Capital times and Media Wales) of the proposals. This will identify the locations/times of roadshows but also present the scheme and invite any comments.
- Special Interest Groups Cardiff Council Access Focus Group / 50+ forums

  - to ensure a wide spread understanding of the changes in place and information is provided in a variety of formats

28. Once the comments have been received they will be considered and a prioritised list of scheme amendments will be made. This will be communicated to the public through further engagement, as the detailed design progresses.

Interim Arrangements

29. Ensuring that effective Interim Arrangements are in place for when the Bus Station closes is essential. As outlined in paragraph 11 above it is the Council's intention to progress with the closure of the existing bus station on 1st August 2015. August is the quietest time of year for public transport use and therefore the best time of year to manage a transition to interim arrangements. It will also enable the new interim arrangements to be fully embedded before the commencement of the Rugby World Cup in Cardiff on 19th September.

30. In anticipation of the bus station closure the Council has undertaken a series of enabling works across the city centre to provide additional on-street capacity for buses. These works are now completed.

31. Details of the proposed (interim) arrangements for the movement of buses through the city centre for the period of time the city needs to operate without a bus station are outlined in **Appendix 3**.

Next Steps

32. If the preferred concept design for a new bus interchange presented in this report is approved by Cabinet, the Council and the developer will immediately begin work to produce a detailed scheme with a view to submitting a planning application for the new bus interchange towards the end of this year. The proposed timetable of activities is outlined below:

- **31st July:** Submit planning application for the demolition of the Wood Street NCP Car Park

- **1st August 2015**: Bus station closed to enable transition to interim arrangements and commencement of preliminary works and service diversions.

- **October:** Provisional date for signing of BBC agreement to lease with development to start on site immediately after.

- **October:** Detailed scheme and preferred funding approach for a new bus interchange to be presented to Cabinet for approval.

- **December 2015:** Submit planning application for new bus interchange.

- **December 2015:** Begin demolition of Wood Street NCP Car Park.

- **December 2015:** Submit planning application for the demolition of Marland House.

- **March 2016:** Begin demolition of Marland House.

- **April 2016:** Begin construction of new bus interchange.

Reason for Recommendations

33. To provide Cabinet with an update on the delivery of a new bus interchange and to seek approval for the chosen concept design.

Financial Implications

34. This report seeks to approve a concept design progression to detailed design and to progress a public engagement programme for a new central bus interchange.

35. In terms of revenue implications, the cost of operating the existing bus station is largely funded via departure fees paid by the operators using the station's services. Once closed, it is understood that the existing bus station's operating costs will cease. The cost of the additional on-street capacity will be managed as part of the existing bus shelter management contract. In addition, temporary driver facilities have been made available, any costs arising to the council (in respect of driver facilities), along with the cost of the public engagement exercise will need to be met jointly from existing City Operations and Economic Development revenue budgets.

36. The operating arrangements, including any revenue implications associated with the new facility will need to be considered in a future report to determine any net revenue budgetary impact to the council.

37. Capital works to enhance the existing on-street capacity have recently been completed and the final cost statements are being prepared. It is understood that final cost amounts to circa £700k.

38. As the council will be reliant on its ability to recycle its investment in Central Square to fund the new bus interchange, it is essential that an updated Central Square development appraisal is prepared in conjunction with progressing work on the detailed scheme. This will provide Cabinet with an updated assessment of the level of capital receipts that may be available to fund the facility as well as risk and cash flow timing of receipt. Where revenue or other income streams are assumed again this will need to be considered as part of the affordability of the proposal and risks to achievement. There will need to be consideration of wider potential financial impacts such as VAT and stamp duty land tax, particularly when working with other partners, so that full financial implications can be determined

39. The report outlines that a full financial appraisal will be developed as part of the detailed design with the aim of delivering the new facility on a cost neutral basis. This will need to include all costs for the facility itself, for any hub interchange points located outside the City centre as well as any other junction and associated infrastructure enhancements required. The 2015/16 Budget Report set out indicative capital budgets to 2019/20 and the Medium Term Financial Plan to 2018/19. The report clearly outlined the increasing financial pressures on council resources in future years and the severe financial challenges the council faces in order to identify new allocations. It is therefore essential that the financial appraisal (along with any associated impacts) is developed with Financial Services at an early stage, given the potentially significant financial implications associated with the delivery of a new central bus interchange.

40. Any changes in concepts following start of detailed design could result in abortive costs. Where expenditure is being incurred, this is being done on the assumption of a future capital receipt. It is important that any such work is done on the assurance of receipts actually being received within a short timescale in order to reduce the risk and financial impact to the Council.

41. It is understood that the conditional legal agreement between the developer and the BBC is progressing in-line with the agreed timetable. But, until such time as that agreement becomes unconditional, there remains a financial risk that an element of costs incurred to-date may prove to be abortive.

Legal Implications

42. The Council will be required to ensure value for money by ensuring proper process in regard to the provision of the proposed new bus exchange by the developer and the funding of that provision. In carrying out consultation the Council is legally required (a) not to have made a decision in advance (b) to provide sufficient information (c) to allow

sufficient time and (d) to consider the responses properly. Equality Impact issues will need to be taken into account by the decision makers.

RECOMMENDATIONS

Cabinet is recommended to:

1. Approve the preferred concept design for a new Central Bus Interchange as presented in this report;

2. Delegate authority to the Director of City Operations and the Director of Economic Development in consultation with the Leader of the Council, Cabinet Member for Transport, Planning and Sustainability, Cabinet Member for Corporate Services and Performance, Section 151 Officer and the Director of Governance and Legal Services to progress with the preparation of a detailed scheme, updated development appraisal and full financial appraisal for the delivery of a new Central Bus Interchange and to return to Cabinet in October in advance of submitting a planning application;

3. Provide authority to begin a public engagement process on the 3rd July 2015 for 4 weeks to present the proposals for a new bus interchange to the public and to consult on a number of issues relating to the facilities to be provided within the new bus interchange and to raise awareness of the interim arrangements in advance of the closure of the current bus station on 1st August 2015.

ANDREW GREGORY
Director
26 June 2015

NEIL HANRATTY
Director
26 June 2015

The following Appendices are attached:-

Appendix 1: Bus Station Technical Specification
Appendix 2: Preferred Concept Scheme
Appendix 3: Interim Arrangements

Appendix 1

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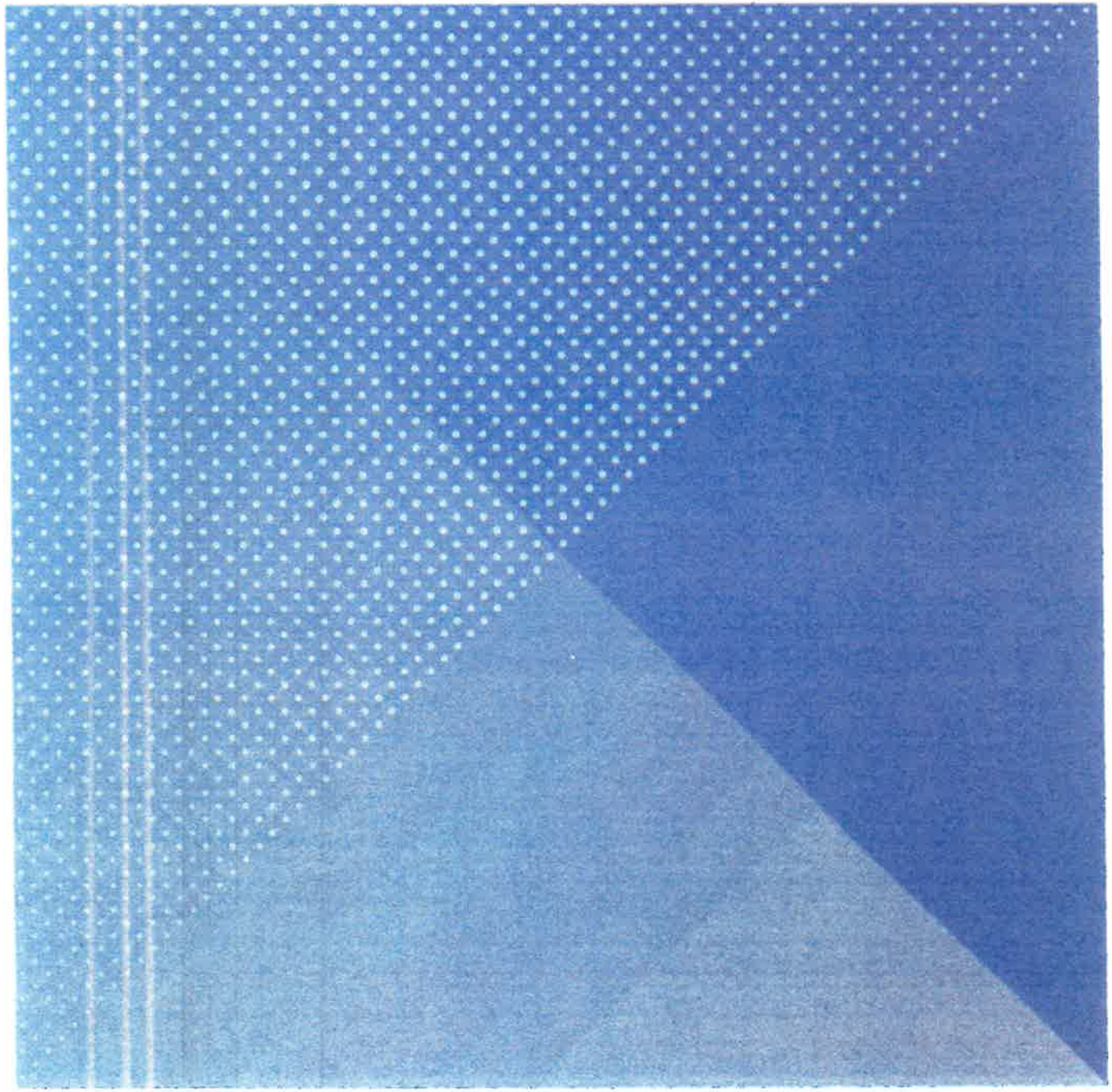

Central Square - New Bus Facility

Final Report of Stage 2
March 2015

The City of Cardiff Council

Our ref: 22715902
Client ref:

steer davies gleave

Central Square - New Bus Facility

Final Report of Stage 2

March 2015

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Our ref: 22715902

Client ref:

Prepared by:

Steer Davies Gleave

28-32 Upper Ground

London SE1 9PD

+44 20 7910 5000

www.steerdaviesgleave.com

Prepared for:

The City of Cardiff Council

Coleridge Road

Cardiff

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1 Introduction

Background

Steer Davies Gleave's (SDG) has undertaken extensive work to date which has shown that a new bus facility can be accommodated within the Central Square masterplan layout and that the forthcoming planning applications do not preclude either a new bus station or a future transport hub on Central Square.

The Central Square New Bus Facility and Potential for a Transport Hub report (October 2014) presented three bus station layouts that could operate on plots 9-13 of the Central Square masterplan. This was informed by discussions with bus operators, user groups and traffic consultants involved in the area. Following this study, the City of Cardiff Council has engaged further with these stakeholders obtaining feedback on the bus station layouts. Feedback received was that the preferred layout was Option 3 – Drive in Reverse Out (DIRO).

Following this feedback, the City of Cardiff Council appointed Steer Davies Gleave to take forward this option to the next stage of design development and respond to particular constraints and operational requirements. This report summarises this second stage of design work.

Scope of Work

The scope of work is formed of two components, with each informing the other, leading to design iterations. The two components of the scope are to:

1. further develop the concept design of the new bus station (Option 3 – DIRO only) to optimise the layout and address comments received from the City of Cardiff Council, Rightacres Property, the bus operators and user groups (work led by SDG); and
2. undertake traffic capacity analysis (VISSIM modelling) to test the design and performance of the proposed bus station and of the surrounding highway network (work led by AECOM).

Ultimately this stage of work seeks to refine the design to a level of detail that can satisfy the various stakeholders and be used as a baseline and checking measure against the proposals from the design competition, which is being run in tandem with this report. The October 2014 report formed part of the supporting information for the design competition brief.

The design iterations and final design are to a concept level only. No consideration is given to utilities and other elements that would be addressed

up to preliminary design, with the exception of a Welsh Water easement which is known to be located in the area of the proposed bus station. This has been taken into consideration in the final iteration of the option only, as the information was provided subsequent to earlier options being developed (AutoCAD file received by SDG on 19 January 2015). It should be noted that the design competition is being developed with consideration given to site constraints.

Study Area

The area examined for this stage of work is limited to the proposed location of the bus station; an area of land alongside and including Great Western Lane between Wood Street and Saunders Street. This is the area for which SDG have prepared internal layout designs for the bus station.

Consideration has also been given to the highways layouts for junctions that govern access to the bus station and are within close proximity to the site, namely: Saunders Road/ St Mary Street; Wood Street/ Havelock Street; Wood Street/ Westgate Street; and Wood Street/ St Mary Street. These constitute the extents of the wider area for which AECOM has been studying and testing permutations of highways designs.

2 Option testing – traffic model results

AECOM has undertaken traffic capacity analysis to test the design and performance of the proposed bus station layout, and examine options for the surrounding highway network work. This work is based on the existing VISSIM model used to assess the impact of the Cardiff Central Square plots 2 and 3 planning application, and enhances it by modelling the internal bus station circulation.

AECOM prepared a technical report *VISSIM Modelling Results Technical Note* (10 December 2014) setting out results of modelling, and drawing conclusions in relation to the highways layout and the bus station. This chapter summarises key findings. The full report is included at Appendix A.

Summary of results

Highways options

Three network designs, and a fourth variation on a design, were tested in VISSIM to better understand their impact on the local highway network. The options considered include:

- Design 005: Bi-directional bus only on the southern part of Westgate Street between Park Street and Wood Street, reversed direction on Scott Road, single lane in each direction along Wood Street and signalised exit from the bus station.
- Design 006: Bi-directional on the southern part of Westgate Street between Park Street and Wood Street with bus only in the southbound direction, Havelock Street closed to all vehicles, Scott Road reversed, single lane in each direction on Wood Street with an eastbound flare at the Westgate Street junction and signalised exit from the bus station.
- Design 007: Similar to the existing layout, with priority exit from the bus station and a single lane in each direction along Wood Street.
- Design 005 reversed: As Design 005, with the direction of traffic on Havelock Street and Scott Road reversed to allow northbound vehicles on Scott Road, and southbound vehicles on Havelock Street.

Drawings for each of these options are included in the AECOM report at Appendix A.

The results of the VISSIM testing indicate that there is no clear frontrunner for a preferred highway option to take forward; all designs perform within acceptable levels of highways and transport expectations to be considered as satisfactory options.

Bus station internal operation

The preferred internal bus station layout developed by SDG (Option 3 = DIRO) was also tested using the VISSIM model. Figure 2.1 shows the bus station layout in the context of the wider area, and Figure 2.2 zooms in to the bus station area itself.

The modelling of the internal bus station operation shows there is sufficient capacity for buses to circulate within the bus station and access and egress available stands. Preliminary analysis has indicated improvements and efficiencies would be needed over the existing operation to accommodate the bus demand. This could include optimised timetabling, re-allocation of layover to other parts of the road network, bus priority improvements to increase bus journey time reliability, and use of bus station Dynamic Stand Allocation (DSA).

The potential for use of DSA is discussed further in Chapter 3 of this report and accompanying analysis by AECOM at Appendix D.

Figure 2.1: Bus station layout – Option 3, DIRO (wider context)

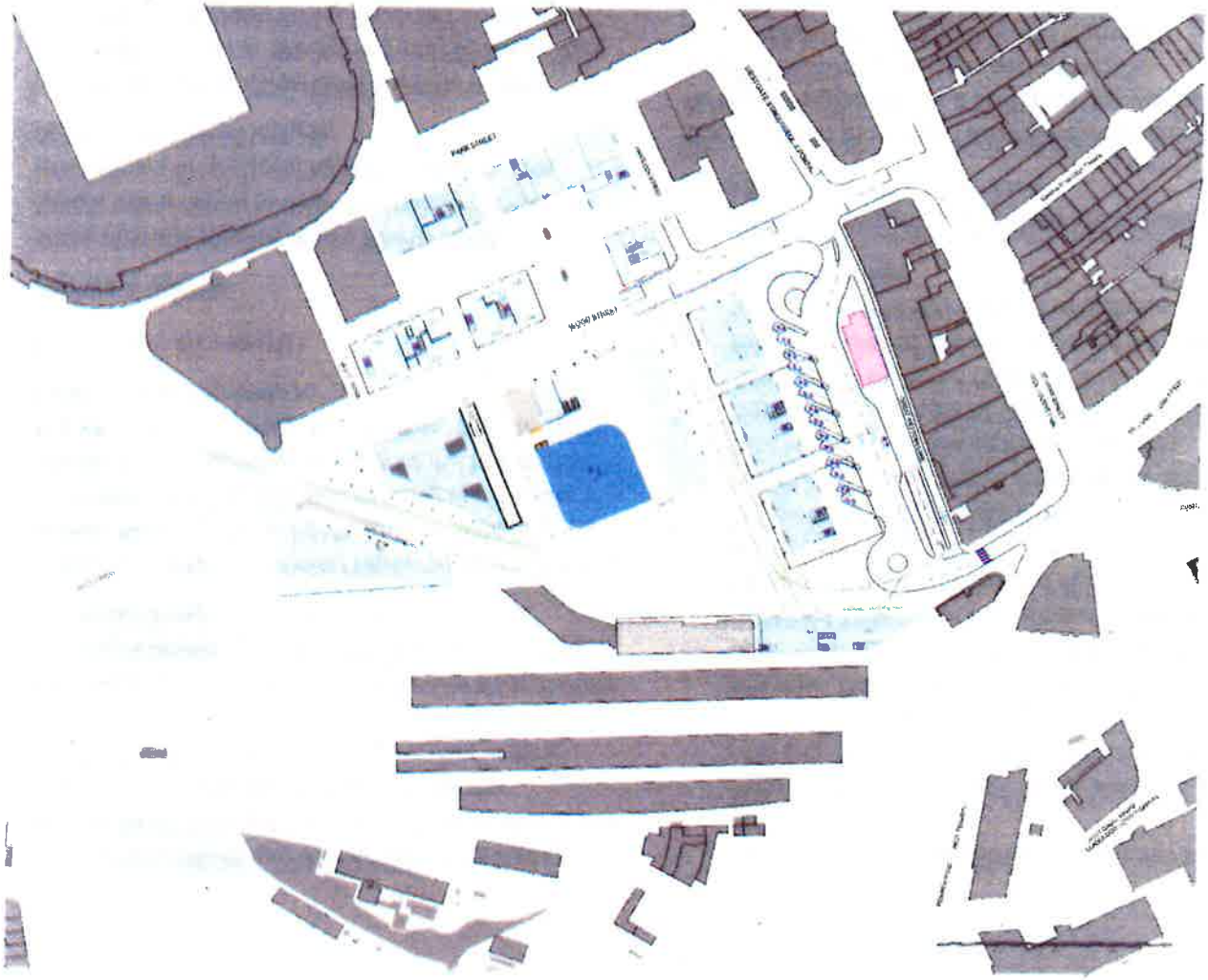


Figure 2.2: Bus station layout – Option 3, OIRO

Model conclusions

The key findings that drive further design development for a new bus station facility are that:

- there is sufficient capacity for buses to circulate within the bus station, and access and egress available stands - this is based on the assumptions that have been employed to test the design (these are set out in the full technical note at Appendix A);
- a more detailed assessment is required in relation to bus operations to accommodate bus demand (e.g. timetabling, stand allocation, re-allocation of layover etc.); and
- all three highway layouts are acceptable in terms of traffic operations to be considered as possible design options.

Assessment framework

Following the modelling work an additional assessment was undertaken by SDG of the highway layouts to provide further guidance on which highway layout to take forward in relation to the final design of the new bus facility. A qualitative assessment framework was developed based on proposed principles derived from the Foster's masterplan for the wider area. This was used to help prioritise the three layouts and the layout variation as described above.

The full results of this assessment are included at Appendix B. A total score is given for each option, however the assessment framework is designed to give a comprehensive overview of multiple considerations when deciding the most desirable option. Some impacts may have a greater weighting that others or be considered totally unacceptable. On this basis decision makers should review the full impacts of each option, considering the various elements before deciding on a particular highways layout to take forward.

3 Bus station internal layout design

Stage 1 draft design option

The starting point for this stage of design work was the preferred concept design from the stage one work – Option 3, DIRO, as illustrated in Figure 2.1.

Stakeholder comments

Meetings were held on with the bus operators and the client group on the 16th and 17th December 2014 respectively to present the bus station design along with the highway layouts and modelling results. The aim of the meeting was to gain feedback on the design and confirm actions for design development, leading to a single design for sign-off.

In summary the main points of feedback received on the internal layout of the bus station include:

- The bus operators would like the Saunders Road access to be in operation all days (not just during events), however as this link would be the access for the car park this would put a lot more vehicles on this link and potentially increase conflict with pedestrian movement between St Mary Street and the rail station. Furthermore this is something that would need to be considered in relation to the longer term, city-wide bus operations strategy (and the air quality issue on Westgate Street) and therefore goes beyond the scope of this study.
- It was agreed that the bus station needs to be flexible to accommodate future operation / growth and therefore able to accommodate all movements from all access points.
- The bus operators' main concern is bus station capacity, particularly allowing sufficient dwell time/ layover to operate services. Layover space for four to five buses is required.
- It was agreed that two options would be explored and designed:
  - A. Expanding the bus station footprint west to allow more space for bus circulation. It is recognised that this will affect the masterplan layout. No additional layover space would be provided.
  - B. Use Great Western Lane as the southbound bus lane and removing the southern turning loop. Issues with car park ramp relocation will need to be considered. Great Western Lane must still allow for servicing access.

Following on from this meeting Steer Davies Gleave prepared two further iterations of the design options, which are presented in the following section. Full sized drawings of the design options are included in Appendix C.

Design development

Option 3, variant A

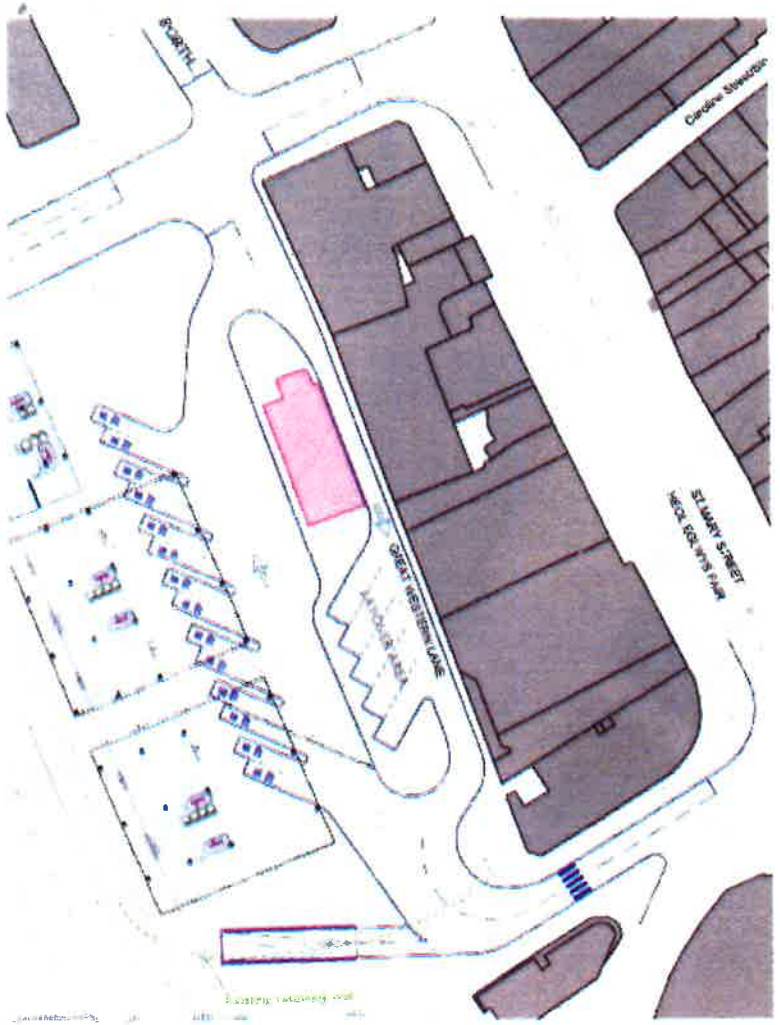
The option illustrated in Figure 3.1 illustrates the first variant of the bus option based on comments received at the meetings in December 2014. Changes include:

- The southern turning loop in the original design is removed.
- Southbound buses are routed along Great Western Lane, to the east of the sub-station, whilst still allowing servicing access to rear of retail properties.
- Bus station footprint expanded westwards.
- Layover space in DIRO arrangement to be accessed via Great Western Lane.
- The underground car park access ramp is relocated to the west end of Saunders Road.

This variant would have an impact on the land to the west of the bus station. To allow for an adequate waiting area for bus passengers the buildings along this side will need to be designed in such a way as to accommodate this; i.e. constraints provided by the proposed footprint of the buildings changed.

This layout accommodates 14 stands and five layover bays.

Figure 3.1: Bus station internal layout – Option 3, variant A



Option 3, variant B

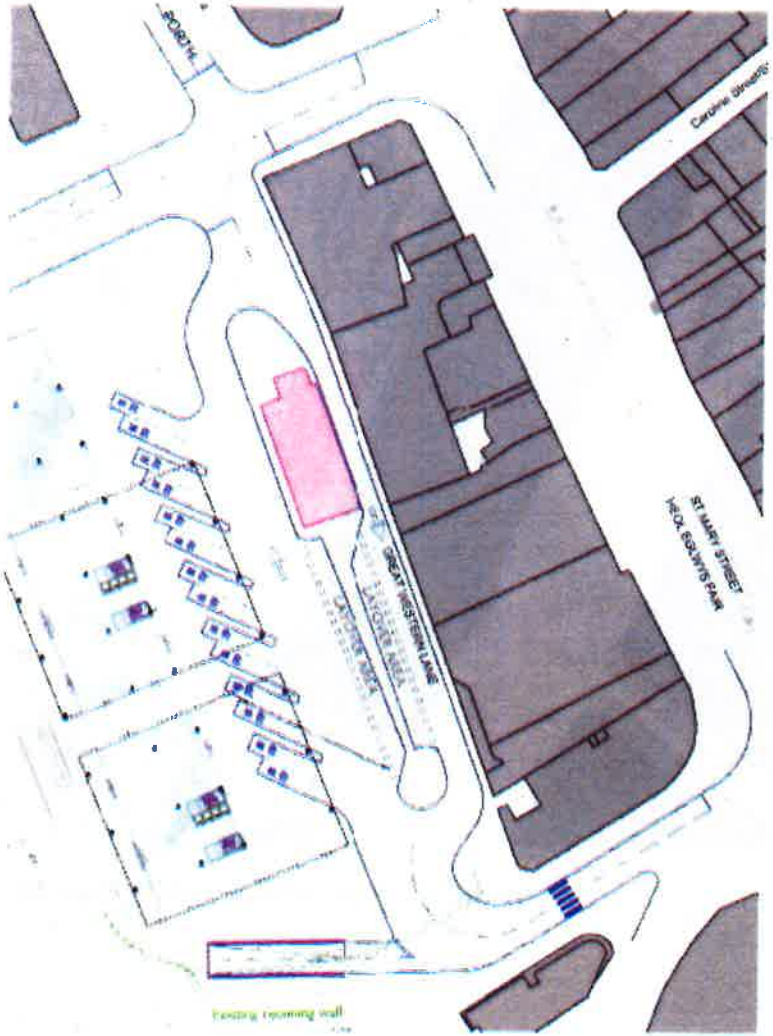
The option illustrated in Figure 3.2 illustrates the second variant of the bus option based on comments received at the meetings in December 2014. Changes include:

- The southern turning loop in the original design is removed.
- Southbound buses are routed along Great Western Lane, to the east of the sub-station, whilst still allowing servicing access from here for retail properties.
- The underground car park access ramp is relocated to the west end of Saunders Road.

Unlike the arrangement in variant A, this option would not directly affect the buildings located to the west of the bus station.

This layout accommodates 14 stands and four layover bays.

Figure 3.2: Bus station internal layout – Option 3, variant B



Final design option

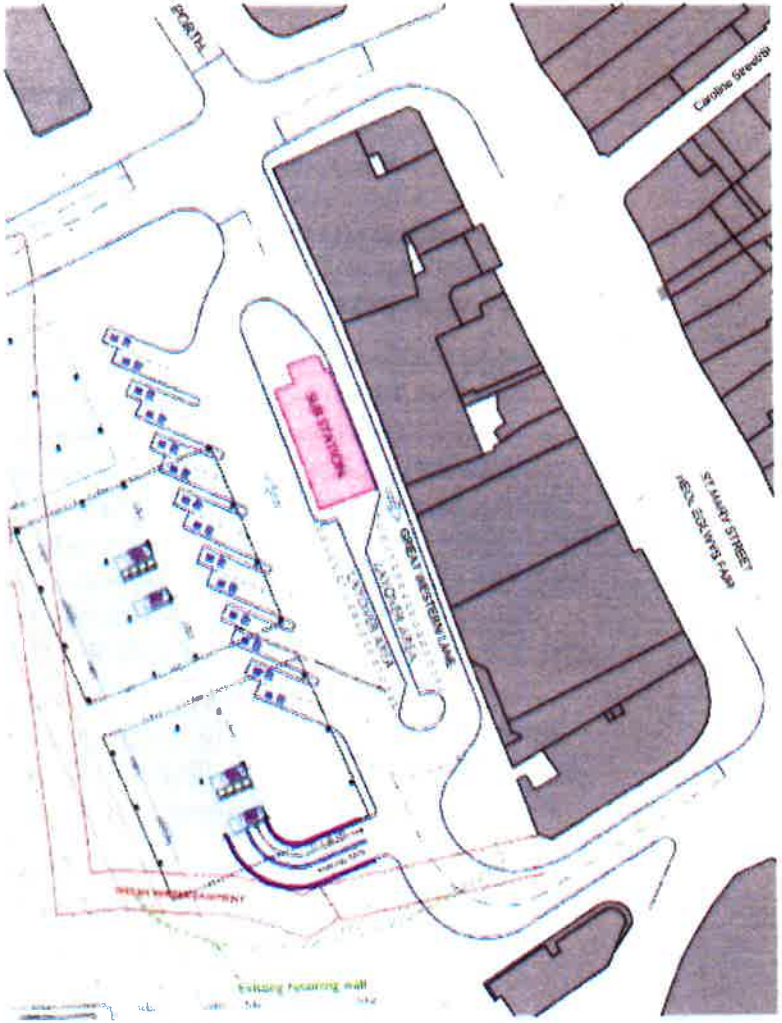
Following preparation of variants A and B, a further design iteration was drawn to take account of the easement of a Welsh Water pipe that runs east-west across the southern end of Great Western Lane. This is illustrated in Figure 3.3. Changes include:

- Relocation of the underground car park access ramp to the north of the water easement.
- Relocation of the bus stops further north to allow adequate space for the access ramp.

The layout include 14 stands and four layover bays.

The ramp geometry meets minimum standards set out in Design Recommendations for Multi-Storey and Underground Car Parks (4th edition, Institution of Structural Engineers). The ramp on the inner curve is 25 metres long at a 12% gradient, enabling the foot of the ramp to achieve a clearance of approximately three metres below the ground floor of the building above. Allowing for the floor slab at the base of the ramp means this would leave approximately 2.6 metres clearance. This clearance will be sufficient for cars, and also vans up to medium height (e.g. a Ford Transit van - medium roof is 2397mm tall) however the design would need to be revisited should there be a need to allow access for taller vehicles (e.g. Ford Transit van - high roof is 2611mm tall).

Figure 3.3: Bus station internal layout – Final option



The location of the car park access means that an uninterrupted at-grade pedestrian connection between the bus station and the train station via the most direct route is not possible. Consideration should be given at the next stage of design to how to better provide for people walking between the bus and train stations. Potential this could include for example adjusting the footprint of the proposed buildings adjacent to the bus station to provide direct and legible pedestrian route, or providing a walkway that ramps up from bus station to rail station and overarches the car park entrance.

Bus station operation - Dynamic Stand Allocation

Initial consideration has been given to the use of Dynamic Stand Allocation (DSA) for operation of the new bus station in order to make most efficient use of the limited space available.

DSA is intended, in its ideal form, to result in a more compact and user-friendly bus facility. Traditionally each bus line has its own stop at the station, which results in some stops being empty or less utilised, even during rush hour. The application of DSA makes use of stops in a more flexible manner, by assigning any available stop to any incoming bus, and using electronic signing to advise passengers of where to board their bus.

AECOM have previously undertaken research on dynamic stand allocation in relation to Cardiff and have produced reports on the matter. These are included for reference at Appendix D.

In summary, it would seem from these reports that the effectiveness of DSA is highly variable. The technological challenge of ensuring data accuracy / transfer between systems is one key reason as to why the capability / benefits of DSA have not actually been realised where it has been implemented. However the reports also note that where implemented the enhanced service delivery is generally well received and appreciated by users.

DSA does provide a possible approach to managing bus station operations, however the initial evidence suggests that it is not always successful. More work will need to be done as part of future studies on bus station operations in order to make a more informed decision of whether incorporation of DSA within the bus station would be beneficial.

4 Summary of issues and constraints

Key issues and constraints

The final preferred design described in chapter two is recommended for use as the benchmark for the design competition against which the proposed layouts generated through the design competition can be analysed and compared. In taking this design forward the following issues will need to be taken into account:

- The directions and general arrangements required for vehicles to access the station, including the need for station access to 'flip' to allow access on match days.
- The dimensions and arrangement of the vehicular areas as set out in the drawing to enable safe and efficient vehicle circulation within the station.
- The space required to accommodate 14 stopping bays and layover for four buses, as set out in the final design option drawing.
- Provision of the most direct and safe routes for pedestrians between stops and to external destinations, that reduce the likelihood of passengers crossing operational areas of the station, or making unpredictable movements.
- Passenger desire lines to destinations such as the railway station, city centre, Millenium Stadium and future development opportunities.
- Space requirements for passenger areas, taking into account the need to comfortably accommodate people waiting for and people alighting from bus services.
- Space requirements for passenger facilities, and separate staff/ operational facilities.
- The relationship between the underground car park access ramp and the lift core within the building above. As noted in chapter 2 the circulation internal to the building may need to be adjusted to accommodate the basement entrance.

In addition to the above, there are a number of critical constraints that must be accommodated:

- Retention of the Welsh Water pipe in situ, with no encroachment into its easement.
- Retention of the existing substation in situ on Great Western Lane.
- Allowing servicing and fire tender access on Great Western Lane to rear of buildings which front onto St Mary Street.
- Retention or reprovision of the existing loading bay facility to rear of the same buildings, at the southern end of Great Western Lane.
- The minimum dimensions for a car park access ramp, as described in chapter two and drawn in the final option layout.

A Appendix - Cardiff Bus Station Technical Note: VISSIM modelling results (AECOM)

Technical Note

AECOM

Project:	**Cardiff Bus Station**	Job No:	**60329051**
Subject:	**VISSIM Modelling Results: Issue 1**		
Prepared by:	**Ellena Caudwell**	Date:	**09/12/2014**
Checked by:	**George Lunt**	Date:	**09/12/2014**
Approved by:	**George Lunt**	Date:	**28/03/2015**

1. Introduction

AECOM has been requested by Rightacres to support Steer Davies Gleave (SDG) in the design of the re-located bus station. AECOM's work uses the existing VISSIM model used to assess the impact of the Cardiff Central Square plots 2 and 3 planning application, and enhances it by modelling the internal bus station circulation.

This report is the first stage of works, showing the initial modelling results, and will help make decisions on the network and bus station design going forward. The remainder of this Technical Note is structured as follows:

- Section 2: Option summary;
- Section 3: Modelling Results;
- Section 4: Highway design discussion;
- Section 5: Bus station internal operation; and
- Section 6: Summary and conclusions.

2. Option Summary

Three proposed highway network designs have been modelled for comparison, with the internal bus station modelled using the preferred design (SDG Option 3). Copies of the three designs are included in **Appendix A**. A fourth design option has been tested for consideration, which is a slight change on Design 005. The options are summarised below:

- **Design 005**: Bi-directional bus only on the southern part of Westgate Street between Park Street and Wood Street, reversed direction on Scott Road, single lane in each direction along Wood Street and signalised exit from the bus station.
- **Design 006**: Bi-directional on the southern part of Westgate Street between Park Street and Wood Street with bus only in the southbound direction, Havelock Street closed to all vehicles, Scott Road reversed, single lane in each direction on Wood Street with an eastbound flare at the Westgate Street junction and signalised exit from the bus station.
- **Design 007**: Similar to the existing layout, with priority exit from the bus station and a single lane in each direction along Wood Street.
- **Design 005 reversed**: As Design 005, with the direction of traffic on Havelock Street and Scott Road reversed to allow northbound vehicles on Scott Road, and southbound vehicles on Havelock Street.

Direct Tel: +44 (0)117 901 7116
T +44 (0)117 901 7000
F +44 (0)117 901 7099
E Ellena.Caudwell@aecom.com
www.aecom.com

3rd Floor, Portwall Place
Portwall Lane
Bristol
BS1 6NA
United Kingdom

3. Modelling Results

Journey time and network performance results have been collected to compare the four options. These are presented below. In summary, all options show similar journey time performance results across the network for both buses and cars.

3.1 Journey Times

Table 3.1 – AM Journey Time Results

		AM			
		Design 005 reversed	Design 005	Design 006	Design 007
Bus	Bus station to Wood St	01:13	01:13	00:57	01:02
	Wood St to Bus Station	01:48	01:50	01:50	02:20
	Bus station to Cowbridge E	03:45	03:44	03:29	03:18
	Cowbridge E to Bus station	04:23	04:24	04:22	04:06
	Bus station to Castle St	04:14	04:16	04:04	03:53
	Castle St to Bus station	04:31	04:26	04:30	04:09
Car	Cowbridge E to Callaghan Sq	06:18	06:51	07:04	05:55
	Cowbridge E to Wood St	03:56	04:16	04:14	04:39
	Castle St to Callaghan Sq	05:56	06:37	06:59	05:50
	Castle St to Wood St	03:41	03:56	04:02	04:19
	Callaghan Sq to Cowbridge E	04:42	04:36	05:05	04:30
	Callaghan Sq to Castle St	05:30	05:22	05:29	05:04
	Callaghan Sq to Wood St	03:37	03:48	03:58	03:44
	Wood St to Cowbridge E	02:55	03:21	03:52	02:50
	Wood St to Castle St	03:18	03:43	04:10	03:13
	Wood St to Callaghan Sq	04:04	04:08	04:17	04:25

Table 3.2 – PM Journey Time Results

		PM			
		Design 005 reversed	Design 005	Design 006	Design 007
Bus	Bus station to Wood St	01:21	01:16	01:02	01:07
	Wood St to Bus Station	01:43	01:59	01:33	02:53
	Bus station to Cowbridge E	03:51	04:02	03:39	03:44
	Cowbridge E to Bus station	05:31	05:22	05:18	04:02
	Bus station to Castle St	04:44	04:52	04:34	04:37
	Castle St to Bus station	05:08	04:57	04:58	03:56
Car	Cowbridge E to Callaghan Sq	05:57	06:35	06:50	06:00
	Cowbridge E to Wood St	04:46	04:38	04:35	04:52
	Castle St to Callaghan Sq	06:06	06:27	06:54	06:04
	Castle St to Wood St	04:03	03:48	03:53	04:03
	Callaghan Sq to Cowbridge E	05:55	06:29	05:58	06:00
	Callaghan Sq to Castle St	06:53	07:23	07:07	06:56
	Callaghan Sq to Wood St	04:07	04:25	04:46	04:33
	Wood St to Cowbridge E	03:12	03:57	04:00	03:22
	Wood St to Castle St	04:02	04:50	04:56	04:05
	Wood St to Callaghan Sq	03:55	04:10	04:26	05:12

3.2 Network Performance

Table 3.3 – AM Network Performance Results

	AM			
	Design 005 reversed	Design 005	Design 006	Design 007
Total travel time (hrs) Bus	52.4	52.6	52.7	51.2
Total travel time (hrs) Car	217.8	219.7	222.7	218.8
Total delay time (hrs) All Vehicles	174.5	177.4	181.5	174.2
Average delay time per vehicle (s) Bus	391.1	393.3	395.0	368.8
Average delay time per vehicle (s) Car	82.2	83.2	85.7	83.0
Average speed (mph) Bus	7.0	7.0	7.0	7.2
Average speed (mph) Car	11.5	11.4	11.1	11.3
Latent demand, All Vehicle Types	200	183	206	196
Number of vehicles that have left the network, Bus	158	157	157	157
Number of vehicles that have left the network, Car	5506	5518	5486	5505

Table 3.4 – PM Network Performance Results

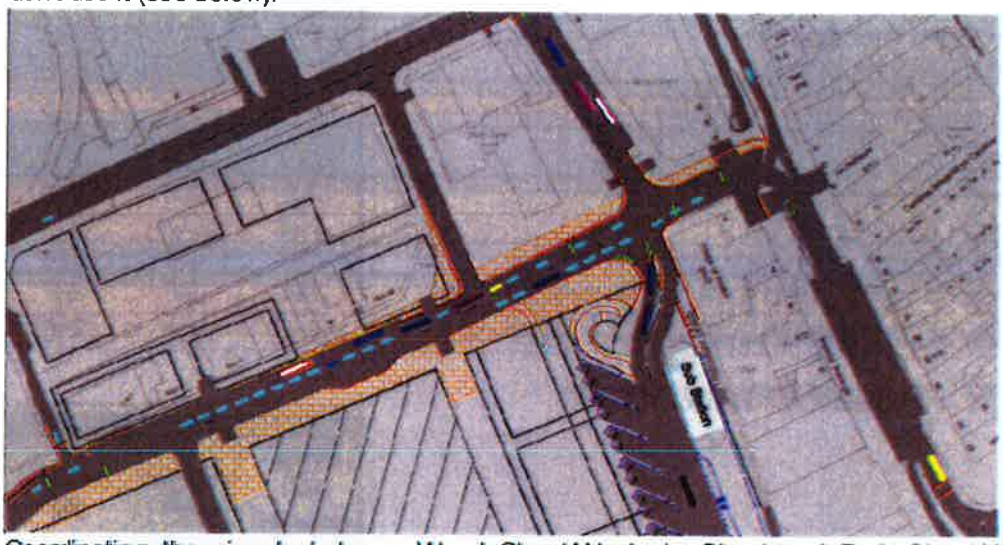
	PM			
	Design 005 reversed	Design 005	Design 006	Design 007
Total travel time (hrs) Bus	60.7	60.8	60.6	59.0
Total travel time (hrs) Car	226.5	231.1	232.2	230.3
Total delay time (hrs) All Vehicles	198.7	204.4	206.3	201.7
Average delay time per vehicle (s) Bus	467.6	467.5	464.9	436.9
Average delay time per vehicle (s) Car	92.6	95.7	96.6	95.4
Average speed (mph) Bus	6.3	6.3	6.3	6.6
Average speed (mph) Car	10.6	10.3	10.3	10.3
Latent demand, All Vehicle Types	5	5	5	5
Number of vehicles that have left the network, Bus	169	169	169	170
Number of vehicles that have left the network, Car	5367	5361	5362	5365

4. Design Discussion

This section sets out key points for each design which has been modelled in VISSIM, and in particular any sensitive areas of the models.

Design 005

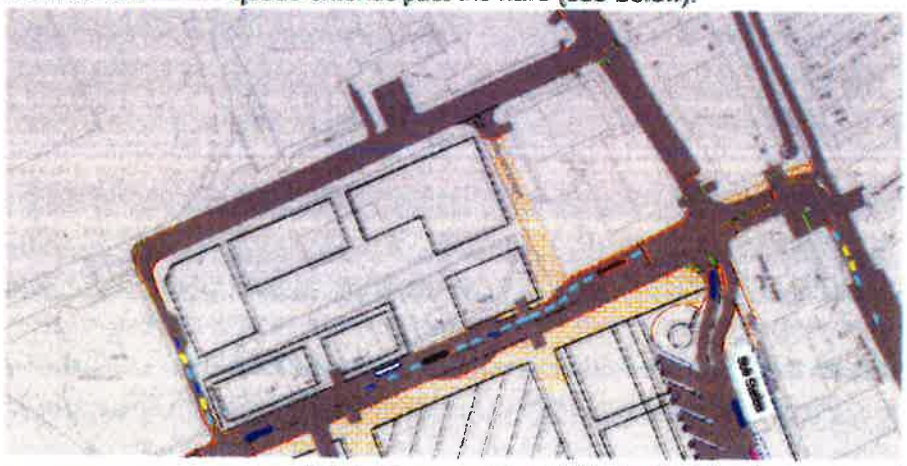
- Right turn into Havelock Street is sensitive, but less problematic than design 007 because buses don't use it (see below).



- Coordinating the signals between Wood Street/Westgate Street and Park Street/Westgate Street junctions for bus movements – ideally the southbound through movement and the northbound through movement would be coordinated, but at the Park Street/Westgate Street junction they are opposing movements so need to compromise.
- Improved southbound traffic on Westgate Street, increased eastbound traffic on Wood Street (some of this may reroute, and there is the option of banning the left turn out of Scott Road).
- More control over queuing in bus station due to signalisation.

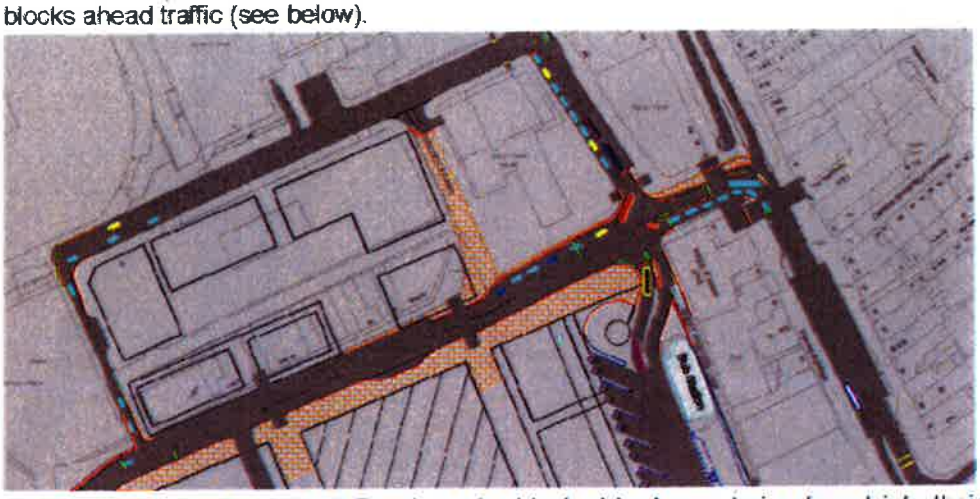
Design 006

- The flare on Wood Street eastbound to allow buses their own left turn lane doesn't offer too much benefit as the queue extends past the flare (see below).

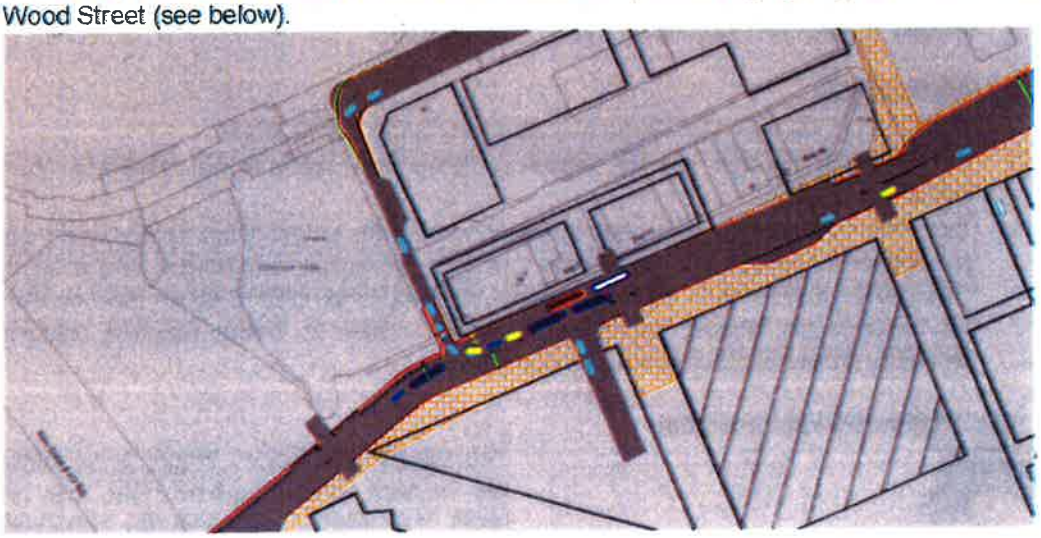


- Coordinating the signals between Wood Street/Westgate Street and Park Street/Westgate Street junctions – ideally the southbound through movement and the northbound through movement would be coordinated, but there are opposing movements to compromise.

- Improved southbound traffic on Westgate Street, increased eastbound traffic on Wood Street (some of this may reroute, and option of banning left turn out of Scott Road).
- More control over queuing in bus station due to signalisation.
- General traffic right-turn into Westgate St from Wood St can be waiting some time, and this blocks ahead traffic (see below).

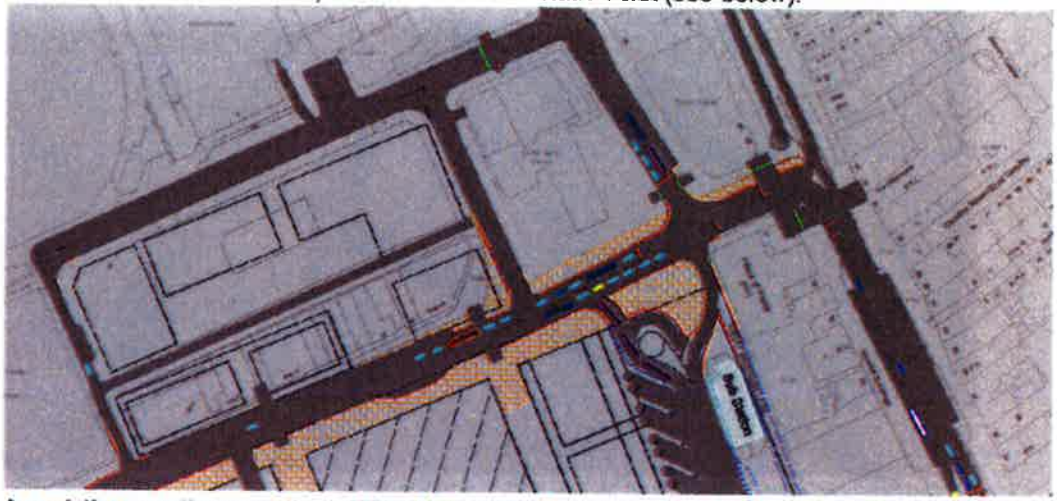


- Southbound traffic from Scott Road can be blocked by buses trying to get into their stops on Wood Street (see below).



Design 007

- Right turn into Havelock Street is a sensitive area, and if it is blocked it can cause queuing westbound on Wood Street, and block the bus station exit (see below).

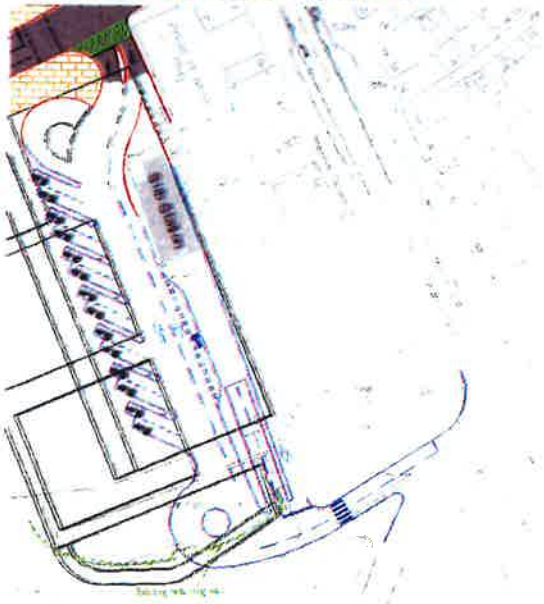


- As existing, southern section of Westgate Street is congested, and vehicles illegally turning left.
- Priority exit from the bus station rather than signals.

Design 005 reversed

- Same as 005 except Scott Road and Havelock Street are reversed.
- This removes the right turn into Havelock Street from Wood Street. Therefore the bus station exit is not blocked.
- Also, 005 in its existing form has northbound vehicles on Havelock Street which are conflicted by westbound vehicles on Park Street. The lights are green for Westgate Street southbound and Park Street eastbound in the same stage, causing underutilised green time on Park Street as the vehicles are queued on Havelock Street – there is limited stacking capacity between Havelock Street and the signals on Park Street.

5. Bus Station Internal Operation



The internal bus station design is consistent between the network design options, and was provided by SDG. This section highlights the assumptions made, how these were modelled in VISSIM, and key results

5.1 Design

The proposed design is located to the east of the existing bus station at Marlond House, with access via Wood Street under normal operation, and via Saunders Road on event days. The exit to the north slightly varies between proposed designs.

5.2 Assumptions

A number of assumptions have been provided for the bus station design by SDG, and these are detailed below along with clarification on how these are modelled in VISSIM, if necessary.

- **Bus station speed limit**: the speed limit for the proposed bus station is unknown, but 10mph has been assumed at this stage of the modelling. This corresponds to the speed limit in the existing bus station.
- **Southbound traffic**: reversing buses are assumed to have no impact on the southbound lane, and similarly can reverse from their stand whilst a vehicle is passing in the southbound lane.
- **Bus 'zone of influence'**: buses are unable to reverse from their stand when there is a bus moving from an adjacent stand.
- **Coaches (National Express)**: coaches can only use left hand stands, where there is access to luggage storage. Therefore they have been allocated two stands which are separated by one.
- **Bus dwell time**: bus dwell time is currently modelled with a uniform distribution between 4 and 6 minutes.
- **Stand allocation**: detailed stand allocation has not been undertaken in this piece of work. A rough estimate of each services stand has been put together using information of their existing stand use. Buses are directed to their allocated stand on entering the bus station, and if this stand is unavailable they are directed to another available stand.
- **Layover area**: the layover area has not been modelled.
- **Event day**: the event day scenario has not been modelled.

5.3 Internal Modelling Results

The bus station internal operation has been observed in the model, and some information on the number of buses able to access their allocated stand has been taken.

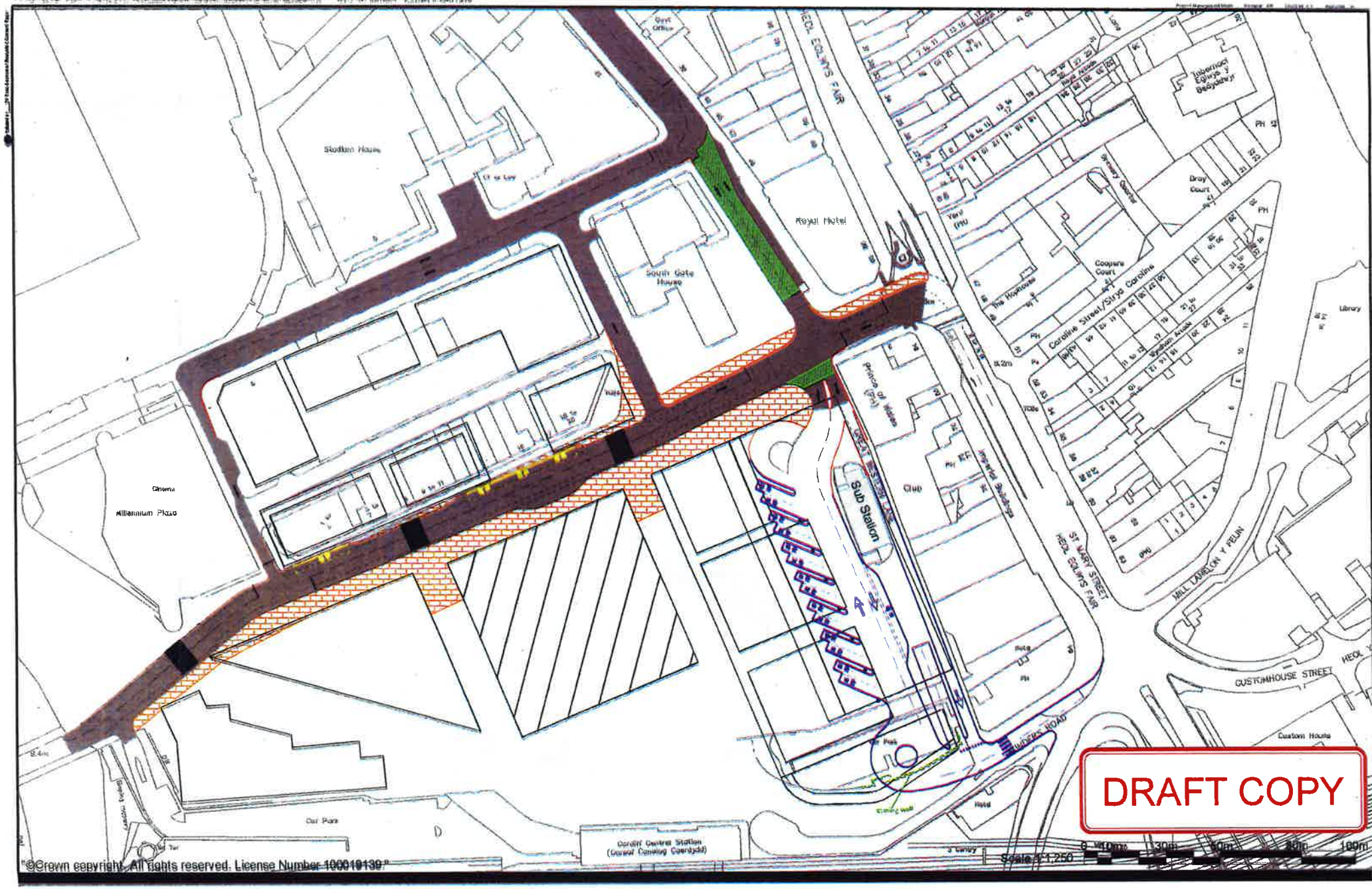
- Based on a random dwell time between 4 and 6 minutes, 65% of buses were able to use the "correct" stand.
- A sensitivity test was carried out to test a random dwell time between 8 and 10 minutes (this is based on surveyed dwell times in the existing bus station). After 20 minutes, the bus station stands were all taken and the buses entering the bus station were unable to use any stand.

6. Summary and Conclusions

Three network designs, and a fourth variation on a design, have been tested in VISSIM to better understand their impact on the highway network. There is no clear frontrunner for the preferred highway option to take forward, and all designs operate well enough to be a possible option.

The modelling of the internal bus station operation shows there is sufficient capacity for buses to circulate within the bus station and access and egress available stands. Preliminary analysis has indicated improvements and efficiencies would be needed over the existing operation to accommodate the bus demand. This could include optimised timetabling, use of bus station dynamic stand allocation, re-allocation of layover to other parts of the road network, and bus priority improvements to increase bus journey time reliability. Event day operations would need further analysis.

Appendix A
Highway Network Design Options



Central Square Planning Submission

SDG Option 3

Date: 2014-09-19

AECOM

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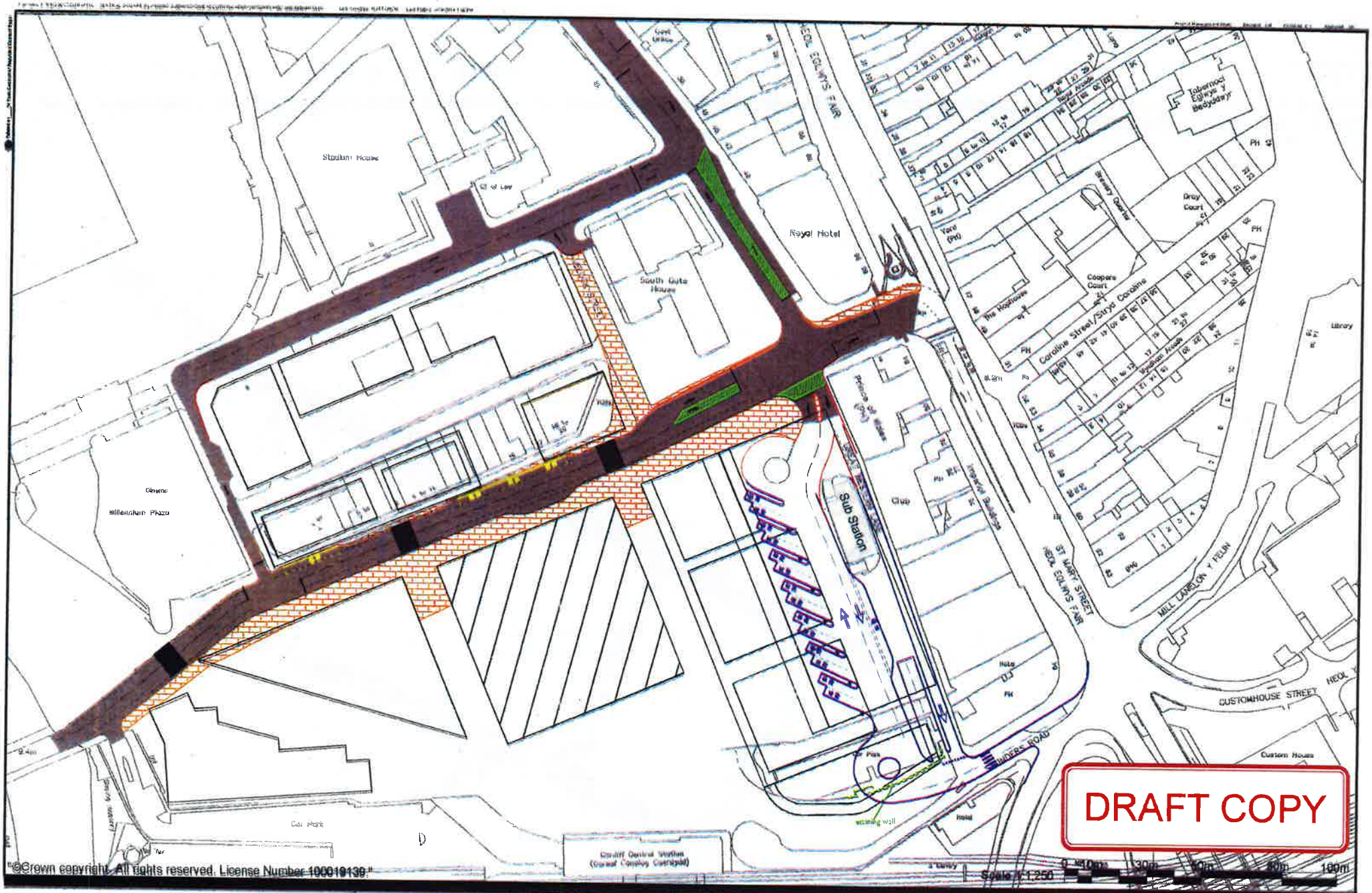

Central Square Planning Submission

SDG Option 3

Date: 2014-09-19

AECOM

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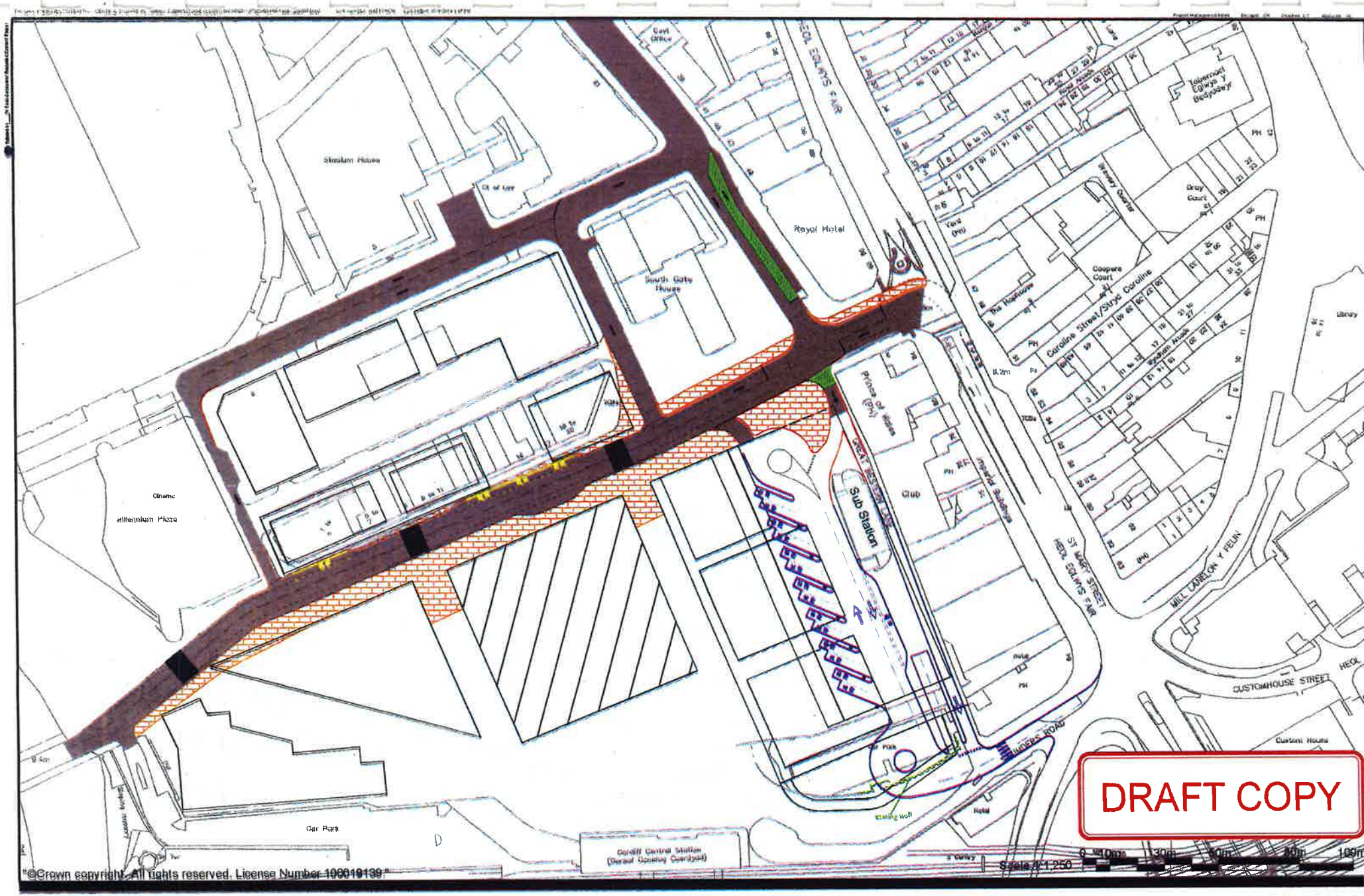

Central Square Planning Submission

SDG Option 3

Date: 2014-09-19

AECOM

6032905
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B Appendix – Assessment Framework

As set out in the preceding Appendix, the modelling work undertaken by AECOM indicates that all three highway layouts operate effectively enough to be considered as possible options. Within the scope of this stage of the project, the question is therefore which highway layout to take forward in the final design of the new bus facility. The answer is that broadly any option is possible, and in essence the detail of highways operation is not essential to the design competition to be held at a later stage. However we have developed a qualitative assessment framework based on proposed principles in order to help prioritise the three layouts and the variation.

Proposed Objectives / Principles

Previous bus station studies have referred to the WelTAG Transport Planning Objectives (TPOs); however, the objectives are out of date (one has a target date of 2013) and are quite narrowly focussed on the bus station itself. It was therefore considered that the WelTAG TPOs would not be suitable to prioritise highway layouts to accommodate the new bus station, particularly with consideration of the longer term aspirations of the Central Square area.

The Central Square Masterplan was developed in 2014 by Foster & Partners and is used as a template for development and infrastructure planning in the Central Square area. The Masterplan includes transport principles underpinned by the Central Square development for the city centre. These principles include the following:

- To promote and extend the use of public transport;
- To reduce through traffic and tensions between the various modes of travel;
- To provide an inviting environment for pedestrians and cyclists;
- To maintain good access to the main car parks;
- To not compromise the proposed metro system; and
- To improve the access to and effectiveness of the public transport offer.

It should be noted that the full set of principles also includes: to ensure an appropriate balance of short stay car parking with effective strategic pricing. This principle is however not relevant to the bus station design and has therefore not been considered here.

With these principles identified within the Masterplan as a means of achieving the transport vision, they have been used as the basis of an assessment framework to prioritise highway layout options.

Assessment Framework

The assessment framework is shaped around the Masterplan Transport Principles for the city centre as described above and employs a scoring system of +3 to -3, where +3 = strongly supports the principle, 0 = neutral effect, and -3 = strongly conflicts with the principle.

A total score has been provided that sums the scores for each principle. These are presented in the table to the right. However, the total scores should be used with caution as the assessment framework is designed to give a comprehensive overview of multiple considerations when deciding the most desirable option. Some impacts may have a greater weighting that others or be considered totally unacceptable. Therefore decision makers should review the full impacts of the options, using total scores as one element of their consideration.

Option assessment

The following pages set out the full results of the assessment. These are ordered from best performing option overall, to worst performing option.

Table 4.1: Assessment Framework Summary Scores

Option number	Total score
Design 005 reversed	+6
Design 005	+2
Design 006	0
Design 007	-2

Additional Option – Design 005 Reversed

Principle	Score	Rationale
Promote and extend the use of public transport	+3	The new bus station design will allow for bus services to operate to / from Central Square with the potential to form an integrated, multi-modal transport hub. As all highway layouts operate satisfactorily, they are assumed to all support operation of the bus station, and therefore promote and extend the use of public transport.
Reduce through traffic and tensions between the various modes of travel	+1	The reversal of the traffic flow on Havelock Street and Westgate Street utilises green time more effectively and therefore reduces queuing on Park Street and from Wood Street. This results in a minor positive impact.
Provide an inviting environment for pedestrians and cyclists	+1	The single crossing point at the bus station access would be more desirable for pedestrians along Wood Street (compared to two crossing points). Wood Street is a proposed cycling route, and increasing traffic on Wood Street could make the cycling environment less desirable. This could be managed through the implementation of high quality, fully-segregated cycling facilities. At this stage of design, these factors on balance are expected to therefore have a slight positive effect.
Maintain good access to the main car parks	0	Access is maintained to the proposed car parks with no apparent limitations introduced by traffic flow.
Not compromise the proposed metro system	-1	The proposed metro alignment is on Wood Street. Therefore greater traffic flow on Wood Street will increase its importance as a traffic distributor road, and threaten the delivery of the metro. It is possible that traffic will re-route to other routes and could be managed during development of the metro scheme. Therefore the impact is expected to be minor.
Improve the access to and effectiveness of the public transport offer	+2	Buses can access and egress the bus station from all directions, particularly to/from Westgate Street (current major route for buses). Traffic does not queue across the bus station access, and signalisation controls the level of queueing to egress the facility. Bus journey times are not optimal compared to other options.
TOTAL SCORE	**+6**	

Design 005

Principle	Score	Rationale
Promote and extend the use of public transport	+3	The new bus station design will allow for bus services to operate to / from Central Square with the potential to form an integrated, multi-modal transport hub. As all highway layouts operate satisfactorily, they are assumed to all support operation of the bus station, and therefore promote and extend the use of public transport.
Reduce through traffic and tensions between the various modes of travel	-1	Signal coordination is slightly problematic. Southbound traffic on Westgate Street is reduced, but eastbound traffic on Wood street increases. Wood Street has been identified as a primary vehicular street in the Masterplan, therefore this impact is not considered to be major.
Provide an inviting environment for pedestrians and cyclists	+1	The single crossing point at the bus station access would be more desirable for pedestrians along Wood Street (compared to two crossing points). Wood Street is a proposed cycling route, and increasing traffic on Wood Street could make the cycling environment less desirable. This could be managed through the implementation of high quality, fully-segregated cycling facilities. At this stage of design, these factors on balance are expected to therefore have a slight positive effect.
Maintain good access to the main car parks	-1	Access is maintained to the proposed car parks from Saunders Road and Wood Street, although traffic queuing eastbound along Wood Street could limit ease of access into the BBC car park off Wood Street. This impact is expected to be minor.
Not compromise the proposed metro system	-1	The proposed metro alignment is on Wood Street. Therefore greater traffic flow on Wood Street will increase its importance as a traffic distributor road, and threaten the delivery of the metro. It is possible that traffic will re-route to other routes and could be managed during development of the metro scheme. Therefore the impact is expected to be minor.
Improve the access to and effectiveness of the public transport offer	+1	Buses can access and egress the bus station from all directions, particularly to/from Westgate Street (current major route for buses). Bus station signalisation controls the level of queueing to egress the facility; however, the right turn for traffic onto Havelock Street has the potential to cause queuing across the bus station entrance on rare occasions, restricting bus access and limiting service quality. Bus journey times are not optimal compared to other options.
TOTAL SCORE	+2	

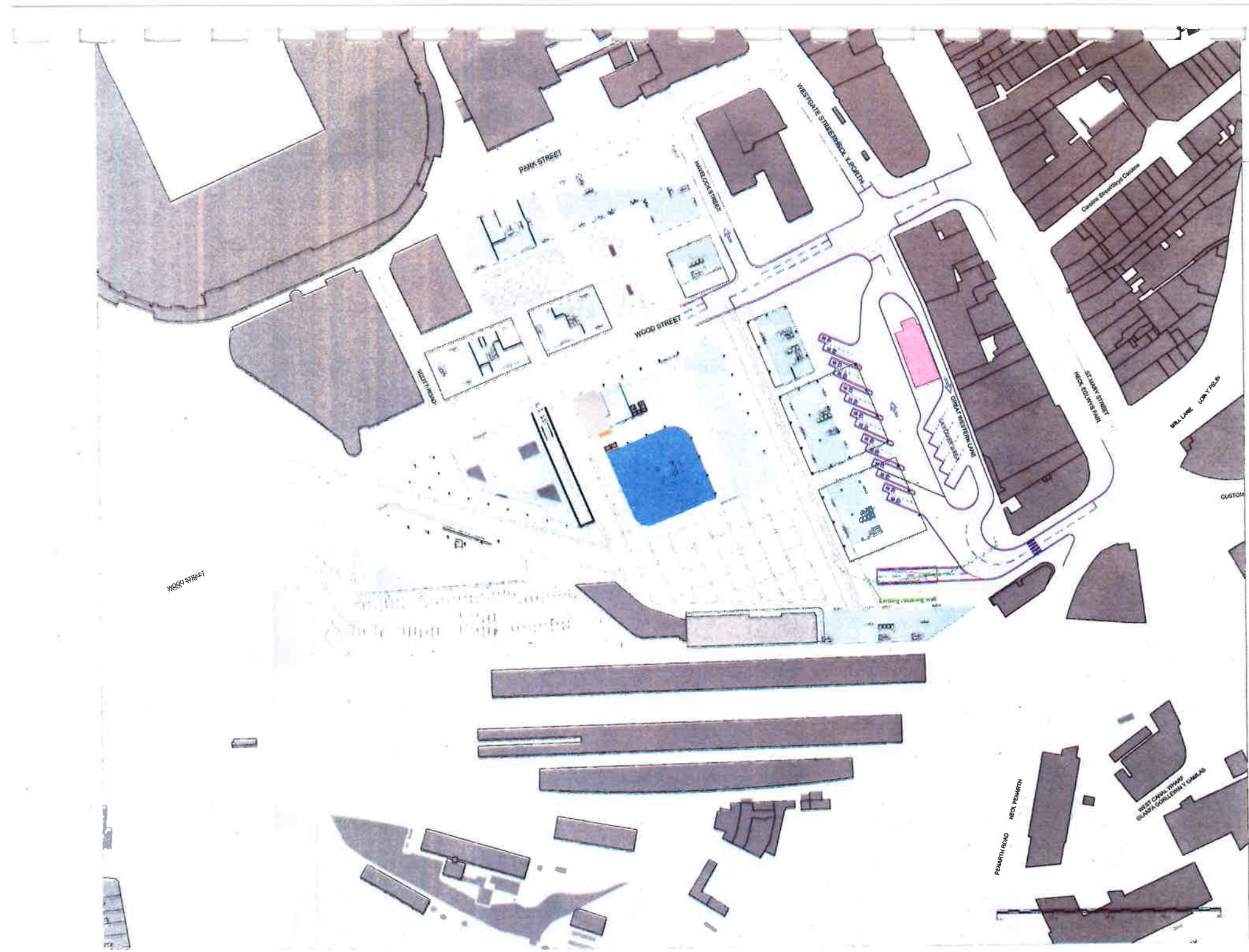
Design 006

Principle	Score	Rationale
Promote and extend the use of public transport	+3	The new bus station design will allow for bus services to operate to / from Central Square with the potential to form an integrated, multi-modal transport hub. As all highway layouts operate satisfactorily, they are assumed to all support operation of the bus station, and therefore promote and extend the use of public transport.
Reduce through traffic and tensions between the various modes of travel	-1	Signal coordination is slightly problematic. The traffic right turn onto Westgate Street from Wood Street blocks through traffic and creates a queue round to St Mary Street. This could introduce more conflicts between pedestrians and traffic as it is a significant pedestrian desire line. Pedestrianising Havelock Street, however, will reduce inter-modal conflicts for northbound / southbound pedestrian movements. As Wood Street to St Mary Street is expected to be a greater desire line than Havelock Street due to its location between Central Square and the retail area, the overall effect is expected to be slightly negative.
Provide an inviting environment for pedestrians and cyclists	0	The flare on Wood Street increases the crossing distance for pedestrians and reduces the quality of the public realm. However, the public realm on Havelock Street could be significantly improved due to it being closed to traffic. For cyclists, the flare on Wood Street may reduce the amount of land available for a designated eastbound cycle lane on the proposed primary cycle route. The impact is therefore considered neutral. If the flare was to be removed (which is possible due to its limited efficacy), this score would be +2. There is still the issue of queuing traffic on Wood Street to St Mary Street preventing a +3 score.
Maintain good access to the main car parks	-2	Access is maintained to the proposed car parks, although greater levels of traffic coming southbound on Scott Road and turning left could restrict access and egress to the BBC car park. This impact is expected to be greater than for Design 005.
Not compromise the proposed metro system	-2	The proposed metro alignment is on Wood Street. The flare on Wood Street may reduce the amount of land available for the proposed metro. Also greater traffic flow on Wood Street will increase its importance as a traffic distributor road, and threaten the delivery of the metro. It is possible that traffic will re-route to other routes and could be managed during development of the metro scheme. If the flare was to be removed (which is possible due to its limited efficacy), the impact would be similar to Design 005 and this score would be -1.
Improve the access to and effectiveness of the public transport offer	+2	Buses can access and egress the bus station from all directions, particularly to/from Westgate Street (current major route for buses). Traffic does not queue across the bus station access, and signalisation controls the level of queueing to egress the facility. Bus journey times are not optimal compared to other options.
TOTAL SCORE	0	With the removal of the flare on Wood Street the total score would be +3.

Design 007

Principle	Score	Rationale
Promote and extend the use of public transport	+3	The new bus station design will allow for bus services to operate to / from Central Square with the potential to form an integrated, multi-modal transport hub. As all highway layouts operate satisfactorily, they are assumed to all support operation of the bus station, and therefore promote and extend the use of public transport.
Reduce through traffic and tensions between the various modes of travel	-2	Priority egress for the bus station increases tension between buses and other traffic / pedestrians / cyclists as buses attempt to exit the bus station. This impact is expected to be moderate as Wood Street becomes a multi-modal, more vibrant streetscape with delivery of the Masterplan.
Provide an inviting environment for pedestrians and cyclists	-1	Option is less pedestrian friendly as pedestrians have to cross two access points for the bus station rather than one. No significant impacts or benefits for cyclists.
Maintain good access to the main car parks	0	Access is maintained to the proposed car parks with no apparent limitations introduced by traffic flow.
Not compromise the proposed metro system	0	The proposed metro alignment is on Wood Street. This layout does not appear to impact delivery of the metro as planned.
Improve the access to and effectiveness of the public transport offer	-2	Buses can access the bus station from all directions but cannot egress eastbound on Wood Street. The right turn for traffic onto Havelock Street can cause queuing westbound on Wood Street, blocking the bus station egress. Absence of signalisation means that the level of queueing to egress the facility is not controlled. The southern section of Westgate Street is congested, with illegal left turn movements from traffic. This could limit the quality of service for buses accessing the bus station. However, this option provides the most optimal journey times. The two pedestrian crossing points at the bus station access / egress could make it more difficult for pedestrians to access bus services from St Mary Street / Wood Street.
TOTAL SCORE	-2	

C Appendix – Option drawings



CARDIFF BUS STATIO

OPTION 3, VARIANT

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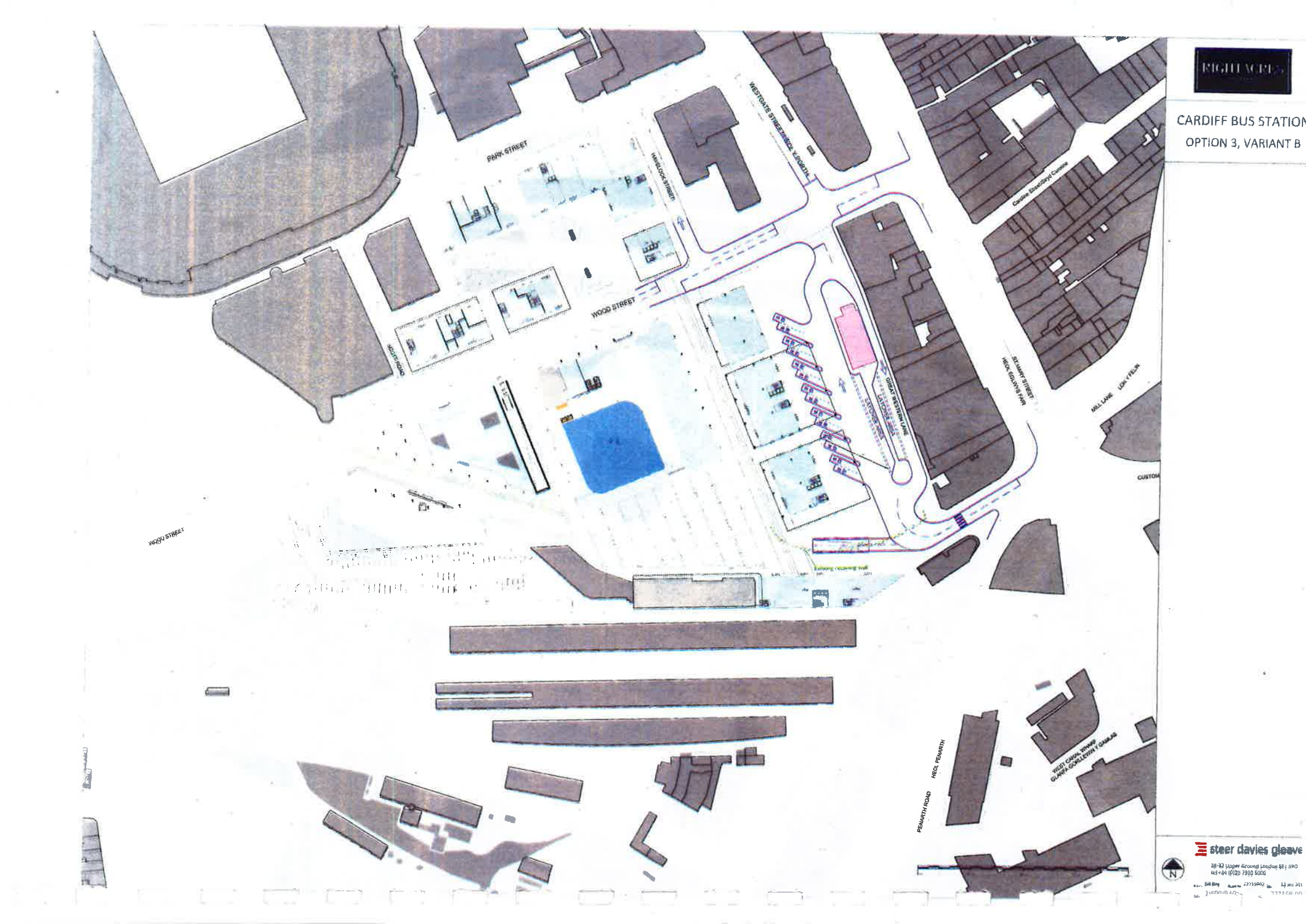

CARDIFF BUS STATION

OPTION 3, VARIANT B

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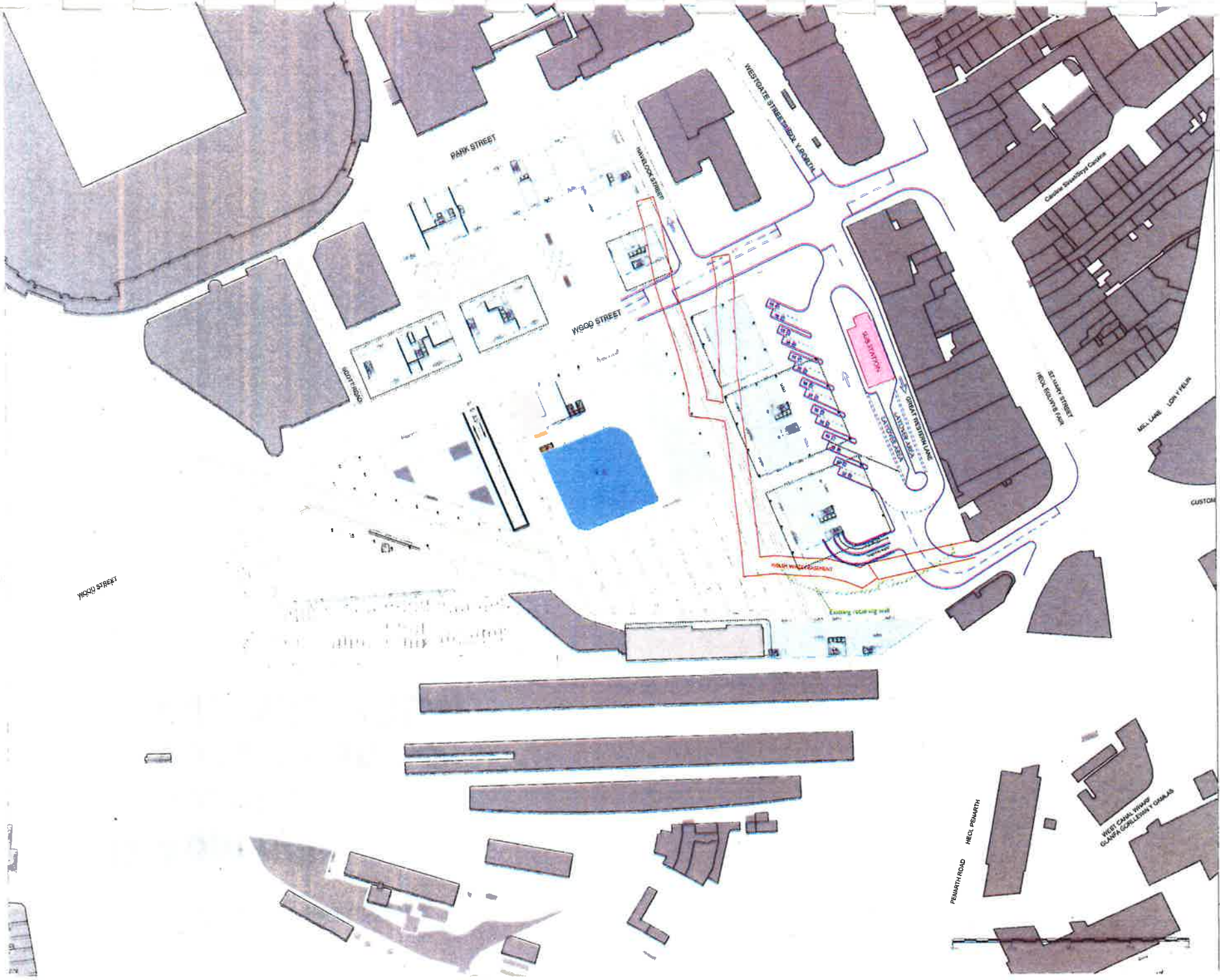

EIGHTMOPPS

CARDIFF BUS STAT

OPTION 3 - FINAL

steer davies

28-32 Upper Ground Lond
tel +44 (0)20 7910 5000

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D Appendix – Reports on Dynamic Stand Allocation (DSA)

Project:	**Cardiff city centre bus station modelling**	Job No:	**60197354**
Subject:	**Potential Application of Dynamic Stand Allocation (DSA) – Report of External Consultations – Issue 1**		
Prepared by:	**Steve Tarry**	Date:	**20th April 2012**
Checked by:	**Graham Stevenson**	Date:	**23rd April 2012**
Approved by:	**George Lunt**	Date:	**23rd April 2012**

1 Introduction

Objectives of This Report

This report concerns consultations held with potential suppliers of Dynamic Stand Allocation (DSA) equipment and with authorities which have either implemented DSA or have considered its future use.

DSA is being considered as a way to increase utilisation of available stands within a proposed new Cardiff bus station. This would potentially prolong its operational life; building in added capacity to cater for future increases in demand and reducing land take requirements. However, the specific way this might be achieved, how such a system might operate and its likely costs and benefits are yet to be determined.

As a result, AECOM has been appointed to assess the feasibility / merit of the application of DSA within the context of the new bus station and how such a system would need to be accommodated in any future design.

The Study involves the following tasks and associated Deliverables:

Desk Top Study - Deliverable 1 (a copy of which is appended, for ease of reference), which has reviewed UK and worldwide experience of the application of DSA. The report sets out key next steps for the Study, including the external (supplier and authority) consultations reported here.

Report of External Consultations – Deliverable 2 (this report), which reports on the outcome of the consultations and identifies specific issues that would need to be taken into account in subsequent stages of the Study.

Assessment Report – Deliverable 3, which, if agreed, would consider the transferability of operational experience of DSA to a new Cardiff bus station, the likely benefits, potential costs and associated Risks in taking forward DSA within the scheme's design. This would be used for internal consultations, considering the merit of proceeding further with the study, alerting interested parties to what is under consideration and gaining feedback on the proposals.

Stakeholder Consultations – Deliverable 4, which would set out preferred option(s) for DSA, taking on board comments and feedback received from the internal review. This deliverable would be used for the purpose of external consultations to be held with operators and other end user representatives.

Final Report – Deliverable 5, which would summarise the work undertaken in the study as a whole, would reflect upon the Stakeholder Consultations and update initial conceptual design(s)

accordingly. This deliverable would form the basis of a design brief should a decision be taken in the future to proceed further with the scheme.

Report Structure

Following this brief introduction, the remainder of this report is structured as follows:

Section 2 summarises the conclusions and recommendations from the initial Desk Top Study. This provides the context within which the subsequent external consultations were held.

For completeness and ease of reference, a copy of the Report is included within an Appendix. Relevant extracts from the Papers reviewed as part of the study, including during the consultations phase are included within a separate Annex.

Section 3 summarises the results of the consultations and draws out a number of conclusions and recommendations related to the next stages of the Study.

Finally, **Section 4** presents conclusions from the work to date with suggested next steps.

2 Desk Top Study

Introduction

The Desk Top Study (Deliverable 1) covered the following issues:

- The current state of the art in the application of DSA,
- Technology requirements for DSA and potential equipment suppliers
- Operational requirements and experience of DSA within the UK, the Netherlands, Australia and New Zealand
- Design Implications for Cardiff Bus Station, including Principles of Operation

A copy of the report and supporting papers are included as an Appendix

Based on a consideration of the above, the Desk Top Study identified a number of issues to be considered further, set out within the report's Summary and Conclusions; they are summarised below for completeness

Summary of Conclusions from Desk Top Study

It is clear that the potential use of DSA would, in theory, enable more efficient use to be made of facilities at the proposed new Cardiff bus station. However, it is also clear that implementing DSA would not only require significant investment to be made in appropriate technology but would also impose a number of physical constraints on the design of a bus station

Where DSA has been considered and, in some circumstances actively pursued by other authorities, this has been dependent on local circumstances, which vary between sites and on the particular policy of the authority concerned.

Consequently, while generic factors influencing the merit of DSA can be identified (and, in the case of GMPTE can be incorporated within guidance on bus station design), a careful review of such factors and how they would apply to a new Cardiff bus station will need to be an integral part of a future design process allowing an assessment to be made of the benefits DSA might deliver, relative to the costs involved (see reference to planned Deliverable 3, in the introduction to this report).

To better inform the development of practical options for assessment purposes, the desk top study recommended that a number of external consultations be held, with suppliers and local authorities, to identify key lessons learnt, in addition to those reported in published papers and explore further the underlying issues associated with the application of DSA.

The results from these consultations are summarised in the following section (details of the discussion guide used for the consultations are included within the Appendix). The feedback received forms a key input to the development of the options to be assessed in the next stage of the Study.

3 Consultations

Consultations with Potential Suppliers

VIX Technology – Michael Hart

- Currently VIX have a full DSA site at Chatham, Kent and a reactive system at Aylesbury, Buckinghamshire. Although currently not in full operation, due to issues with data transfer between VIX systems and the RTI system, this is due to be resolved shortly.
- VIX offer 2 elements/ways to make a bus station 'dynamic':
    - Reactive and Reallocation mode: The bus has a 'normal and planned stand', but if on arrival this is occupied, then the bus goes to another stand and the system reacts to that movement. Displays change and passenger information is updated accordingly. This system is deemed to be attractive to operators and friendly to passengers.
    - Full Dynamic operation: The system allocates an appropriate stand and advises the driver as the vehicle approaches giving sufficient time for passengers to move to the correct stand.
- Also discussed was the issue of providing information to the driver (via ticket machine for example) as this poses potential health and safety issues (as drivers should be stationery when assimilating such information).
- VIX prefer an alternative (and simpler from a number of perspectives) method of having a large display at the entrance to the bus station.

Trapeze – Paul Attenborough

- Currently, Trapeze bus station management systems have no DSA functionality; manual operation would be required to assign vehicles to appropriate stands in real time;
- However, Trapeze are willing to add this to their product road map, if DSA is of interest to Cardiff City Council and would be pleased to work with the City Council should they wish to jointly research the practical application of DSA (as part of a Research Group).

RSL

- RSL have no operational experience of DSA, although they purport to have the appropriate expertise and have bid for a couple of DSA pieces of work (but have not won them).

INIT – Jens Mullak

- INIT have developed a concept for DSA, but have not tested this in a real life situation;
- They have, however, developed a Terminal Management System (TMS) that has been deployed at St Margret's bus station in Leicester, providing real time travel information to passengers regarding the route number off buses, destinations, bay numbers, times of timetabled departures // expected times of departure.

Hogia – Gary Umpleby

- Hogia have reservations about DSA, related to techniques for accurate vehicle positioning and appropriate data transfer, recognising the importance of accurate data on which to make real time operational decisions.
- Hogia would choose to avoid a complicated project that may damage their reputation (as well as that of Cardiff City Council).
- Hogia would in any case only provide the software – hardware would have to be sourced from other providers,

Connexionz UK – Russell Gard

- Connexionz UK have experience of using DSA in Christchurch NZ. The system was operational there for a number of years and has been rebuilt since the earthquake.
- This is the only place where this particular system has been implemented.
- The system notifies drivers of their stand on a screen at the entrance to the station. Passengers are notified 5 minutes before the vehicle arrives. The station in Christchurch has a maximum of 30 seconds (approx) walking time between any stand.

Consultations with Local Authorities

In addition to the discussions with potential technology providers discussions have also taken place with a number of local authorities who either have DSA in operation, or have considered its implementation. Salient points from the discussions are detailed below.

Buckinghamshire CC – Paul Goodwin

- The VIX system, installed 4 years ago (using Avonwood equipment) at Aylesbury Bus Station (the current station stretched to capacity) is only used as a confirmation (reactive) system (i.e. that buses arriving on stand are the ones expected). Each bus contains a tag and each bay has a wakeup antenna;
- There have been some issues with the installed communication systems – currently legal discussions underway to establish which party is at fault.
- The system is well received by passengers however who appreciate the information it provides.
- Full DSA will be considered when the bus station is rebuilt (it will have fewer stands than at present) – although this is years away as a planning application has not yet been submitted.
- High Wycombe bus station is also being considered for DSA. Funding has been applied for through the Better Bus Fund; a decision should be known by the end of FY 11/12 with money to be spent by the end of FY 12/13.
- It was felt that the best way for DSA to operate would be include a separate drop off zone, a waiting/layover area for buses (with no passenger facilities) and a separate concourse with controlled departure gates for passengers.
- There is potential for bus communication through the ticket machine to minimise additional hardware to be installed on bus.

Jersey – Connex Bus

- Currently there is a VIX system installed in the main bus station in St Hellier,
- The system was installed 4 years ago. However, it was only operational for 2 months and then was switched off due to passenger complaints and the system sometimes not being as clever as employees (e.g. delayed terminating bus being replaced by another vehicle to undertake its next service, but the system still showed the next service as delayed and altered the stand even though it was departing on time).
- There is a clear need to ensure that data are accurate, something that needs to be kept on top of at all times.

TfL – Joel Adams (Strategy and Planning Manager, Bus Infrastructure)

- TfL do not use DSA routinely (it is used within Victoria Bus Station, but this is operated by Victoria Coach Station Ltd).
- There are a number of facilities where, due to capacity constraints, there is some degree of informal dynamic stand allocation (buses arrive, alight passengers, find a free space to park and layover). Brent Cross Bus Station would be an example of this, as is Heathrow (operated by BAA)
- Sites without stands marked for individual routes generally require more active management by both TfL staff and service controllers working for the bus operating companies and can be problematic where there are a number of different bus operators using the same site.
- It was felt that dynamically allocating stops and stands would be more suitable for a site with a high proportion of long-distance or low frequency routes rather than a busy urban bus station principally served by high-frequency buses.

4 Summary, Conclusions and Recommended Next Steps

It is clear that the consultations have reinforced the conclusions drawn from the Desk Top Study: that the use of DSA is in its infancy; that the driving force behind its consideration and in some cities its application; and the way / degree to which true DSA is operated (i.e. stands allocated in a true dynamic way) varies significantly between different installations.

Consultations have also reinforced the view that the effectiveness of DSA is highly variable and while the effectiveness of DSA is clearly dependent on local circumstances, a recurring theme from the study to date is that the technological challenge of ensuring data accuracy / transfer between systems is frequently cited as the reason why the full capability / benefits of DSA have not actually been realised.

Nevertheless, despite the number of identified issues associated with the deployment and efficient operation of DSA, it is also a truism that where it is / has been used, the enhanced service delivery is generally well received and appreciated by users.

As such, DSA undoubtedly provides a possible approach to extending the operational life of a new bus station and can be a key element of a strategy to encourage a behaviour change towards the increased usage of public transport.

If used effectively DSA would provide some future proofing, enabling growth in demand and / or significant changes in operational requirements / numbers and frequencies of services to be catered for within the same bus station 'footprint'.

However, whether the benefits that DSA could deliver would justify the costs involved and whether the inherent risks associated in deploying a relatively novel approach could be effectively managed within the design of and operational procedures for of the new facility will require further detailed analysis of options.

This should be the particular focus of the next stage of the Study. Conceptual designs should be assessed for operational efficiencies, with and without the use of DSA and ball-park costs should be identified for each considered option. A risk analysis should also identify those factors effecting both the costs and benefits of the application of DSA and identify how these might be mitigated within a future detailed design process.

This information would enable a better informed decision to be made of the specific merit of proceeding further with the incorporation of DSA within the design of the new bus station.

Subject to the review and agreement by Cardiff Council to this recommendation, a detailed specification for the work to be undertaken will be agreed upon prior to proceeding to the next stage of the Study.

Appendix – Desk Top Study Report - Including Discussion Guide for Consultations

1 Introduction

Objectives of This Report

This report concerns the feasibility / merit of the application of Dynamic Stand Allocation (DSA) within the new Cardiff bus station. The use of DSA in its ideal form could contribute greatly to delivering a truly dynamic bus station, which would be both a compact and user friendly facility for users of public transport; enhancing the operation of the facility and extending its lifespan.

DSA could potentially be used to dynamically allocate incoming buses to a bus bay. As a result, the increased utilisation of available stands would prolong the operational life of the bus station; building in added capacity to cater for future increases in demand and reducing land take requirements. 'Footprint' reductions through the application of DSA are site specific (physical layout, numbers of operators and frequency of services), but the experience of the application of DSA elsewhere has shown savings in land take of up to 50%.

There are undoubtedly many potential benefits to using DSA on a surface bus station to reduce the footprint/cost and make better use of the land for development or amenity purposes; the use of DSA will also potentially add to the attractiveness of public transport to travellers through the provision of dynamic signing and travel information, real time arrival and departure information. However, for it to be effective, there are a number of features which will need to be incorporated within the design of the bus station (location of waiting area, itinerary for passengers and orientation of bus bays / stands) which will potentially add to the overall cost of the bus station and impose a potential constraint on land use within the site. This note reviews the impact of such issues on the overall design of the facility. It is predicated on a review of the application of DSA at other sites, building on the experience of those who have chosen to adopt DSA and the issues involved with its effective operation.

Traditionally, each bus line has its own stop at a bus station, which implies that many of the stops are empty, even during rush hour. Using the available stops flexibly, in the sense that these are assigned to any incoming bus, opens up the opportunity to reduce the total platform length / number of stands required. This has been shown to be an attraction to authorities when developing new bus stations in areas where space is scarce, as can often be the case at central railway stations, where the largest bus stations are often found.

Report Structure

To achieve the aims of the study, a desktop review has been undertaken, as summarized in **Section 2**, of the current and future state of the art related to DSA.

The use of DSA would typically require investment in a range of supporting technologies, in order to operate in a fully automatic way; although a lower technology solution might also be envisaged, involving some degree of manual intervention. Consequently, the review of DSA is set within the context of incorporating technology and conventional measures within the overall physical design of the new Cardiff bus station, its operation and management.

In later sections of the report some consideration is given to a level of manual intervention within the operation of DSA, however, the review in Section 2 focuses in particular on automated operation; it is considered that investment in an automated DSA system would contribute significantly to the achievement of key objectives for the development of the new bus station, notably;

- facilitating simple and seamless journeys, with easy interchange of passengers between modes
- ensuring efficient and reliable operation and management of the facility, with some flexibility in operation, and capacity for expansion
- providing facilities which are convenient, accessible and easy to use, with appropriate information and guidance to provide a pleasurable, relaxing and positive experience
- delivering a safe and secure, clean, attractive and welcoming environment for end users

Following the state of the art review, **Section 3** highlights some of the practical issues associated with the implementation and operation of DSA, based on experience within the UK, the Netherlands; Australia and New Zealand. It identifies specific operational features of DSA which have impacted on the design of the particular facilities reviewed. Some lessons to be learnt from the application of the approach are evident; particularly from sites where the application of DSA has proven to be less successful than anticipated.

The report goes on to present in **Section 4** some possible options for the implementation of DSA within a new Cardiff bus station, in terms of physical requirements and technology infrastructure and the impact on the potential layout of the bus station

A summary of the desk top reviews and conclusions drawn are presented in **Section 5**.

It is planned for this note and the options presented herein to be used as input to stakeholder consultations including bus operators, passenger groups and the Council's telematics team regarding the potential application of DSA within the new Cardiff bus station. Those issues of particular concern are summarized in **Section 6** along with key next steps.

A potential need for site visits was identified, when framing the terms of reference for the study, to discuss in greater detail the experiences of authorities/operators which have engaged in the application of DSA. However, it is considered that this is ideally a subject for consideration following a review of this note and of the issues highlighted herein, by the City Council. In the interim, it is intended to undertake a limited consultation, via a phone interview with selected authorities, to validate the conclusions drawn and recommendations likely to be made as a result of this review.

2 State of the Art Review

Introduction

The correct application of technology, in particular automated DSA, can contribute greatly to the smooth operation of the Bus Station. The use of technology will, in general:

- enhance integration between travel modes
- enhance the traveller experience through provision of real time information
- support seamless traveller transition between modes
- improve management and service operations
- help creates a safe and secure environment
- provide flexible expandable and upgradable solutions for changing situations (with Dynamic Stand Allocation as an example of how this might be achieved).

The review undertaken for this study has highlighted that an integrated design approach involving traditional infrastructure and new technology will help deliver a pleasing and friendly environment for the traveller, increasing the use of public transport and making public transport a mode of choice not a necessity. While the application of DSA can undoubtedly deliver significant benefits, if designed and operated in an appropriate way, the review has also highlighted situations where the operation

of DSA has not been as intended, often as a result of an inappropriate layout of the facility, failures in the technology deployed and a lack of sufficient demand to warrant its use (it should be recognised that the use of DSA can result in some uncertainty amongst regular users and inconvenience for those with a physical / visual impairment, who would prefer the same service always to depart from the same stand, so should not be used without a reasoned justification).

Technology Requirements for DSA

Undoubtedly, the design of the technology infrastructure at an early stage will be crucial to the success of DSA, with infrastructure and supporting technologies designed in an integrated way. Without this, the efficiency and value of the bus station will inevitably degrade (as passengers attracted to public transport who receive poor information, with ambiguous directions to their next mode of travel return to private transport).

Whilst much can be done without using technology (providing static passenger directional signing and travel information and co-ordinated timetables, with a high quality design for the interchange and traveller waiting area) many essential elements will still be missing, such as real time information for travellers, an ability to respond automatically to changing situations and to manage the interchange as a whole, not just individual services. As a consequence the ability to meet many design / operational objectives (for example, facilitating simple and seamless journeys, with easy interchange) will be compromised.

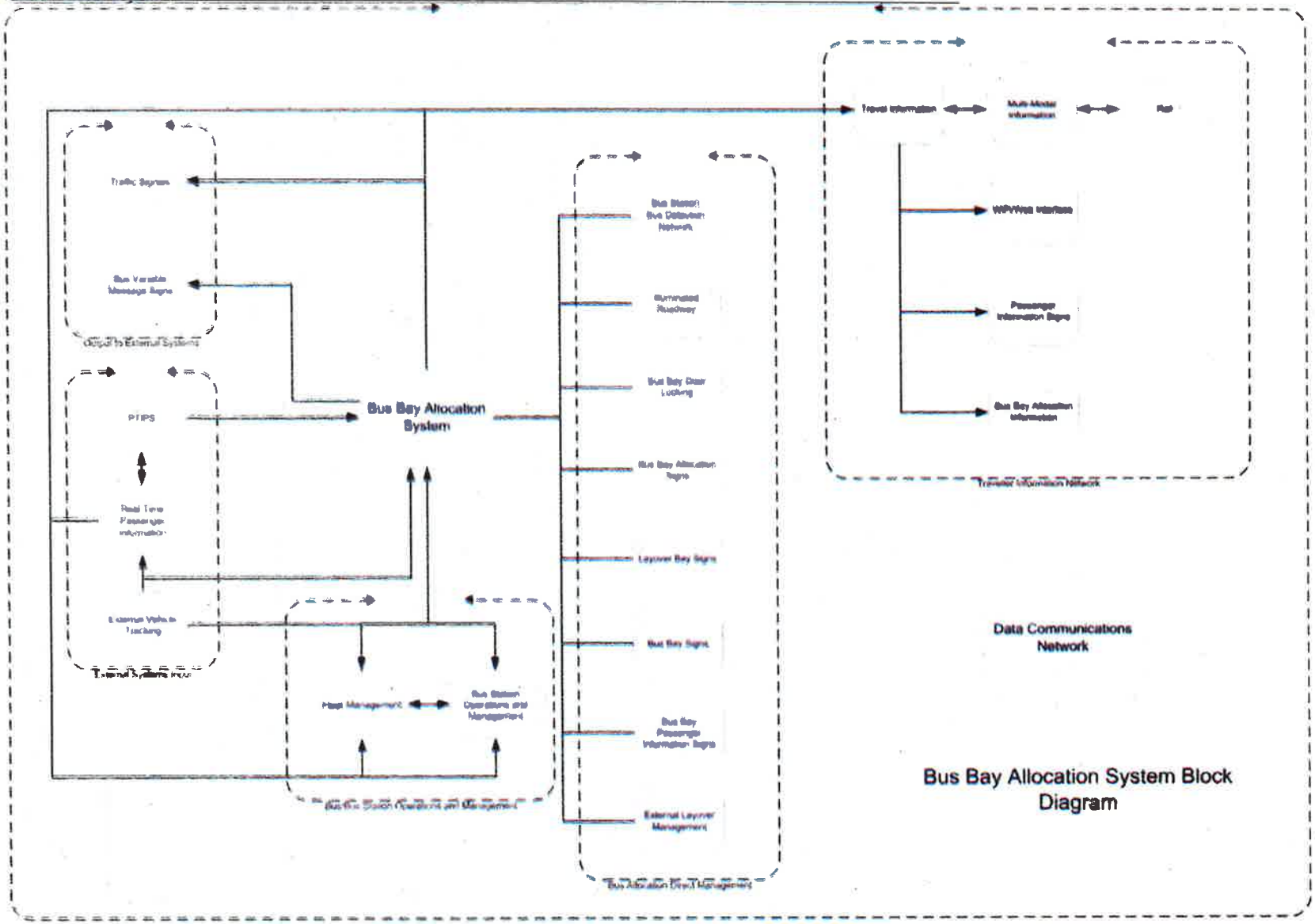
Key services underpinned by investment in appropriate technology could include, amongst many others:

- Real time, cross-modal traveller information
- Fleet management and dispatching
- Dynamic bus bay (stand) allocation (DSA)

In terms of DSA in particular, generic technology components required to facilitate the automated allocation of buses to stands include systems for:

- Real-time bus tracking;
- Communication of instructions / directions to bus drivers and passengers;
- Bus-stand door control, and
- Real-time passenger information;

A block diagram showing the relationship between individual technology components used to deliver DSA (as applied in Perth, Australia – described further in Section 3) is presented overleaf. It highlights the necessary linkages between DSA and other "internal" and "external" systems, including traffic signal controllers and dynamic VMS signs and wide area public transport information provision. This emphasises the need to integrate DSA within the overall, co-ordinated management / operation of the bus station and of the surrounding road network.



Bus Bay Allocation System Block Diagram

Potential Technology Suppliers

A number of technology companies have been cited within the documentation reviewed for this study which operate within the field public transport and which are reported to have the capability to provide products which could support the deployment / operation of DSA. They include:

- Vix Technology and Trapeze - global software and hardware solutions providers
- Regional Services Limited (RSL) – a Coventry based company offering a range of traveller information products and services
- INIT supplier of Intelligent Transportation Systems and Electronic Ticketing Systems, initially founded within Germany

No contact has been made, to date, with these companies to determine the current state of the market / capability and availability of systems to deliver DSA within a new Cardiff bus station.

As noted in the final sections of this note, it is recommended that consultations be held with authorities whom have previously invested in / are considering investment in DSA technology. Within a wide range of issues to be explored, the consultations would seek to ascertain which DSA system suppliers have been contacted / retained and the experiences gained as a consequence.

Based on the feedback received an 'exploration' is proposed of the capabilities of candidate DSA solutions / suppliers, in order to ascertain what limitations / constraints the deployment of the technologies and supporting infrastructure would impose on the design of the bus station. The review would also seek to determine what potential additional capacity might be delivered, taking on board the specific systems' capabilities / service operational regimes that might be supported. This would potentially feed into a subsequent value judgement of the merit of investment of DSA within the context of a new Cardiff bus station.

The Potential for Manual Intervention

Whilst the review has focussed on the technology requirements for DSA, manual intervention can potentially play some role in the operation of DSA (and would be a fall-back position in the case of a failure of the technology - if DSA was to be maintained).

Conceptually, decisions concerning the allocation of buses to a particular stand could be made by an operative based on a knowledge / appreciation / perception of likely demands for stands and anticipated arrival and departure times of buses (it is understood that Glasgow Buchanan station operates such a form of 'DSA' with a 'banksman' on the entrance to the bus station guiding buses to their stand).

Such an approach essentially replicates the algorithms which ensure a DSA system allocates stands on a Fair, Reasonable and Non-Discriminatory (FRND) basis, 'hard wired' within an automated DSA system. This would not have a big impact on the physical design / layout of the bus station but the anticipated benefits of efficient and reliable operation and management of the facility would likely be undermined.

3 The use of DSA in Practice

Introduction

The practical experience of DSA within the UK is quite limited; hence the study has also reviewed the application of the approach within the Netherlands, Australia and New Zealand.

The bus stations studied all have their own individual reasons for considering the use of DSA, for example:

- where there is a desire to minimise the footprint of the bus station for aesthetic purposes;
- where there is an opportunity to significantly reduce costs;
- in order to release additional land for development or landscaping.

and the actual approach adopted depends to a great extent upon the authorities own specific objectives.

Where space constraints are an issue, as in Perth, where they wanted to build an underground bus station but the cost was prohibitive, using DSA enabled the costs to be significantly reduced. In Christchurch, New Zealand the application of DSA was similarly chosen as a way to reduce land take; they were building in the city centre, with land space restrictions and didn't want to build a huge imposing structure in what was a beautiful city centre.

In many applications of the approach, a central waiting area is used to hold passengers prior to the allocation of a stand for each bus, with information provided to passengers on where to go as the bus approaches.

In other applications, bus stations are zoned into stop groupings. This means that people know the general area where to wait, as the bus would always arrive in the same area (group) and passengers would simply need to walk to the bus bay as the bus approaches (with no central waiting for passengers).

What is clear from the following review is that the application of the approach can be achieved in a number of different ways with differing levels of success and no one solution suits all circumstances. Nevertheless, the review has revealed some valuable lessons to be learnt concerning the use of DSA in practice, which are further explored, in terms of key design considerations for Cardiff bus station, within Section 4.

UK Experience of DSA

Chatham's new bus station was planned to be operated using a dynamic allocation system, although the reality is that the system works in a somewhat less than automatic way. The objective was to provide a station that is of a coherent form and of sufficient size to allow for future growth, improving operational efficiency and thus minimising the number of stands required to meet the anticipated future growth.

Chatham Bust Station

The layout and size of the new station was directly influenced by the requirements of a dynamically operated station.

It was divided into six platforms; two central platforms of 4 stands each, and four perimeter platforms with 2 stands each. Bus services were to be allocated to a platform but could depart from any stand within that platform.

Users are directed to wait within a specific platform for their service. As the bus approaches the station, the actual stand from which the service will depart is identified, giving the user sufficient time to get to the correct stand. Additional roadside stands ((4 no.)) and layover bays ((4 no.)) are also provided, adjacent to the main concourse.

The layover bays are provided for short stay only and improve the efficiency of the station by enabling services which sit on stand for longer than 8 minutes to be located elsewhere. The roadside stands are suited to drop-off only and the more frequent and regular services such as the park & ride and dockside shuttle.

The dynamic allocation system and the station layout was designed to allow for the closure of part of the station during evening hours when there is a reduced service profile. Concentrating services onto one or two platforms is not only beneficial from a personal safety point of view but also minimises the amount of artificial lighting required.

In practice, now that station operations have settled down, fixed stands are used, including two in Waterfront Way (away from the main concourse), with the remaining four used for layover. Consequently, there is considerable room for expansion of services within the bus station, without the actual need for dynamic stand allocation.

DSA was also a factor in the consideration of a proposed new interchange facility in **Barking**, where the construction of an off-street bus station could facilitate the future use of a dynamic stand allocation system; although it was recognised that a number of conditions would need to be met before justifying its application and that the usual advantages of DSA may be diminished as frequencies are already quite high and readily well catered for at present.

The potential for the use of dynamic stand allocation, to reduce the number of stands required, has been investigated, as part of a feasibility study for a new bus station facility in **Plymouth**. The study highlighted other examples where DSA has been used to advantage, including **Heathrow Airport Bus Station** and at **Victoria**. This is exclusively used by a large number of long distance scheduled services. At both stations, passengers wait mainly in an indoor waiting area for their bus service number to be displayed together with the bus stand area. This prevents congestion of the passenger concourse and enables a sharing of stands between services. It is believed that the Heathrow Bus Station is not primarily used as a timing point hence the coaches remain on stand for a minimum length of time.

In other towns, DSA has apparently been considered, but not applied in its truest sense. The new **High Wycombe** bus station allocates buses between a group of adjacent stops but it does so without recourse to technical sophistication and complexity (and, even at this level of 'dynamic' stand allocation, early experience apparently shows some passenger confusion).

The reasons for not applying DSA will inevitably vary according to local circumstances and, as highlighted in Section 5, further consultation is planned with relevant authorities to understand the reality / rationale for the decisions taken regarding the application of DSA. In **Hanley** Town Centre, for example, where the arrival and departure times are decided not only by the individual operators but also by local traffic congestion, while the design of a new interchange facility would allow buses to set down at any stand, they would only be able to load at the stand allocated to that service. This stops passengers potentially having to move quickly between stands to get to their bus.

In other towns such as **Bristol, Burnley**, while DSA may not currently be in operation and was not necessarily a prime consideration when the facility was designed and built it is clear that certain necessary features, such as a common waiting area departure bays with automatic doors and electronic departure boards are present and the future use of DSA may be a practical possibility.

Bristol Bus Station

Burnley Bus Station

The same applies to the Liberation bus station at St Helier on Jersey.

The station, which opened in September 2007 includes 11 interior stands giving passengers an undercover waiting facility. As the buses pull on to the stands, the drivers activate the automatic doors allowing passengers to board directly from the safety of the concourse

St Hellier Bus Station

In at least one town, **Warrington**, government funding is being sought to enable buses to be suitably equipped, in order to facilitate DSA at the central bus station.

Warrington Bus Station

The bus station already includes many of the features recommended in design to support the operation of DSA (see Section 4), but the real time tracking of and communication with all appropriate vehicles is apparently lacking.

It is understood that the Borough Council is particularly keen to develop this technology in partnership with other local authorities across the country.

Use of DSA at Bus Stations within the Netherlands

The dynamic bus station concept was introduced in The Netherlands around 1990. Early examples were those of **Eindhoven** and **Leeuwarden**. The first one is still operational, the second one was disabled two years after its implementation, partly because of operational problems, and partly because it was superfluous. Departure frequencies and times were such that hardly ever all platforms were in use, let alone by two buses.

Since then DSA has become operational at Bus Stations in **Almelo, Nijmegen** and **Leiden**. These projects were in fact part of a nationwide effort to improve the attractiveness of public transport in general and that of major railway stations in particular. Often it included a modernisation of the railway station and a reconstruction of its environment with considerable redevelopment in favour of

office employment. Overall, however, there was no systematic development of dynamic bus stations as such and the application of DSA and its success is very variable between bus stations

A survey undertaken by Delft University of dynamic bus stations within the Netherlands revealed problems with the siting of facilities, sometimes with information provided at the wrong side of the railway station building from the bus interchange; insufficient shelter at the waiting area, problematic routes to the platforms and no weather protection on the platforms; no real /effective assignment of buses to platforms; quite often only an indication of scheduled departure times and not of; and, in a few cases, break down of electronic information (based on this review minimum standards have been suggested for the effective application of DSA, which are referred further to within Section 4 of this note).

The review also found that even at 'dynamic' bus stations, generally implemented as a result of space restrictions, a fixed location tends to be the foundation for the distribution of buses between platforms (bus users are perceived as mostly habitual customers who are not willing to find out every time where the bus will depart). Where space is not a real problem, as in **Delft**, even when all the facilities required to support DSA are in place (an ideal location and orientation relative to the train station and a dedicated waiting area provided with real time service information), there is no dynamic platform assignment whatsoever.

Delft Bust Station

Use of DSA in Australia and New Zealand

A dynamic bus bay allocation system is proposed for a newly developed underground bus station in **Perth**, Australia. The idea is that buses will have zones; they will not always go from the extreme ends of the facility. They could come to any one of three or four stands. There will be both video and audio announcement capability so that people can check which gate they need to go to. Staff will be on hand for people with disabilities so that passengers can be managed much better in what will be a really nice passenger environment.

The specification for DSA operations at the new bus station prescribes the following functionalities:

- Dynamic stand allocation for buses approaching or already within the bus station. The system must be capable of efficiently allocating buses to one of 16 active stands or internal/external layover bays based on vehicle length and service status (e.g. commencing a route, drop-off only, out of service);
- Capacity to manage up to 212 scheduled bus trips per hour, which is the forecast demand during the PM peak in 2031;
- Real-time bus tracking within the bus station, as well as all underground approaches, surface approaches and layovers. The control system implemented within the new bus station must also

include a failsafe mechanism for managing bus and passenger movements and the capability for manual intervention, both during normal operations and in any circumstances where the primary bus station control system may be unavailable.

- Automatic and manual communication of instructions / directions to bus drivers stipulating required movements, bay allocations, layover etc. The system must also be capable of monitoring the status of buses within the facility to ensure that instructions have been carried out e.g. that a bus has vacated a layover bay and moved to its allocated bus stand;

- Bus-stand door control, based on the presence of a bus at the stand. This could be automatic or controlled by the bus driver, e.g. via the driver interface;
- Real-time passenger information within the terminal to advise passengers about approaching services and allocated boarding/alighting points;

A DSA system is also installed in the Queen Street Mall Bus Station in **Brisbane.** However, (presumably due to a lower than anticipated demand), the system apparently operates in 'default' mode, allocating the same stand to a particular bus service every time.

In **Christchurch**, New Zealand before the earthquake, the central bus station had six bays catering for around 100 bus movements per hour.

To obtain this efficiency there was a central waiting area and buses were dynamically allocated to stands as they arrived and the information displayed on a screen. To speed loading, passengers were encouraged to use an electronic card for which there was a discount from cash fares. With pricing and the various regular user discounts the card had proved popular with commuters.

Christchurch Bus Station

4 Design Implications for Cardiff Bus Station

Principles of Operation

With Dynamic Stand Allocation, buses arriving at the station would typically drop off passengers and then proceed if appropriate to a holding area (at which they can also take layover), to be allocated a departure bay in real time, with passengers being informed via electronic displays within a central waiting area. This enables all stands within a bus station to be used only at the time of bus departure and, as a consequence to remain free from buses laying over between services that often have the effect of taking much needed stands out of use.

Buses are typically monitored as they approach a bus station and within a few hundred metres of the facility the driver is notified of the available stand number to approach in order to set down and pick up bus passengers through in-cab information systems. Simultaneously, passengers within the bus station concourse are advised of the next departures and stand numbers by an automated audio announcement and electronic departure boards and are notified with enough time to move from a central seated waiting area to the appropriate stand for their departure.

Passenger access to busses may be controlled, with the arrival of each individual bus confirmed at the access door to the appropriate stand (akin to airport operations), with the bus-stand door regulated by the presence of a bus at the stand. Operation of the door could be automatic or controlled by the bus driver.

Impacts on Bus Station Design

In practice, the actual application of DSA / degree of dynamism within the operation of the bus station and the impact of this on the layout and design of the bus station will depend on local factors and how they apply to particular characteristics of operating a 'dynamic station'.

Key design features identified by Delft University in their review of facilities in the Netherlands (referred to in Section 3) centre on the location of the bus station and its orientation to the railway station, the location of a waiting area, Itinerary for passengers and shelter and Information provision. Particularly in terms of the latter, there is a distinct need for conceptual designs of the new bus station, particularly if incorporating DSA, to take into account the physical needs of the traveller and especially those with reduced abilities.

Overall, in order to meet the requirements imposed by the effective use of DSA, the review concluded that the design of the bus station requires a particular consideration to be made of the following key aspects:

- The location of the bus station relative to the railway station: with a location right in front of the main entrance being preferable (given the general compact nature of a dynamic bus station, it appears that a new facility could conceivably be located close to the existing station entrance),
- An appropriate pedestrian route to the central waiting area is required: preferably straightforward and without disturbance from traffic, with appropriate shelter provided at the waiting area;
- The provision of appropriate information at the waiting area, including static information such as maps, schedules, fares, boarding procedure, conditions for use etc;
- Orientation of the waiting area towards the bus platforms, offering a complete overview of these, preferably without having to walk around with clear visibility of departure information at the bus platforms as seen from the waiting area. These signs should be readable under all light conditions,
- Where platforms are remote from the waiting area, pedestrian route(s) to the platforms should preferably be straightforward and without disturbance from traffic with shelter on the platforms (if required, due to their remote location), to be sufficient to protect a significant proportion of rush hour users,
- Where platforms are accessed directly from the waiting area, access to stands to be controlled using a 'gate' system, with buses typically operating in a drive in – reverse out mode (set down / layover areas typically remote from pickup areas to ease possible congestion at gates).
- Degree of dynamism in platform use, the essence of the dynamic bus station, ranging from 100% to 0% and degree of dynamism in travel information, up to complete provision of actual arrival/departure times, with back up / fail safe facilities should a complete system breakdown occur.

GMPTE has also identified key design features for effective DSA operations within their bus / rail interchange design guide. Assuming appropriate technologies are already in place the Guide concludes that DSA can be applied in theory to any stand layout design although as the passengers are required to move once their stop is announced all the boarding points should be close to each other.

This in practice requires the design to be of the drive in/reverse out type where passenger walking distances will be shorter. It is noted that island platforms are also in use at some locations in

particular in the Netherlands, but this requires passengers to walk across the roadway to board and is not recommended.

Whereas there is some latitude in terms of stand layout, making use of a central and enclosed passenger concourse is deemed by GMPTE to be critical to DSA operation.

5 Summary and Conclusion

The potential use of DSA as part of a new bus station for Cardiff would enable a more efficient use to be made of bus station resources. Greater flexibility in stand utilisation would release capacity that might otherwise be tied up by vehicles laying over.

However, as highlighted by this note implementing DSA at a bus station not only requires investment in appropriate technology, but also imposes a number of physical constraints on its design. Consequently, the practical use of DSA and evidence of the benefits it delivers, relative to the costs involved, is limited.

The desk top review identified only a small number of stations where DSA has been implemented and operated in an automatic way. These include:

- Heathrow Airport and Victoria Coach Station in the UK;
- Almelo, Nijjmegen and Leiden in the Netherlands;
- Perth in Australia; and
- Christchurch in New Zealand

DSA has also been implemented at a number of other bus stations, but is not being used to dynamically allocate stands to buses. These include:

- Chatham and High Wycome in the UK; and
- Brisbane in Australia

A number of other bus stations have been identified where DSA is under active consideration within the UK, including:

- Barking
- Plymouth
- Warrington

DSA has also apparently been considered for use in Handley bus station, but is not currently being taken forward. There are also examples, including Leeuwarden in the Netherlands where DSA was implemented, but was subsequently taken out of service..

Given the overall numbers of bus stations being developed it is clear that the use of DSA, in the UK at least, is in its infancy and is by no means seen as a universal panacea to enhancing station efficiencies.

The reasons why DSA may or may not be pursued will be dependent on local circumstances, which will vary between sites and on the particular policy of the authority concerned. Nevertheless, a number of generic advantages and disadvantages to the use of DSA have been identified within the GMPTE design guide, as follows;

Advantages	Disadvantages
Increased capacity for new or upgraded bus services using a facility with finite capacity in the heart of a town / city	Potential under capacity at peak times that requires careful management to avoid queuing buses and delayed services (particularly if DSA ceases to be operational)
Use of RTI systems in conjunction with audio announcements to improve passenger information at bus stations	Announcements need to be clear and unambiguous and need to be repeated. There may be problems at peak times, with a large number of announcements having to be made

Advantages	Disadvantages
Utilisation of a central waiting area enabling printed information, help desks and refreshment facilities to be located around a central area and in turn minimising the spread of passengers across the station and crowding effects at bus stands	A central waiting area may cause excess walking to be incurred by some passengers; particularly detrimental to those with mobility impairments. Could be issues relating to large movements of people all at once towards a single stand, including safety and pedestrian floes. Does not allow the formation of an orderly queue
Allows busses and drivers to layover in areas away from the main passenger concourse allowing for better rest and refreshment facilities and less confusion over in-service and out-of-service buses within the main terminal area	The lack of regular stands for frequent and / or well used services may cause confusion and frustration amongst passengers
	Boarding information must be provided in all necessary formats, including audible announcements and visual electronic displays
	All operators using the facility need to have the technology and all spare vehicles must be equipped – this may lead to high capital costs with smaller operators in particular wishing to leave the station facility and use on-street bus stops where they exist
	Increased use of stands can lead to greater risk of accidents due to increased congestion

A careful review of such factors and how they would apply to a new Cardiff bus station should be an integral part of the future design process.

6 Next Steps

As noted, a number of authorities have been identified with supposedly practical experience of DSA or have considered its application.

- It is proposed that phone-based consultations be held with selected authorities to explore why particular decisions were made regarding DSA and any lessons learnt which might be transferable to Cardiff.

To assist with the Council's consideration of this proposed approach, an initial list of issues to be discussed with consultees is presented as an appendix.

A number of potential system suppliers have also been identified as part of this desk-top review (and consultations with authorities may suggest other candidate suppliers).

- It is proposed that some exploratory talks also be held with selected companies (on a non-discriminatory basis) to determine the practical limitations of potential solutions and their potential to increase the effective capacity of a new Cardiff bus station.

Anticipated Questions to be asked of Selected Consultees

Introductory questions to be asked of all Consultees:
• What made you decide you wanted a DSA system, who did you work with on the project and what were their roles?
• How was the layout of the bus station adapted to cater for potential DSA operation?
• What other systems did you consider, what made you choose the system you did? What other examples of DSA did you consider?
• How did bus operators react to the idea of DSA, what about passengers?
• What additional capacity do you think you can get out of the bus station with DSA?

Supplementary questions to be asked depending on whether or not DSA is actually operational:
• What particular benefits do you envisage might be / have been realised through the use of DSA? Would / do the benefits outweigh the cost?
• When did you / will you start using DSA?
• How would / do buses communicate with the bus station? And visa versa? What % of buses is /will be equipped?
• What fail-safe mechanisms are / would be in place in case there are issues with communication (in both directions)?
• What information do you / are you envisaging showing passengers at the bus station?
• How much time do / would passengers have to get to the right stand?
• How does / will the system interact with and inform the screens in the bus station and drivers on street?
• At what stage is / would the decision be made regarding the stand to be used by the bus, temporally and physically?
• How are / would the drivers be advised of the stand to park up at and how much notice does / would this give them?
• How does / will the system interpret where clashes are likely to occur and thus when buses need to be moved?
• What percentage of services do you expect would be / have been diverted from their normal stand?
• Is / will there be any prioritisation of particular stands when buses are moved (e.g. move to nearest stand to the usual one which is available, or to one end of the bus station)?

Concluding questions to be asked of all Consultees
• What are the key 'lessons learned' from your experience of considering / implementing DSA?
• What would you advise others to pay particular account of if considering the use of DSA? What are the down sides and what are the keys to success?

Papers Reviewed to Date as Part of the Study

The following papers were reviewed in the development of the Desk Top Study:

- The Dynamic Bus Station, A User Friendly Facility? Delft University AET Conference 2009,
- ITS, Enhancing the Multimodal Experience, AECOM 2011
- Taunton Bust Station Technical Report, Somerset County Council, Atkins June 2007
- GMPTE Bus / Rail Design Guide, Jacobs September 2009

The following papers were also reviewed, during the course of the consultations:

- Christchurch Bus XChange, Connexionz
- Changing the image of public transport, Connexionz and Parsons Brinckerhoff, September 2002

Relevant extracts from these papers are included in a separate Annex to this report

Appendix – Anticipated Questions to be Asked of Selected Consultees

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• How was the layout of the bus station adapted to cater for potential DSA operation?
• What other systems did you consider, what made you choose the system you did? What other examples of DSA did you consider?
• How did bus operators react to the idea of DSA, what about passengers?
• What additional capacity do you think you can get out of the bus station with DSA?

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• What information do you / are you envisaging showing passengers at the bus station?
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Direct Tel: 0117 901 7167
T +44 (0)117 901 7000
F +44 (0)117 901 7099
E george.lunt@aecom.com
www.aecom.com

3rd Floor, Portwall Place
Portwall Lane
Bristol
BS1 6NA
United Kingdom

Annex to Technical Note Issue 1

AECOM

Project:	**Cardiff city centre bus station modelling**	Job No:	**60197354**
Subject:	**Potential Application of Dynamic Stand Allocation (DSA) – Papers Reviewed as part of the Study**		
Prepared by:	**Steve Tarry**	Date:	**20th April 2012**
Checked by:	**Graham Stevenson**	Date:	**23rd April 2012**
Approved by:	**George Lunt**	Date:	**23rd April 2012**

1 Introduction

This Annex to the Report of Consultations, undertaken as part of the study into the potential application of Dynamic Stand Allocation (DSA) within a proposed new Cardiff bus station, presents copies of the Papers that have been reviewed as input to that Deliverable.

Direct Tel: 0117 901 7167
T +44 (0)117 901 7000
F +44 (0)117 901 7099
E george.lunt@aecom.com
www.aecom.com

3rd Floor, Portwall Place
Portwall Lane
Bristol
BS1 6NA
United Kingdom

THE DYNAMIC BUS STATION, A USER FRIENDLY FACILITY?
Principles and practices at railway stations in The Netherlands

Enne de Boer and Ronald Krul
Delft University of Technology, Faculty of Civil Engineering and Geosciences,
Department of Transport and Planning

ABSTRACT

The dynamic bus station in its ideal form is both a compact and user friendly facility. Traditionally each bus line has its own stop at the station, which implies that many of the stops are empty, even during rush hour. Using the available stops flexibly, in the sense that these are assigned to any incoming bus, opens up the opportunity to reduce the total platform length. This is attractive where space is scarce, as is the case at central railway stations, where the largest bus stations are found.

Dynamic travel information is a quality being introduced, because travellers are more likely to be attracted to bus transport when they can get information on the actual departure time and location of the bus that serves their travel destination. In dynamic bus stations this up-to-date information is necessary, because a combination of delays and constantly changing bus stops creates maximum uncertainty for the passenger.

The dynamic bus station was introduced in The Netherlands around 1990. Early examples were those of Philips town Eindhoven and of the Frisian capital of Leeuwarden. The first one is operational still, the second one was disabled rather soon. It is now completely static. It shows that the fate of this facility may be uncertain.

TU Delft undertook a research project to assess the user-friendliness of all Dutch dynamic bus stations located at railway stations, both for disabled and non-disabled users. The bus stations were visited with a checklist, observations were made as were inquiries into backgrounds of local layout and practice.

We looked at the following aspects:

- location as related to the main entrance of the station,
- pedestrian route to the central waiting area,
- shelter provided at the waiting area,
- information provided at the waiting area,
- orientation of the waiting area towards the platforms,
- visibility of departure information at platforms as seen from the waiting area,
- pedestrian route(s) to the platforms,
- shelter on the platforms,
- degree of dynamism in platform use,
- degree of dynamism in travel information.

The variety in qualities was surprising. To mention some:

- the location is sometimes bad, at the wrong side of the tracks or of the railway station building,
- there is often insufficient shelter at the waiting area,
- pedestrian routes to the platforms are usually problematic,
- at several places there is no weather protection on the platforms.

Most surprising and disappointing was that the dynamic character of the bus stations was often quite modest:

- hardly dynamic assignment of buses to platforms,
- quite often only an indication of scheduled departure times and not of delays,
- in a few cases break down of electronic information.

The causes of partial failure of the concept will be discussed and minimum standards suggested.

1. INTRODUCTION

The *traditional bus station* is a static facility, in which a bus running on a certain line stops at a fixed location on a platform, which it may share with buses of a number of other lines.
If these lines are operating independent of each other quite a few buses may use it. This may be confusing for infrequent travellers, but the frequent ones know where to find the bus.
If the bus station serves as a node, offering connections between lines or with trains, quite a lot of space will be required, because quite a number of buses will be present for several minutes. Then the visibility of individual buses will be minimal, even at bus stations of a circular shape, which are difficult to create at most railway stations. One does find examples though in such different places as the Dutch new town of Almere (underneath the elevated railway line) and in the reconstructed town center of Japanese Hamamatsu (on the station square and accessible by an underground connection).

The *dynamic bus station* is supposed to solve these problems by compressing the station and making the presence of the bus visual. This is only partly possible by simply showing it to the waiting traveler. Conspicuous information is required to announce location and departure time of the vehicle.

The ideal process as developed in The Netherlands is the following one:

- a traveler leaving the railway station and looking for connecting bus transport finds his way to the conspicuous bus station close by the main entrance, following an obvious trail to a sheltered central waiting area,
- an incoming bus is assigned a platform or a location on a platform with more than one bus stop, which allows for immediate arrival and departure,

- in the central sheltered waiting area a display, with planned departures for the next period of 30 to 60 minutes, indicates the actual departure time and location of the incoming bus,
- a display at the platform, visible and readable from the waiting area, indicates that the bus will depart from there at a certain time,
- on arrival of the bus, which can be identified by its line number and destination at the front side, the traveler walks towards it.

This process is not without problems for the layout of the bus station and for the traveller, especially the visually disabled one. These problems were reason for TU Delft to analyse the existing Dutch dynamic bus stations to develop recommendations for a manual on accessible transport. In this paper these will be treated only superficially.

2. Application of the concept in the Netherlands

In little more than a decade over ten dynamic bus stations have been created at railway stations in The Netherlands. These projects were in fact part of a nationwide effort to improve the attractiveness of public transport in general and that of major railway stations in particular. Often it included a modernisation of the railway station and a reconstruction of its environment with considerable redevelopment in favour of office employment. There was no systematic development of dynamic bus stations as such, which implies that some of the larger stations, like those of the provincial capitals Groningen and Zwolle are lacking one, whereas smaller ones like Almelo and Apeldoorn did get one.

In 2005 five 'Sleutelprojecten' (turn key projects) for the largest railway stations, Amsterdam, Arnhem, Breda, Rotterdam and Utrecht, and their environment are being developed. Some of these will be provided with dynamic bus stations, but other ones will not. Evidently not all planners are convinced of the qualities of the concept.

Typical of the disparity between expectations and practice is the fate of the Leeuwarden dynamic regional bus station, serving a large rural area around the Frisian capital (population 90.000). Four railway lines are radiating to seven of the 11 ancient towns of the region, but buses are serving two more and several other, often more important settlements.
Around 1990 the surroundings of the railway station were redeveloped. Northwest of the station building a vast area of a former freight station and the former regional tramway station, serving as regional bus station, was grossly under utilized. Location and quality of the regional bus station were distinctly sub-standard.
Close to the railway station, to the west of its main entrance, a new urban bus station (city of Leeuwarden), and behind it a regional bus station (national Ministry of Transport), were constructed according to entirely different principles. The urban bus station was and is a static bus station for less than ten lines, operating in a quarter hour schedule at most. It is a nice example of an accessible and comfortable 'island' bus station with a transparent central

pavilion, provided with ample seating, and with a continuous roof above the 8 bus stops around it.

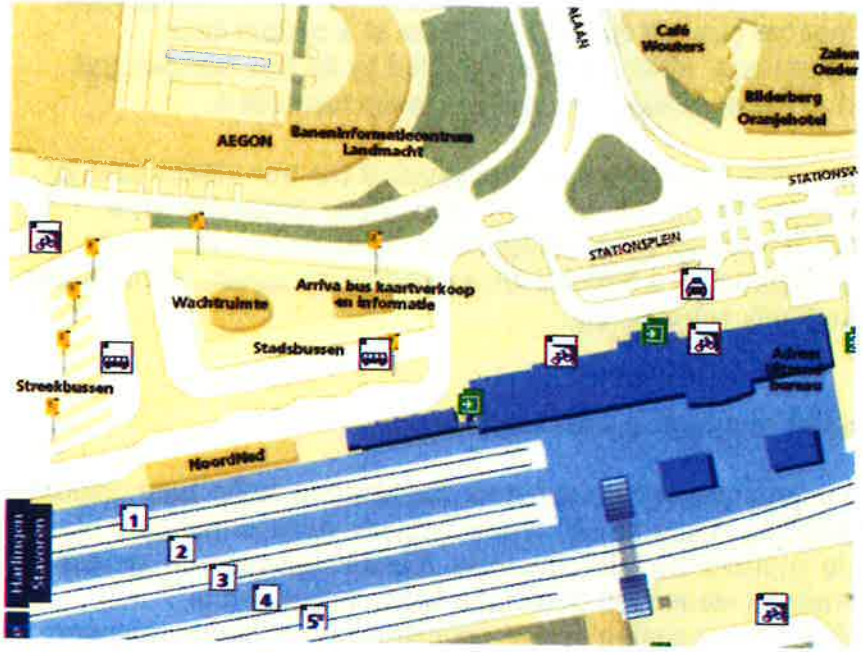

Figure 1 **Leeuwarden railway station with its separate bus stations for urban bus (stadsbus) and regional bus (streekbus).**

The regional bus station was for some time a dynamic bus station with roughly normal features:

- a central display of planned departures at the entrance,
- a long platform for waiting passengers, with modest shelters without seating,
- in front of which a one way bus lane of about 10m wide, for departing buses,
- across that lane seven parallel narrow platforms in a fish-bone pattern for approximately 25 bus lines with usually less than a half hour service,
- above these a portal with a display for each platform, indicating the next departures,
- behind this another one way bus lane for (empty) arriving buses, coming from a separate bus parking,
- in front of the station a platform for getting off arriving buses.

The regional bus station was completely inaccessible in the sense that provisions for wheel chair users and the like and for people with visual disabilities were completely absent.

The dynamic character lasted for less than two years, partly because of operational problems, and partly because it was superfluous. Departure frequencies and times were such that hardly ever all platforms were in use, let alone by two buses.

An integrated dynamic bus station for both urban and regional buses might have made sense. This integration is a standard for new projects.

3. TU RESEARCH OF INDIVIDUAL BUS STATIONS

TU Delft has been involved in a number of projects in the realm of accessibility. Especially the effort to portray exemplary regional projects on assignment of the Dutch Ministry of Transport caused serious doubt about the quality of bus stations in towns like Doetinchem, Dordrecht, Leeuwarden and Maastricht, all static in character. Modern dynamic bus stations seemed to both promising and threatening for the disabled. (de Boer 2003).

Therefore we started a survey of these bus stations. First the dynamic bus stations were identified, by inquiries amongst public transport experts. Then an observation scheme was designed, following the itinerary of a train passenger leaving a station and taking a bus for the remaining part of his trip. Both the layout of the bus station, including the adaptations for the disabled, and the information for the traveler were analysed.
The authors visited all dynamic bus stations but one (Hilversum) individually, arriving by train. The outcomes were compared and discussed. In case of a difference of opinion a location was visited again.

We looked at the following aspects:
- *location as related to the main entrance of the station*: a location right in front of it being preferable,
- *pedestrian route to the central waiting area*: preferably straightforward and without disturbance from traffic,
- *shelter provided at the waiting area*. It should be sufficient to protect 5 – 10% of rush hour users from rain and wind,
- *information provided at the waiting area*. In the waiting area different types of information should be available: maps, schedules, fares, boarding procedure, conditions for use,
- *orientation of the waiting area towards the bus platforms*, offering a complete overview of these, preferably without having to walk around,
- *visibility of departure information at bus platforms as seen from the waiting area*. These should be readable under all light conditions,
- *pedestrian route(s) to the platforms*: preferably straightforward and without disturbance from traffic,
- *shelter on the platforms*. It should be sufficient to protect 5 -10% of rush hour users,
- *degree of dynamism in platform use*, the essence of the dynamic bus station, ranging from 100% to 0%,
- *degree of dynamism in travel information*, ranging from complete (mentioning actual arrival/departure) or absent (only static information). Of course the system might suffer from a complete breakdown.

Figure 2 **Enschede central waiting area: Good orientation towards platforms; no shelter from wind and rain; mark the positions of the roof stanchions and of the pedestrians.**

4. DESIGN OF THE INVESTIGATED DYNAMIC BUS STATIONS

4.1 Introduction

Our assessment of the accessibility is summarised in tables 1 and 2. Table one contains the information about the central waiting area. Table 2 contains the information concerning the bus platforms. The accessibility aspects were included in the assessment of the aspects but were not scored separately. The aspects mentioned in the previous section are scored in a simple way according to a scale of 0 to + +.

In this section and the next one extreme scores will be discussed. The case of Delft will be used to give a realistic impression of qualities and deficiencies.

Table 1. The design of the central waiting area of dynamic bus stations

Aspects / Cases	Location	Itinerary	Shelter	Information	Orientation
Almelo	0	+	0	+	+ +
Amersfoort	+	+ +	0	+ +	+
Apeldoorn	+	+	0	+	+
Delft	+ +	0	+ +	+	+
Eindhoven	0	+	+	+	+
Enschede	+	+	0	0	+
's-H.bosch	+	+	0	+	+
Leiden	+	+	+ +	+	+
Nijmegen	0	+ +	+ +	+ +	+ +

0 = absent or bad, + = present or bearable, + + = good

4.2 Design of the central waiting area

Following the scores in table 1, there proves to be no ideal dynamic bus station yet, regarding the design of its central facilities. There is just one case with only positive scores: Leiden. Nijmegen, about the same age, is the only case with four good scores: for a well marked route, spacious effective shelter from rain with ample seats, most complete information provision (both inside the railway station and at the central waiting area) and a good overview of the bus platforms.

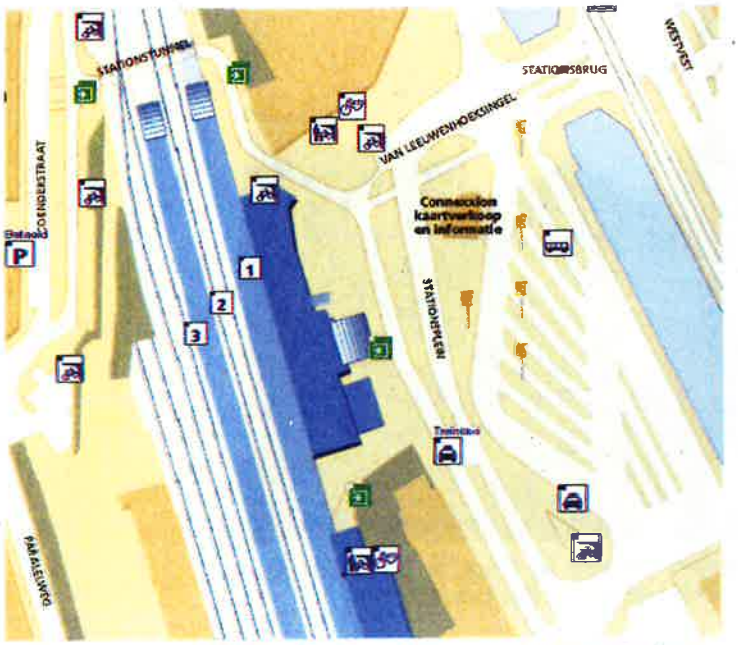

Figure 3 **Delft railway station and dynamic bus station**

Delft counts two good marks: for location and for shelter. See figure 3. The bus station lies right in front of the main entrance of the railway station and it has a nice and functional station building, with a closed (unique) and an open part, which is decently weather protected.

Figure 4 **Delft dynamic bus station: seen from the central waiting area.**

At Eindhoven the bus station is located at the back entrance/exit of the railway station. At Almelo it lies behind the short wing of the L-shaped railway building opening to the opposite side. At Nijmegen the bus station lies at some distance (>50 m) of the main entrance/exit of the station in spite of a vast unused station square.

Figure 5 **Nijmegen: empty square in front of the station; the lady is walking towards the bus station**

The Delft pedestrian itinerary on the other hand is quite silly. The bus client has to cross partly separated lanes for cars, bicycles and buses. There is a pedestrian crossing on the northern brink of the precinct, as part of a pedestrian route to the town centre, running behind the back of the bus station building. It implies that pedestrians cross elsewhere, i.e. everywhere and quite disorderly so.
The Delft orientation is not ideal because the 8 bus platforms are located on a long diagonal with the first platform far from the station building and the last one to its side and behind it as (not) seen from the station.

On information Delft scores only one +. There is a conspicuous roofed central information panel with electronic and paper sources, but no information for the visually disabled. Because of the presence of that at Apeldoorn and Amersfoort both scored + + on this aspect.

4.3 The design of the bus platforms

All these dynamic bus stations followed the Eindhoven and Leeuwarden examples of a layout with a series of parallel platforms at an angle, often a right angle with the platform of the central waiting area, separated from this by a wide zone of 12 meters or more, which is required for buses departing from their platform. This bus circulation zone is likely to be a problem for the disabled and more specific for the visually disabled people.

A standard feature of the dynamic bus station is an electronic indication of line number, destination and departure time on a large panel above the individual bus platform (table 2, information visibility). It should be readable from a distance of about 20 metres, irrespective of light conditions. If this is not the case travellers may become confused and may walk towards the panel to have a better look, which is possible only when standing on the bus lane. They may walk all the way to the platform too, guessing that the original information at the waiting area is still correct. Quite a few passengers on the other hand may decide to stay in the waiting area until the bus with its readable line number does appear, although it might depart from a different platform ...
The readability is often modest, because too small letters are used (Almelo), the colour contrast is insufficient, or protective material is reflecting light (Eindhoven).

The degree of uncertainty thus created makes the traveler's behaviour less predictable, crossing for instance in a hurry and at the very last moment. This is threatening to traffic safety and to the general satisfaction with this modern facility. It might be reduced by short and structured crossing facilities.
A half fish bone structure for departure lane and bus platforms may serve to shorten the crossing distance, because it eases the curve for departing buses (table 2, pedestrian route). It is applied for instance at Apeldoorn and at Delft, but in the wrong way in the latter city, by putting the departure lane in a diagonal position. People will tend to cross in front of the chosen platform anyway. At Delft this implies that they will have to bridge 7 m in stead of 5.
When bus platforms are used optimally buses will appear at the platform just in time, a few minutes before departure time at most. This means however that a buffer area for waiting buses will be required.
Upon arrival of the bus the group of waiting travelers will cross and maybe concentrating more on their destination than on crossing bus traffic, especially so if it is uncertain whether a seat will be available for everyone. When, during rush hour, this is most unlikely, travelers will tend to go to the right platform as soon as they know the bus will arrive, in order to improve their opportunities.
The bus platforms though are not designed to accommodate large numbers of passengers.

Table 2. The design of bus platforms

Aspects / Cases	Information visibility	Pedestrian route	Shelter
Almelo	+	+	+ +
Amersfoort	++	0	+ +
Apeldoorn	++	+ +	+ +
Delft	+	0	+
Eindhoven	0	0	+
Enschede	++	+	0
's-H. Bosch	+	0	0
Leiden	++	0	0
Nijmegen	0	+	0

0 = bad, + = modest, ++ = good

In a few cases, there is no shelter whatsoever on the bus platform, maybe to prevent the behaviour mentioned before. The best provisions, a paneled and roofed continuous shelter with seats are provided in Almelo, Amersfoort and Apeldoorn, which and rightly so, because in these cases the central shelter is poor. At Enschede both the central waiting area and the bus platforms are ill sheltered.

5. DYNAMISM OF DYNAMIC BUS STATION

Dynamic, i.e. unpredictable platform use is the essence of the dynamic bus station. To compensate for this dynamic travel information is presented. It tells the waiting traveler which bus platform will be used by a bus of a certain line and a certain departure time, thus reducing uncertainty.
The analysis of dynamism yield disappointing results. The scores in table 3 show that dynamic platform assignment is in fact absent in most of the cases. Dynamic travel information is generally modest and in some cases in fact absent.

At most 'dynamic' bus stations a fixed location is the foundation for the distribution of buses about the platforms.
It is generally acknowledged, that public transport users are mostly habitual customers who are not willing to find out every time where the bus will depart. Planners wisely adapt station operations to this consumer preference.
Where space is not a real problem, like at Apeldoorn and Delft and Enschede, there is no dynamic platform assignment whatsoever. It is demonstrated at Delft by platform shields with line numbers.
Where space is a bit cramped, regarding the number of lines and departures, it may happen that more than two buses of lines using the same platform have to depart at about the same time, because one of those is over due for instance. Then the computer may assign a different platform to the third one, normally the next platform, in order to keep it comprehensible for the traveler. This is normal practice in places like Eindhoven, 's-Hertogenbosch and Nijmegen. At Leiden it should be working like that, but it does not seem to function (information of the bus company). Of course drivers should follow the required procedures: passing the loop which identifies the bus and arriving at the assigned bus platform. According to the bus companies these aspects of driver behaviour are problematic at Leiden and Eindhoven respectively.

There should be a relationship between dynamic platform assignment, driver behaviour and dynamic platform information.
The platform display may simply show the line numbers using the platform (Apeldoorn, Enschede), a rather modest use of such an expensive facility.
The platform may show the 'theoretical departures', according to schedule (Delft) and indicate delays. At Delft, a bus delayed more than 5 minutes is removed from the display, not to be included again upon arrival; it looks like it is departed. During summer 2005 one of the loops was removed, making some of the departures purely theoretical.
Where actual departures are indicated things may go wrong in a different way: if the driver takes a wrong platform, his bus will not be shown at that place, but

elsewhere. At Nijmegen though, the computer corrects the information on the display.

We made no thorough observations of the actual operations at the bus stations. The funniest thing the author saw in passing (i.e. purely incidental) was an event at 's-Hertogenbosch.
At platform C a bus of line 64 was indicated. A bus of line 73 arrived and was left behind by the driver, probably expecting that someone else would take it over. Line 64 proved to have no departure at all. Instead a bus of line 61 arrived, without being indicated at the display. It departed backwards because the bus of 73 was still blocking the way. The monitor at the bus information desk indicated 64 to be delayed by half an hour. The official looked at it and stated, that it was not planned at all, since the summer schedule was operational. Evidently the computer didn't know (July 15th, 2005, 9.55).

Table 3. The degree of dynamism of dynamic bus stations

Aspects / Cases	Dynamic platform assignment	Dynamic travel information
Almelo	+	+
Amersfoort	0	+
Apeldoorn	0	0
Delft	0	0
Eindhoven	+	+
Enschede	0	0
S'H. Bosch	+	+
Leiden	+	+
Nijmegen	+	+

0 = absent or bad, + restricted, ++ good

6. CONCLUSIONS AND REFLECTIONS

The dynamic bus station is quite popular amongst decision makers, modern as it looks and efficient as it might be.
The compact dynamic bus station could be located close the station entrance when a modest station square is present or might be created during reconstruction of the station area.

The dynamic bus station is in fact only modestly dynamic. The availability of large numbers of platforms (up to 10), fit for accommodating at least two buses each, makes it less necessary. The increasing intensity of real estate exploitation of station locations is likely to increase the pressure for compressing, however ...

> Before 's Hertogenbosch the Eindhoven bus station was visited for a second time (July 15th, 2005, 8.30). It proved to be out of use because of reconstruction of its pavement. Temporary static bus stations were made behind it, at the back of the station (regional transport) and in front of it (urban transport). The latter location, at a parking lot right at

the main entrance, seemed to be suited for a real dynamic, i.e. compact bus station but without a buffer.

The dynamic bus station is certainly not fail safe, in the sense that buses arrive at the correct platform and are indicated correctly on information displays. Most of the time there is no staff which might explain things. This is worrying since there are problematic elements in the physical design of the bus stations as well. These cause discomfort for their users and serious problems for the disabled, who have the right to decent access.

There is a distinct need for conceptual design, taking account of the physical and psychical needs of the traveller and especially those with reduced abilities. A process analysis as presented roughly in this paper is essential for that.

The only Dutch dynamic bus station not analysed (Hilversum) was visited by the first author only. It proved to operate in an unusual, but no doubt dynamic way. Bus drivers can use their own platform for departure, maybe instructed to choose the lowest number available, i.e. the one closest to the railway building. This would reduce the walking distance for the traveler. It is suggested by the marked itinerary for the visually disabled ones, starting with platform one.
As soon as the bus occupies the chosen platform the central information panel shows its platform number. The distance to the bus however is such (up to 100 metres) that it is difficult for any disabled person to reach the bus in time.

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Intelligent Transport Solutions, Enhancing the Multi-Modal Experience

Author: Neil Perks BSc MIHT MAPM - AECOM ITS Technical Director, Asia
24/f, Tower 1, China Central Place, 81 Jianguo Road, Chaoyang District, Beijing, China
Mobile +86 13911791733, Tel +86 (0) 10 5706 5059, Fax +86 (0) 10 5969 5199
E-mail neil.perks@aecom.com

Introduction

Traditionally bus, rail, air, ferry terminals have grown up over time in a relatively independent fashion. Terminus's tended to be in the city centre, located historically, but very little consideration was given to the idea of connecting different modes of transport, largely due to the fact that very few people often wanted to make these journeys'

Today, however, as journey distances increase and peoples workplaces becomes more widely distributed across the city, each individual public transport mode cannot cover all the journeys required, and it would be unrealistic to expect them to do so. This has meant that many people's journeys often span at least 2 segments', frequently on different modes of transport; and could traditionally be an unpleasant experience in the rain and dark. The development of multi-modal hubs has improved this experience, but it can still be a negative experience trying to find and make your connection, dealing with unpredictable waiting times with limited amounts of information in an unpleasant, often unsafe, environment.

This paper looks at the development of multi-modal transport hubs, the issues they create and the potential technological solutions which can be applied. Multi-modal hubs are generally large open spaces, or a maze of passages and corridors; as well as often being inefficient in their operation, both can be intimidating to the traveller in terms of comfort, safety and security. Much can be done to improve the attractiveness of these interchanges through the correct implementation of technology.

It must be emphasised that technology alone will not solve all the issues at a multi modal hub, but together with appropriate infrastructure and management we can develop a pleasing and friendly environment for the traveller, increasing the use of public transport and making public transport a mode of choice not necessity.

Design of the ITS infrastructure at an early stage is crucial to its success. The systems need to be designed in an integrated manner using established standards and not added at the end of the project when much of the infrastructure has been established and constructed; this is a recipe for disaster. Consideration should also be given to the operation and maintenance of the implementation; without this, the efficiency and value will quickly degrade as passengers receive poor information in an unpleasant environment, driving them back onto private transport.

There is never a "one size fits all" solution for a multi-modal interchange and what works at one location may not at another, but the basic technologies and techniques are still valid, provided they are designed, implemented and maintained in an appropriate manner.

Multi-modal Interchanges

Multi-modal interchanges serve a number of purposes both directly relating to transport and serving as a community focal point. The fact that a multi-modal hub generates a high volume of travellers passing through the interchange also provides the opportunity for provision of other facilities such as retail and commercial. This in turn should lead to a much more hospitable and friendly environment.

A transport hub should principally provide efficient and convenient interchange between transport modes, providing a smoother and seamless experience for the traveller. All transport modes, public (bus rail, air, etc) and private (car, bicycle, pedestrian, etc), should be considered and provision made to accommodate them in a welcoming environment.

In key terms a **transport hub** should provide

- connectivity between alternative modes of transport
- a focal point for transition between private and public transport
- an efficient use of transport resources
- passage for ALL kinds of travellers, whether on foot or in vehicle

Key Objectives

The key objectives in developing a multi-modal interchange must be:

- Maximising the use of the public transport network
- Enabling the interchange of passengers between modes
- Providing simple and seamless journeys
- Efficient and reliable operation and management
- Flexibility in operation
- Convenient, informative and accessible
- Providing a clean, attractive and welcoming environment
- Providing a safe and secure environment
- Providing a community focal point
- A pleasurable, relaxing and positive experience

It is essential that the interchange is designed for the traveller, NOT only for the vehicles; without travellers there would be no need for the vehicles. On exiting their initial mode of transport the passenger will expect to see clear, unambiguous, directions to their next mode of travel. The interconnections should be direct and avoid lengthy walks between modes. There should be complete segregation between vehicles and pedestrians in order to create a clean and healthy environment.

Common Issues

Bearing all these admirable objectives in mind, why do we rarely achieve all these objectives in practice? Maybe it's through restricted investment, lack of real commitment, other competing priorities or simply losing sight of the objectives; whatever the reasons we are frequently faced with a multi-modal hub which fails to meet many of the criteria we have set ourselves.

Problems frequently encountered in multi-modal implementations include:

- Inconvenient and complicated transfer between modes
- Poor, or lack of, information; no clear direction for travellers
- Too much choice, no direction; a mess
- Vehicle, not traveller, centric
- Large and intimidating environment
- Open, dangerous environment

- Lack of security
- Restrictive, crowded
- Stressful, confusing

Many of these issues could be resolved simply through developing a comprehensive design in the first place, meeting all the above objectives, and ensuring throughout the course of the project and beyond that they are fully implemented and maintained as planned

Solutions..... halfway there

Assuming we have the commitment and the resources to fully implement our proposals there are many things we can do to meet our goals specified above. These solutions can be a mix of both traditional and technology, in fact many things can only be achieved through the use of technology.

Looking first at the traditional solutions (i.e. what can be done without the use of technology) and how they can help to meet our objectives:

- Develop a functional interchange design for travellers and design the vehicle infrastructure to complement this
- Develop effective interchange and transport operational strategies
- Provide static passenger directional signing and travel information
- Implement traffic and transport management measures
- Provide coordinated timetables
- Provide static travel information
- Use a high quality interchange construction
- Improve the traveller waiting experience
- Improved image and branding
- Ensure a high security presence
- Make sure staffing is adequate to provide all necessary services

We can do much without using technology, but the result will inevitably be dull and unimaginative. Many essential elements will still be missing, such as real time information for travellers, the ability to respond to changing situations and the ability to manage the interchange as whole, not just individual services.

Technology ..... the complete picture

Without technology the ability of the multi-modal interchange to fully function and meet our objectives will be compromised. Technology provides the above infrastructure with the ability to function in a safe, attractive and efficient manner. It can add the essential services without which it would be impossible to mange effectively.

These services include:

- Real time, cross-modal traveller information, providing a seamless journey experience
- Fleet management and dispatching
- Dynamic bus bay allocation

- Interactive kiosks
- Smart ticketing
- Mobile information
- Car parking and transport management
- Integration with building management systems such as fire detection and protection and ventilation
- Vehicle access systems
- Safety and security solutions
- Provide integration with surrounding road network
- Leisure infrastructure

Through the use of technology we can create a complete and fully functioning multi-modal interchange which is attractive to travellers through providing a comfortable, secure and efficient environment. Travellers arriving through one transport mode will transfer seamlessly and speedily to another through the provision of dynamic signing and travel information, real time arrival and departure information, journey planning information, through-ticketing, improved fleet management and mobile information networks.

The Bigger Picture, outside the interchange

Obviously the interchange cannot work in isolation from the rest of the road network; it requires to be integrated with the rest of the on-street infrastructure such as traffic control signalling, information signing and bus information and management; other related transport networks such as the Traffic Management Bureau and the Transport Operators; as well as integrating with building management systems, essential from the safety and security point of view.

The importance of this integration cannot be overstated and is essential if the interchange is not to become an island, isolated from the rest of the transport network.

Case Studies

The following 3 case studies highlight the importance and benefits of applying technology in developing a multi-modal interchange:

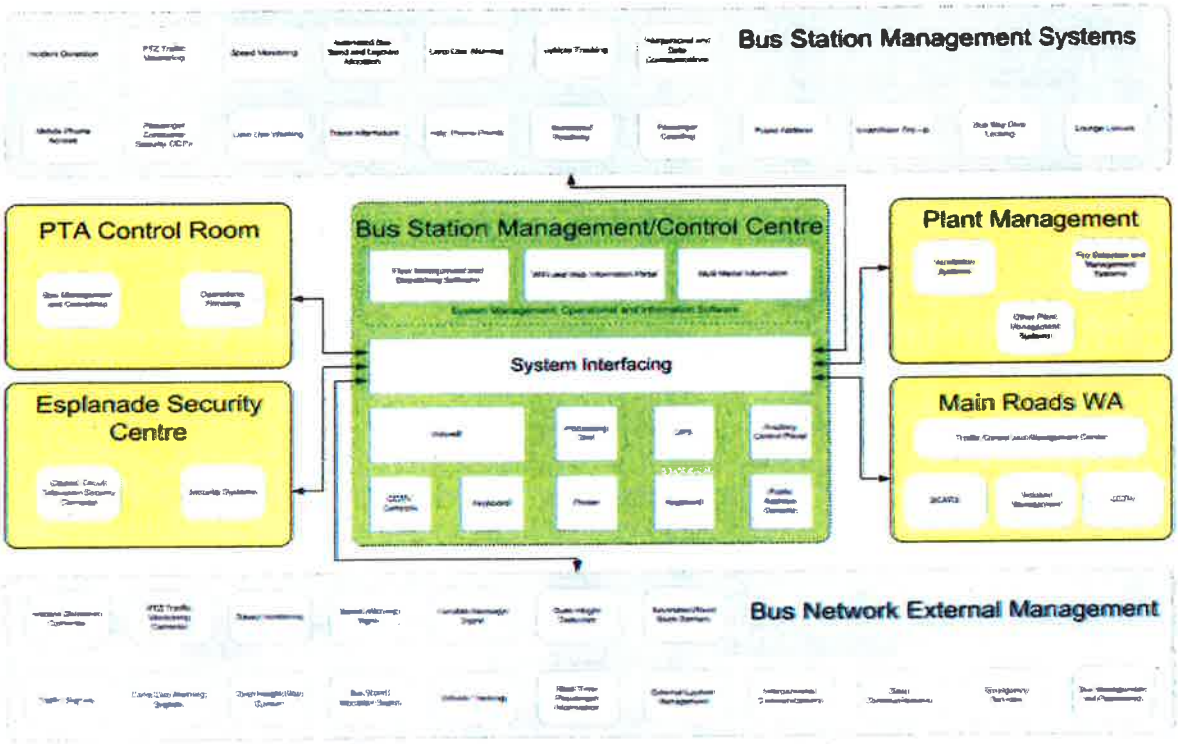
- **Wellington Street Interchange, Perth, Australia** – a city centre bus/rail interchange where a multi-modal solution was required to enable the seamless operation of the interchange, release real estate and reduce costs
- **City Transport Hub, Wolverhampton, UK** – a complex multi-modal hub including bus, rail, metro, taxi and car, where the prime objective was to create seamless transfer between modes
- **Changsha West Interchange, China** – the third example looks at a new initiative and the potential and opportunities which exist for creating a world class transport hub

In all these projects technology solutions are seen as the key to the success of the operation and management of the interchanges.

Wellington Street Interchange, Perth, Australia

The city of Perth in Australia is in the process of redeveloping the existing surface bus/rail station to improve the operation and management of its public transport services.

One of the keys to this project was the requirement to integrate the Control Centre with existing facilities scattered throughout the city (see diagram below). It was important at the early stage to involve all parties to ensure that the integration between networks could be carried out in a smooth and efficient manner. A working party of all interested departments was setup so they could discuss the proposal development with one voice.

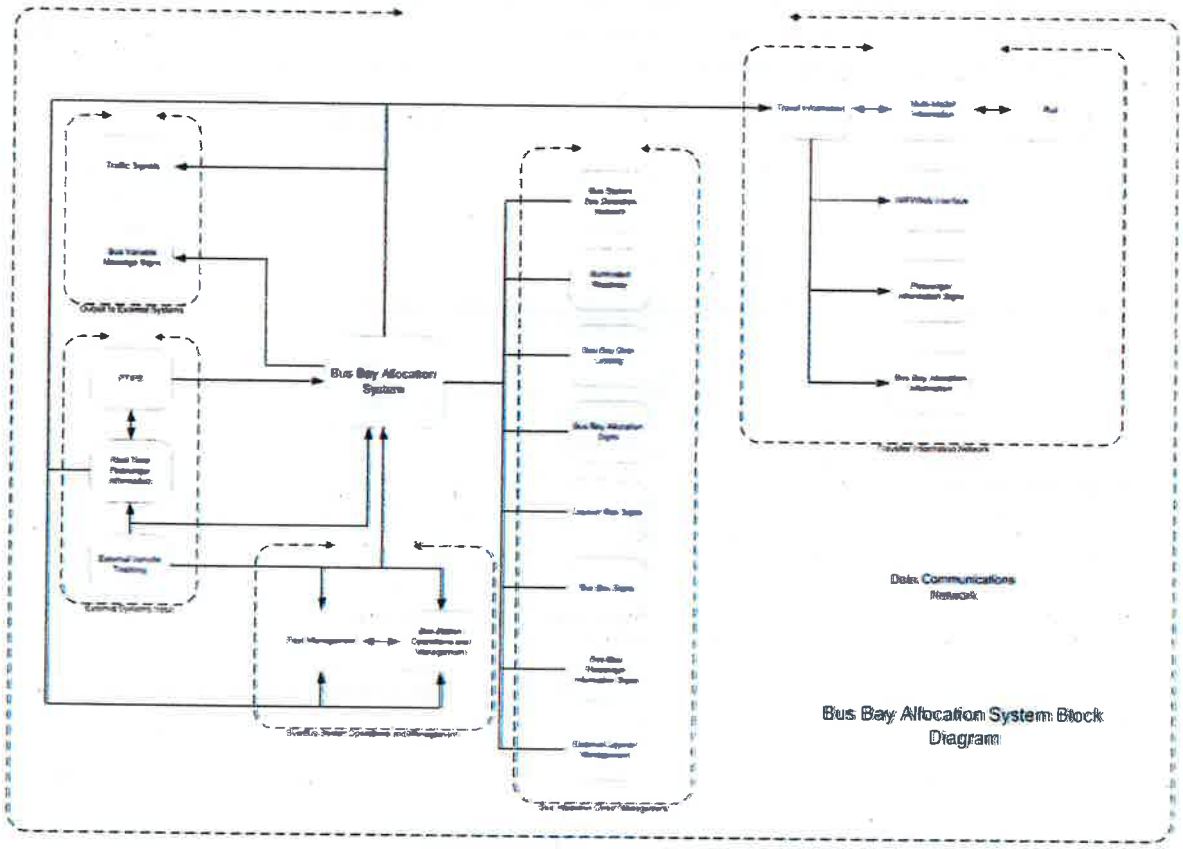


Concept Top Level System Design

In order to improve the environment for passengers and enable the optimum use of bus services the authority decided to implement an underground bus station which allowed for the creation of public amenities and open space on the surface.

In order to develop this concept, integrated technology is to be employed to manage the sub surface operation in terms of safety, security, operations and management. Overall over 20 Intelligent Transport Solutions have been developed and integrated, the key being an automated bus bay allocation system which will dynamically allocate incoming buses to a bus bay. Through using this system they will be able to reduce land take requirements by over 50%.

A block diagram showing the dynamic bus bay allocation system layout is shown below.



Bus Bay Allocation System Block Diagram

Dynamic Bus Bay Allocation Interfacing

The system itself is linked to all the other systems within the bus station and to the surrounding existing traffic management systems, providing a truly integrated experience. The cost of developing the transport interchange is estimated at 4.2Bn RMB of which the ITS is 56M RMB **(1.3% of total cost)**.

As identified by Peter Martinovich, Project Director and client Executive Director for Infrastructure Planning:

"No matter how good the infrastructure, the success or failure of this project will ultimately depend upon, financially, the most minor aspect of this project, the design and implementation of the ITS for the interchange"

The project is currently out to tender and, as can be seen above, the technology elements have already been highlighted as the key to the success or failure of this project

Without the technology to manage the interchange in terms of operation, safety and efficiency it would have been impossible to justify the construction of the interchange as:

- the cost would have been too high
- the safety and security of the interchange would have been seriously compromised
- the efficiency and safety of bus operations would have been impossible to achieve
- it would not appear attractive to travellers
- funding from developers would not have been forthcoming

With the inclusion of the necessary technology and safeguards the project has now been approved by the state and city governments and funding allocated.

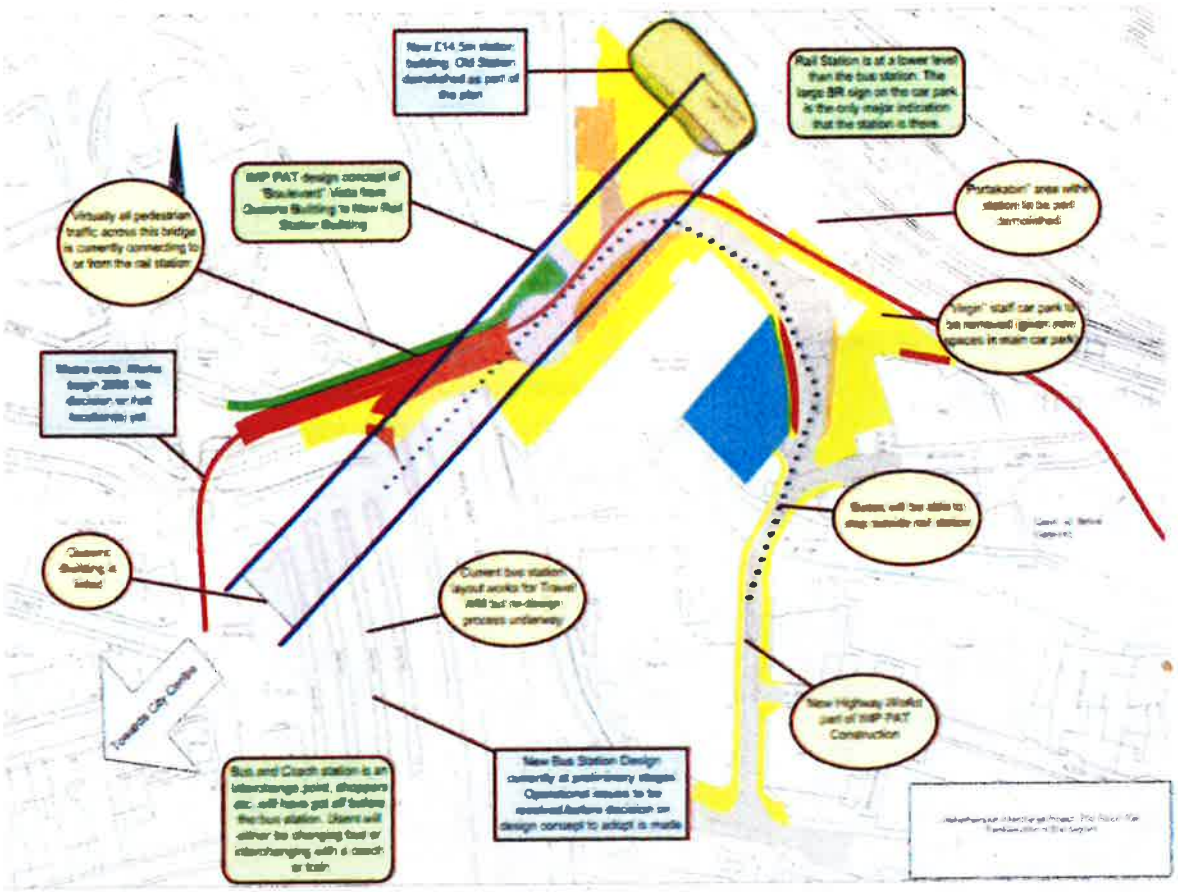
City Transport Hub, Wolverhampton, UK

This is a major regeneration project in the city of Wolverhampton in the UK; the aim of the project being to provide:

- New rail station works replacing tired 1960's architecture
- New Highway infrastructure to improve access
- Replacement of old bus/coach station
- New Light Rail line
- A seamless journey experience between transport modes of Rail, Bus, Metro, Car and Taxi

The overall aim of the Authority was to provide a gateway that the city could be proud of. This was reiterated at the project outset with the statement:

"If people can't tell where they are going, we've failed!"



Wolverhampton Multi Modal Terminal Proposals

To meet the requirements a real-time information network was designed which allowed passengers to seamlessly travel between modes. This was achieved through designing an interchange network around the following concepts and requirements:

- information concept based around three information halls: Bus, Tram and Rail
- an interchange system which has a wide range of integrated multimodal information on display
- in the central hall live traffic information is available

- indicators give more information about the mode you are approaching
- interchange is Wi-Fi enabled – real time updates can be sent to mobiles
- information available includes:
    - Real time bus, train, tram arrivals
    - Real time journey planners
    - Real time road traffic conditions
    - Personal real time trip planning
    - Multi-modal fare comparison
    - Guidance between modes
- provides a real choice for the traveller
- user reassurance is essential
- not forgetting the reassurance also provided by the human interface

Work currently underway on the bus station

The interchange is currently under construction with a construction timetable of 5 years and at a cost of 2Bn RMB. Completion is due in 2012

Changsha West Interchange, China

Proposed Changsha Transport Interchange

The city west bus station in Changsha is currently a terminal for short and long distance coach services to the west of the city. It is an open area coach station with little supporting infrastructure and it is proposed to develop the interchange into a modern multi-modal hub incorporating, not only the short and long distance bus services, but also the, under construction, subway station, local bus services and taxi and car services.

The proposed interchange will also incorporate some retail and commercial development, but will predominantly be a transport interchange. The complex will include separate long and short distance coach stations, long term coach parking, local services bus station, specific taxi facilities, a large underground car park, a subway station, bus maintenance facilities and a petrol station.

The challenge is to incorporate all these facilities into an integrated multi-modal hub, providing travellers with a fast, efficient and enjoyable experience when using the terminal.

There are many challenges and opportunities in developing the ITS functionality for this interchange, a few of which are listed below:

- Build a showcase, world class, transport hub
- Build upon international experience and expertise
- Utilise the latest technologies and techniques innovatively tailored for the local situation in Changsha

- Utilise parking and public transport solutions which attract passengers and motorists, therefore customers and clients
- Employing cost effective solutions WITHOUT major infrastructure changes
- Effectively integrate into Changsha transport network
- Develop a flexible, expandable and upgradable transport hub
- Develop an integrated transport solution using open standards, increasing competition and reducing costs

The success of this project will depend upon recognising that the traveller is the customer who pays for the services the operators provide; without travellers there is no business !!!; the more travellers the greater the profit. Ensuring that travellers are attracted to, and really do want to use, the facilities provided is crucial.

In utilising established, proven and developing technology to its fullest the interchange can become a friendly, attractive, safe and efficient place to be; in conjunction with integrated retail, commercial and social development it can be the focal point for life in the area.

The key is to make it somewhere where people want to be seen, and then you have succeeded.

Summary

The correct application of technology is essential to the smooth operation of any multi-modal hub, it:

- enables integration between all travel modes
- enhances the traveller experience through provision of real time information
- enables seamless traveller transition between modes
- improves management and service operations
- creates a safe and secure environment
- provides flexible expandable and upgradable solutions for changing situations

The aim of a totally seamless transport network can be achieved, and maintained, through the immediate and ongoing investment in the development and operation of the transport network, its interchanges and infrastructure. Most of all attracting the traveller to the public transport network is key; without this the rest is meaningless.

In summary, planning a world class multi-modal interchange without technology is like developing a television network without any channels; you have the infrastructure but few will use it; the use of technology is NOT an option, it's a core component.

Somerset County Council
Taunton Bus Station

Technical Report

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Contents

1. Introduction

PURPOSE

1.1 This report has been prepared in response to a request by Somerset County Council to examine options for bus station provision in Taunton. To do so, we have looked at the impact of various policies and of population growth to come to a view as to the shape and size of bus network that will need to be accommodated in Taunton in future years. Through discussions with various interested parties, we have identified potential sites, produced outline designs and we discuss the opportunities and constraints that each one presents. Finally, we report on the outcome of a workshop held on 6 June 2007 to discuss these options in more detail.

1.2 We would like to thank in particular Mark Pedlar and John Perrett of Somerset County Council's Passenger Transport Unit; Philip Bisatt of Taunton Deane Borough Council; Mark Green and Ian Franklin of Project Taunton, and Lucy Ball of BID Taunton. Given the preliminary and sensitive nature of this project, we have not discussed this work at any stage with any bus operator, and the discussion that follows should be seen in this context.

STRUCTURE

1.3 This report is structured as follows:

- Chapter 2 reviews relevant best practice and national design guidance;
- Chapter 3 reviews local policy and a local review of interchange in Somerset;
- Chapter 4 describes existing interchange facilities and reviews their existing capacity compared with an assessment of current requirements;
- Chapter 5 assesses the future demand for bus services, and uses this to predict the capacity that will be required at bus stops and stands to meet that demand;
- Chapter 6 produces outline designs of various options, and reports in broad terms their merits and drawbacks;
- Chapter 7 reports on a recent workshop to evaluate the various options; and
- Chapter 8 presents our conclusions.

2. Best Practice and Interchange Guidance Review

INTRODUCTION

2.1 This section summarises relevant guidance, and reports on two instances of best practice – one on-street and one off-street – to show that given attention to detail bus passenger infrastructure is capable of providing an attractive image as well as being practical for passengers. The guidance documents reported are:

- DfT "Inclusive mobility, a guide to best practice on access to pedestrian and transport infrastructure";
- DfT "Get on Board: an agenda for improving personal security, guidance for improving personal security for staff and passengers in bus travel";
- "Joining up the Journey: guidance on improving passenger interchange for those preparing Local Transport Plans and similar documents", The Institute of Logistics and Transport; and
- TfL "Intermodal transport interchange for London, best practice guidelines".

DFT "INCLUSIVE MOBILITY, A GUIDE TO BEST PRACTICE ON ACCESS TO PEDESTRIAN AND TRANSPORT INFRASTRUCTURE", 15 DECEMBER 2005.

2.2 The Guidance recommends that bus stops should be ideally distributed in residential areas so that each passenger walks no more than 400 metres from home. In the immediately surrounding area of bus stops, gradients on footpaths strongly affect the maximum walk distance. According to the guidance, for every 1 metre rise or fall, the 400 metres walk distance should be reduced by 10 metres.

2.3 The Guidance says: "For disabled people, bus use falls off sharply if the distance is more than 200 metres (250 metres for able-bodied people)." Special consideration should be given to residential care homes, day centres and other places used by disabled people. It is recommended that bus stops should be located in reasonable proximity, including a pedestrian crossing with dropped kerb.

2.4 The Guidance advises that on single carriage roads bus stops on opposite sides should be arranged so that buses stop tail to tail, preferably 40 metres apart, and should have a pedestrian crossing with dropped kerb between them.

DFT "GET ON BOARD: AN AGENDA FOR IMPROVING PERSONAL SECURITY, GUIDANCE FOR IMPROVING PERSONAL SECURITY FOR STAFF AND PASSENGERS IN BUS TRAVEL", 25 JANUARY 2006.

2.5 The Guidance gives advice on the design and provision of bus stops and shelters:

- bus stops should be highly visible; all the passengers should be able to see them easily;
- both stops and shelters should have locally recognisable names, to avoid or reduce conflict between passenger and driver, and to make the local community part of the service;

- request stops should be clearly identified so that passengers are always aware when they need to hail the bus, reducing the risk of a driver going past the stop;
- bus stops should be situated where there is natural surveillance but it is essential that they are away from pubs, clubs and off-licenses, to avoid potential drunk and disorderly behaviour;
- every stop or shelter should be well-lit, or situated in a generally well-lit area, and not obscured by any overgrown trees, foliage or by other traffic sign;
- seating should be provided for passengers;
- shelters should be designed to provide excellent visibility, including toughened glass in order to resist vandalism;
- ideally a public telephone should be situated close to the bus stop; and
- all shelters should allow easy access and pedestrian movement.

2.6 Architects and operators should provide a comfortable environment for passengers. At the same time, they should take action against young people and others seeking a place to congregate, who can become a cause of anxiety of waiting passengers.

2.7 The guidance also advises on bus stations in particular:

- it is important to maximise visibility and minimise the number of CCTV cameras; therefore bus stations should have clear sight lines, with no recesses;
- provision of public telephones, located and designed so that every passenger can see service display boards and can be seen by other passengers and staff;
- provision of clearly signed Help Points for disabled passengers, including CCTV;
- toilets should be coin-operated or should include staff, to reduce the potential for misuse.

"JOINING UP THE JOURNEY: GUIDANCE ON IMPROVING PASSENGER INTERCHANGE FOR THOSE PREPARING LOCAL TRANSPORT PLANS AND SIMILAR DOCUMENTS", THE INSTITUTE OF LOGISTICS AND TRANSPORT, 2000.

2.8 This Guidance suggests that the aim should be to minimise the number of changes necessary along major corridors of movement and, at the same time, to maximise the number of direct journeys. However the development and management of passenger interchanges, reducing inconvenience and anxiety, is a key role in ensuring that public transport provides better journey opportunities than currently exist.

2.9 The Guidance states that good interchange does not necessarily take place only at bus or railway stations. It is often necessary between buses at on-street stops too. This can be easily facilitated by improving pedestrian crossing, shelters and public information.

2.10 The Guidance shows a hierarchical classification of interchange locations for modes and services:

- category A: minimum facilities, such as two adjacent bus stops offering two different routes;
- category B: basic facilities, such as a series of stops in a town centre;

- category C: larger bus station, including services for passengers; and
- category D: major inter-modal interchange, designed for a large number of passengers, such as airports.

2.11 It then defines the facilities that should be provided at each.

TFL "INTERMODAL TRANSPORT INTERCHANGE FOR LONDON, BEST PRACTICE GUIDELINES" JANUARY 2001.

2.12 The Guidance suggests that a well designed interchange should provide clear routes between services or modes, which minimise the time and effort involved in making a transfer.

2.13 If possible, transfer in both directions should be at the same level. Provision of clear sightlines along pedestrian desire lines will improve wayfinding. It recommends that transparent materials should be used to permit passengers to see where they are going and to increase the perception of personal security. Pedestrian routes should not be obstructed, to avoid congestion.

2.14 Ticket offices and ticket halls should ideally be designed to provide convenient walk links to passengers, in particular considering other public transport facilities.

2.15 All signs should be designed and located taking account of partially sighted passengers. Also, a separate route avoiding physical barriers should be provided for mobility impaired passengers. Additional measures can be tactile markings, colour and tonal contrasts.

EXAMPLES OF ON-STREET STOPS (DUNDEE) AND GOOD QUALITY SMALLER BUS STATION (BURNLEY)

2.16 These are intended to show recent examples of best practice in bus infrastructure design, both on-street and off-street. They are intended to show what bus facilities can look like without pre-judging their suitability for Taunton.

Dundee

2.17 Bus stops and shelters have accessible footways as part of Dundee City Council's commitment to a Barrier Free City, which seeks to create a family friendly and barrier free city. There was a complete stock renewal in the city centre, completed in July 2005, including:

- high quality illuminated shelters, with RTPI and static information;
- modern image bus stop poles with solar powered illuminated static information; and
- raised kerbs, bus boarders and clearway road markings at all bus stops and shelters.

2.18 Some pictures of Dundee bus stops follow.

Figure 2.1: Example of on-street bus stop, Dundee

Figure 2.2: On-street bus stop example, Dundee

Figure 2.3: On-street bus stop example, Dundee, showing passenger information

Burnley Bus Station

2.19 A good example of a new bus station is this £3 million facility in Lancashire, opened in autumn 2002, serving a town of 73,000, and a catchment in the Burnley/Nelson urban area of around 150,000. It was designed to provide a safe and good quality environment for passengers, including: passenger waiting area; 18 departure bays with automatic doors; electronic departure boards; information centre; newsagent; café; toilet including baby changing facilities; CCTV; Taxi rank, and cycle parking.

2.20 The following photos show aspects of Burnley Bus Station.

Figure 2.4: Burnley bus station passenger concourse

Figure 2.5: Burnley bus station bus circulating area

Figure 2.6: Burnley bus station passenger concourse detail

Figure 2.7: Burnley bus station bus departure bays

DYNAMIC STAND ALLOCATION

6.64 An alternative option to reduce the space requirement at each site is that of dynamic stand allocation. The above designs – and assessment of capacity – assume a fixed allocation of services to bays. With dynamic stand allocation, passengers wait in central waiting area equipped with electronic passenger information systems. Buses arrive at the Bus Station, drop passengers off, and then proceed to a holding area, at which they can also take layover. They are allocated a departure bay in real time, with the passengers being informed via electronic displays.

6.65 The system is in its infancy, with installations at Christchurch (New Zealand) and Eindhoven (Netherlands). Concern is often expressed that bus users – many of them elderly – would prefer the reassurance of knowing where their bus will leave from. There is no known application in the UK although Warrington Borough Council has made a Transport Innovation Fund (TIF) bid to Department for Transport to fund a feasibility study to retro-fit its existing Bus Station with a dynamic allocation system to increase capacity.

6.66 Our work in Chapter 5 suggests a scale of bus infrastructure that is a little daunting compared to the scale of Taunton itself. A Dynamic Stand Allocation system might:

- Enable a smaller Bus Station site, which might in itself make a centrally-located facility more palatable; or
- Facilitate a trade-off whereby Dynamic Stand Allocation might enable a centrally-located Bus Station to accommodate all bus services (including those currently operating on-street). The opportunity cost of doing so can then be considered against the opportunity of full pedestrianisation in the town centre should that be considered to be desirable.

6.67 However, it is clear that no such trade-off can be applied to Dynamic Stand Allocation in a fringe-of-town centre location, because on-street stops in the centre will still be required to ensure adequate accessibility.

6.68 As an indication of additional cost, Warrington Borough Council is seeking £50,000 for its feasibility study and estimates that it will need £500,000 to retro-fit its Bus Station. Warrington already has a Real Time Passenger Information system that the Dynamic Stand Allocation system can be built around. Taunton currently has no Real Time Passenger Information system.

6.69 From a practical viewpoint, should Somerset County Council pursue Dynamic Stand Allocation, it will find that a) a bus station in the open air and b) a layout with no reversing will prove most suitable.

6.70 In any case, we recommend that whichever design Somerset pursues, it should consider whether the design can be made to incorporate Dynamic Stand Allocation at a later date. This will provide more 'future proofing' should the demand for bus travel exceed the forecasts made in Chapter 5.

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- Schools;
- Hospitals; and
- Other locations, of a temporary or permanent nature, from where large numbers of passengers are moved.

The type of design for these locations should reflect the designs identified in previous sections, including linear stops, shallow saw tooth stands or a DIRO arrangement. If buses are arriving and departing with minimal layover a linear approach may be most appropriate but each case should be considered according to its circumstances.

The elements of design included later in this section apply equally to these facilities as bus stations and interchanges in more dense urban environments. In particular, consideration should be given to safety due to the passenger desire routes and the behavioural nature of users.

Such facilities may have limited usage and may attract private vehicles or delivery vehicles which could inhibit bus movements so this may have to be allowed for in the design. The design may have to include space for a 'Kiss and ride' facility.

Summary of Bus Station Layouts

There is no correct design for a bus station. Any design must be appropriate for the location and for the use required of it.

There may also be issues of safety, access, spatial relationships and the views of the various stakeholders that will have to be taken into account.

It is not uncommon for the design to be a compromise, often as a result of the available land. It is even more important in such cases that drawings should be checked using suitable software such as Autotrack or similar, and if necessary organising a test using various buses, of different types and dimensions, to ensure the feasibility of the design.

Dynamic Stand Allocation

The concept of Dynamic Stand Allocation is that buses will stop at whichever stop is available at the time of arrival. It can in theory be applied to any stand layout design although as the passengers are required to move once their stop is announced all the boarding points should be close to each other. This in practice requires the design to be of the drive in/reverse out type where passenger walking distances will be shorter. Island platforms are also in use at some locations in particular in the Netherlands and this requires passengers to walk across the roadway to board. This is not recommended on safety grounds.

Real Time Passenger Information (RTPI) and Global Positioning System (GPS) provide accurate up to the minute timetable information and precise vehicle location. These enable a system of Dynamic Stand Allocation (DSA) to be implemented using fewer stands.

Making use of a central and enclosed passenger concourse is critical to DSA operation. Essentially the proposed method enables all stands within a bus station to be used only

at the time of bus departure and, as a consequence to remain free from buses laying over between services that often have the effect of taking much needed stands out of use.

The system of DSA utilises the technology already present in buses for RTPI and GPS systems. Buses are monitored as they approach a bus station and within a few hundred metres of the facility the driver is notified of the available stand number to approach in order to set down and pick up bus passengers through in-cab information systems. Simultaneously, passengers within the bus station concourse are advised of the next departures and stand numbers by an automated audio announcement and electronic departure boards and are notified with enough time to move from a central seated waiting area to the appropriate stand for their departure.

There are a number of potential advantages and disadvantages arising from the application of DSA and these are noted in the following table;

Dynamic Stand Allocation

Advantages	Disadvantages
Increased capacity for new or upgraded bus services using a facility with finite capacity in the heart of a town / city	Potential under capacity at peak times that requires careful management to avoid queuing buses and delayed services
Use of RTPI systems in conjunction with audio announcements to improve passenger information at bus stations	Announcements need to be clear and repeated. May have problems at peak times and if systems used in built up areas at night
Utilisation of a central waiting area enabling printed information, help desks and refreshment facilities to be located around the central area and in turn minimising the spread of passengers across the station and crowding effects at bus stands, potentially assisting in particular those with mobility impairments	Central waiting area may cause excess walking distances to be incurred by passengers, particularly detrimental to those with mobility impairments. Could be issues relating to large movements of people all at once towards a single stand, including safety and pedestrian flows. Does not allow the formation of an orderly queue
Allows buses and drivers to lay-over in areas away from the main passenger concourse allowing for better rest and refreshment facilities and less confusion over in service and out of service buses within the main terminal area	The lack of regular stands for frequent and /or well used services may cause confusion and frustration amongst passengers
	Boarding information must be provided in all necessary formats, including audible announcements and visual electronic displays

Advantages	Disadvantages
	All operators using the facility need to have the technology and all spare vehicles must be equipped – this may lead to high capital costs for smaller operators who may choose to leave the station facility and use on street bus stops where they exist
	Increased use of stands can lead to greater risk of accidents due to increased congestion

The use of DSA is driven by a desire to enable a more efficient use of the existing bus station resources available. The benefit of DSA is that greater flexibility in stand utilisation would be achieved by realising capacity that is currently tied up by vehicles laying over.

Dynamic Stand Allocation has not been applied in the UK to date though Warrington Borough Council is keen to develop this technology in partnership with other local authorities across the country and it is information from this authority which has informed this section within the Design Guide. The new High Wycombe bus station uses this approach between a group of adjacent stops but it does so without recourse to technical sophistication and complexity. Early experience shows some passenger confusion.

Stand requirements and design

The number of stands required is essentially a function of the frequency of the bus services and the lay over time (including time for setting down and picking up passengers) at the bus station.

The GMPTE standards for maximum occupancy of stands are:

Table 9.4 Stand usage

Type of stand	No. departures per hour
Single occupancy stand	12
Double occupancy stand	18
Triple occupancy stand	24
DIRO	8

Each service should be allocated to a stand to ensure at an early stage of the design that it will work. This should consider:

- the numbers of destinations or corridors served;
- any desire to provide separate stands for different operators;

Christchurch Bus Xchange

The pain of public transport management

Christchurch, a steadily growing city in New Zealand's South Island, was experiencing the typical urban growing pains of road congestion, pollution and the rising cost of public transport in a context of shrinking demand.

Public transport was a particular headache for the city's planners and decision makers. Usage was declining, and each of the city's 37 bus routes had its own bus stop on prime real estate around the central city's major tourist hub, Cathedral Square.

When Christchurch City Council decided to upgrade Cathedral Square as part of a wider inner city revitalisation project in 1996, it decided to reclaim this area for pedestrians, meaning that the unsheltered, uncomfortable and potentially unsafe bus stops around the perimeter had to go.

Meanwhile, Environment Canterbury, the city's regional council in charge of public transport management in Christchurch, had set targets to double the number of trips made by public transport from three to six per cent by 2011, diminate congestion outside peak periods and contain carbon dioxide emissions.

The stage was set for a radical improvement in the way public transport was managed.

From bus park to through-point

Property investor Philip Carter, who owns a heritage property close to the central city public transport hub, proposed the concept of a bus exchange that would include retail, educational, and car parking uses. The council supported the concept enthusiastically and identified that Connexionz' real time passenger information system would complement the bus exchange concept perfectly.

The Bus Xchange was designed with an airport style lounge in the middle of the building for waiting passengers to maximise the amount of space available for buses to turn. Rather than queuing, passengers can wait in comfort in the lounge until moments before their bus arrives, meaning they spend minimal time on the platform. This information-assisted flow ensures platforms are occupied with embarking passengers for an average of 78 seconds at peak and 30 seconds off peak.

Connexionz installed a GPS device in each of the city's 215 buses, sending each bus's location back to the central computer via radio telephone every 5-30 seconds. Special Connexionz software combines this information with data gathered on previous trips to calculate how long the bus will take to arrive at the Xchange. Its system displays this arrival information for passengers, enabling them maximum comfort, safety and convenience.

Other Bus Xchange innovations included transforming the central city from a hub for bus routes into a central through-point servicing four "peripheral termini" providing layover and bus parking facilities on the outskirts of the city.

From 31 permanent stops in Cathedral Square at which buses would stop for up to 20 minutes at a time, the Bus Xchange became a central, dedicated drop off and collection point for passengers made up of five platforms, each handling multiple routes.

Contact Connexionz Limited for more details
phone: +64 3 339 4536 or email: sales@connexionz.co.nz

CONNEXIONZ
Real Time Tracking

Fast facts about Bus Finder

- The Bus Xchange has five platforms (three off-street, two on-street), with a total of 15 bus stops
- It serves 37 inbound and outbound routes and five through routes
- It handles 2220 daily trips from the off-street platforms and 1400 trips from on-street platforms
- Peak capacity from the main platform is 48 buses per hour
- Average loading at peak is 18 passengers per bus
- Average dwell time at the bus stop is 78 seconds per bus at peak and 30 seconds off-peak
- Displays are updated every 15 seconds
- Talking signs are deployed at each platform for the visually impaired.

real time information provides a bus passenger
with the certainty of the time (in minutes)
till the next bus arrives

Passenger numbers soar

Since the Bus Xchange was opened in November 2000, the number of passenger trips has increased to more than 13.1 million trips, with patronage rising 22.6 per cent.

Managers at the council are using the information supplied to improve the quality of their planning and to support decision-making on transport-related issues.

Christchurch City Council and Environment Canterbury are now installing Bus Finders on key bus stops along routes, so passengers on the way to and from the city obtain the same high quality real time information as those at the Bus Xchange.

Other innovations that the council plan to implement include the ability for passengers to look up a bus's arrival times on the Internet and to link approaching buses to traffic lights to ensure a green light run and faster commutes for passengers.

Connexionz' role

Connexionz was an integral part of the new state-of-the-art Bus Xchange terminal.

By comparison with other real time passenger information providers Connexionz' systems are relatively inexpensive and easy to implement, meaning transport managers get a fast, scalable solution with minimal civic or social disruption and a fast impact on the quality of passenger experience.

Connexionz has a proven operational system, which can be easily deployed for other bus interchanges.

1MIN

2MIN

3MIN

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CONNEXIONZ
Real Time Tracking

Changing the image of public transport

Robert Burke, Connexionz Limited
Brian Smith, Parsons Brinckerhoff

Abstract

For many years, bus transport has been the poor cousin of public transport. Inner city bus exchanges and termini invoke images of being cold, windy, dirty and unsafe. At peak times, by fact of numbers, termini can be relatively safe, but in quiet times they are considered unsafe and people feel uncomfortable going there.

To increase passenger numbers the image of the system has to be improved. Increased passenger numbers will result in more services and routes. This will require an increase in the size of existing termini or a new approach. Simply increasing the size is not an option, as inner city real estate is expensive and often unavailable.

In Christchurch, New Zealand, the new central city Bus Exchange offers bus passengers the level of comfort that we expect in airports, yet uses significantly less space than the old terminus. It has also been successfully integrated with central city retail shops.

Background

Christchurch was built around the Cathedral Square and this has been the centre of business and public transport for over 100 years. By 1995 there were more than 30 routes servicing 30 bus stops in and around Cathedral Square and it served as the terminus for most of the routes. At any one time there could be up to 15 buses in the Square – engines idling, obstructing the view. Cathedral Square was dying and was no longer a vibrant city centre. Instead, with buses spread across a large area, there was limited shelter available for patrons, and there were problems with security at night. A number of buildings around the square had been vacant for some time and the future of the central city was looking bleak.

The Christchurch City Council[1] has been reviewing options for Cathedral Square since the 1980s, and presented the first draft proposal to the Canterbury Regional Council[2] (ECan) in 1993.

In 1998/99 ECan and the Christchurch City Council developed and adopted a Public Transport Strategy. As part of this work they projected that Christchurch would experience a 43 per cent increase in car use over the next 20 years. This would have a significant impact on the quality of life in the city in many ways - including the cost of maintaining and improving the roads, the rates and severity of accidents, traffic congestion and air pollution from vehicle emissions. This realisation is the reason why ECan and the City Council are working together to encourage greater use of public transport.

Two years earlier, in December 1996, the City Council decided to review the location of the bus terminal in central Christchurch as part of their focus on redeveloping Cathedral Square. The Council commissioned a study from PPK Environment and Infrastructure Ltd. (Parsons Brinckerhoff) to investigate the best type of bus system

[1] The Christchurch City Council is responsible for providing the infrastructure (bus shelters, seats, etc) and integrating the transport modes and land use.
[2] The Christchurch Regional Council, known as Environment Canterbury (ECan) is responsible for the planning and administration of public passenger transport in the Canterbury region.

for Christchurch. This study found that the best option for Christchurch would be a central exchange, backed with peripheral termini. Buses would drop off/pick up passengers at the central interchange, but would travel to peripheral termini to lay over. This concept was adopted by both ECan and the City Council in August 1998.

The Bus Xchange was made possible by a public-private partnership. Property investor Philip Carter, who owns a heritage property close to the central city public transport hub, dreamed up the concept of a bus exchange that would include retail, educational, and car parking uses. ECan and the City Council provided the support and the know how, and eventually the commitment to manage and maintain the infrastructure. The Councils have also supported the Bus Xchange by extensive traffic management and bus priority.

The Bus Xchange

Figure 1: Inside view of the Christchurch Bus Xchange. The overhead signs and the audio station (for the visually impaired) are clearly visible in the centre of the photograph.

Christchurch City Council opened its new state-of-the-art passenger terminal – the Bus Xchange – in November 2000. The Xchange was built inside the shell of a centrally located historic building (the Arthur Barnett building), and is linked to a food hall and stores by two air bridges.

The off-street part of the Bus Xchange is located on Lichfield street (see Figure 2). It covers around 3,500 m^2 and is at ground floor level to facilitate easy access. There are two storeys of car parking (providing 200 parking spaces) as well as a food mall and a flyover that gives access to department store Ballantynes.

MRK-0075(rep)
Issue date: 12 September 2002

The off-street site provides nine bus stops, and a further six bus stops are located in Colombo Street outside Ballantynes and the Arthur Barnett building.

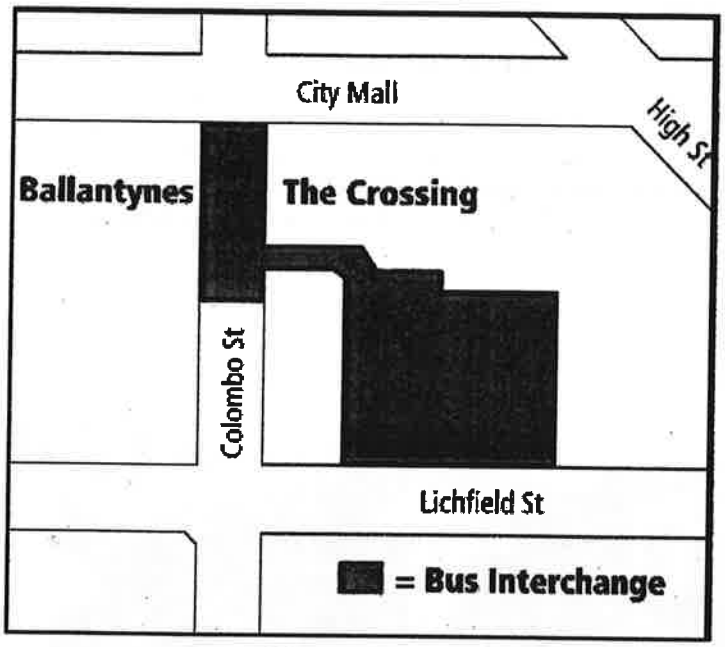

Figure 2: Layout of the Christchurch Bus Exchange

The off-street part of the Bus Xchange consists of a system of linked bus ramps and waiting lounges. The design focuses on providing high levels of comfort and easy access for passengers, and total separation between the buses and the passengers to ensure safety. It enables those waiting for a bus to remain off the street, in an enclosed, warm and dry waiting area. Security, lighting, air ventilation, seating and noise standards will be similar to those experienced by passengers waiting at an airport. Facilities are provided adjacent to the bus stops on Colombo Street for passengers using those buses.

The main passenger entrances to the Xchange are from Colombo Street and Cashel Mall (via the Cashfields arcade). Pedestrians can also access the Xchange from Lichfield Street.

Passengers use the Xchange as follows: Fixed services leave from each platform so passengers know which platform they need to wait at. As passengers enter the platform waiting area (lounge) the real-time passenger information signs show them how many minutes away their bus is. The signs "count down" until the bus arrives and then displays the door at which the bus is going to stop. This information is shown on the main signs and on a sign above the door. A voice announcement is also made. This gives passengers up to 60 seconds warning of the bus arrival and allows them to queue before the bus arrives, which decreases loading times. It has changed the way passengers view waiting for a bus.

Figure 3: The B-lounge at the Christchurch Bus Xchange. Note that the bus doors are open, allowing passengers to embark.

Bus drivers treat the Xchange building as any other stop. They know which platform they are heading for, and the dynamic stop allocation assigns a stop as they enter the building. This information is conveyed to the driver by information signs in the bus lanes as they approach the platform.

Figure 4: TV monitors in the bus entry lanes direct bus drivers to the appropriate stop.

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Issue date: 12 September 2002

Land use

Inner city bus terminals need to be located near where people work and shop. Inner city real estate is expensive and in short supply and with the ever increasing drive to get more people using public transport, the result will be an increase in the number of services, resulting in more buses. Existing termini will not be able to cope with the increase in numbers of buses and simply increasing the size of an existing terminus is in many cases not an option.

The Bus Xchange has demonstrated that a small facility can actually handle more services with greater efficiency than the traditional solutions. This offers major benefits in land use, allowing greater access. The Christchurch Bus Xchange is housed within the confines of an existing building which offers the possibility that it can be moved in the future. Should additional capacity be required, another Xchange can be built as finding a suitable location is much easier if it can be integrated within an existing building.

Xchange facts and figures

- There are 215 buses in the Christchurch city transport fleet, servicing 46 routes.
- The Bus Xchange has a total of 5 platforms (3 off street, 2 on street), with a total of 15 bus stops.
- 37 inbound and outbound routes and 5 through routes operate though the Xchange.
- 670 trips use the 2 outdoor platforms each day, and an additional 1,400 trips depart from the off-street platforms.
- The peak capacity of B platform is 48 buses per hour.
- An estimated 12,000 passengers use the Xchange at peak times

Peripheral termini

The Bus Xchange works because it is a bus stop – not a terminus. A terminus implies that buses would lay over, requiring additional parking. In fact, with a service frequency of less than 20 minutes each route requires its own stop.

In Christchurch, 5 peripheral termini have been established. They are located on the fringe of the central business district and provide parking for buses and facilities for drivers. The peripheral termini are located at differing points of the compass and near points of interest, which includes Christchurch Hospital, the Christchurch Polytechnic, and an entertainment centre. When passengers travel to the Xchange, they can transfer to another bus for free transfer to the termini – a passenger who needs to go the Hospital can now transfer at the Xchange without the need to go outside.

The peripheral layover approach suited Christchurch because data showed that for journeys to work, bus use was only significant for destinations immediately adjacent to Cathedral Square, suggesting that they didn't penetrate the central business district. The benefits of a peripheral layover operation are that buses are better able to serve passenger destinations throughout the city; and the termini/layovers (where buses have space for recovery time etc.) are located in areas where there is less competition for space.

Sydney, for example, is running a peripheral layover operation - this was implemented a little while after Christchurch, with the construction of a bus layover

in Lee Street. At the time, Sydney Buses were planning to eventually change to through-routing.

One issue with peripheral layover operation is that it can result in a lot of bus movements through the city. This can be reduced with through-routing and by providing bus priority or bus lanes (Sydney is extending its red city bus lanes) or by creating transit malls. In addition through-routing buses can also reduce city centre bus movements while maintaining penetration of the city by bus routes.

Benefits of the Bus Xchange

Changing the image

The major single benefit of the Bus Xchange has been changing the image of bus travel. The transformation from a bench seat in windswept Cathedral Square to the air conditioned comfort of the Xchange lounge has made "catching a bus" much more acceptable.

Better land use and flexibility

With the reduction in the number of stops required, the space needed for the Bus Xchange was reduced. This released inner city space for better use and gives options on future locations of new bus exchanges. It also allows for better integration with retail areas and other modes of transport, for example rail.

Easy transfers

It is not easy to transfer from one service to another at a large, dispersed exchange - knowing where the stop is located and walking distances, make selecting alternate services difficult. At the Bus Xchange it has become much simpler - the overall size is smaller, and relevant information is clearly displayed, And if passengers have to wait, they can wait in comfort, with the added security of good lighting, other people, security guards and cameras.

Peripheral termini

These have created effective new trips and inner city links which have become very popular. Passengers can now get directly to the hospital by transferring at the Xchange and on their return they can catch the next bus to the Xchange where they can wait in comfort for their service.

Increasing patronage

Buses leaving the peripheral termini for the Xchange have also become popular as they transport passengers free of charge to the Xchange where they can wait comfortably for their bus. This has had an obvious impact on women passengers who are using buses more at night.

The negatives

Although the overall impact of the Bus Xchange has been positive, the peripheral termini have increased trip distances and times, which has led to an increase in running costs. For example, more driver relief points have to be serviced and maintained.

A trade-off for a more efficient system with lower space requirements is the need to commit to manage and maintain the building. In general the Bus Xchange requires a higher degree of bus and passenger management than a traditional on-street facility, but this is one of the trade-offs that is required for a more efficient system with lower space requirements.

MRK-0075(rep)
Issue date: 12 September 2002

The Bus Xchange has also sporadically had a problem relating to fights and bullying, usually involving teenagers, which has been widely reported in the media. However, police statistics show that prior to the move to the Bus Xchange there were similar levels of problems, but because they were spread over a wider area they were less public.

Technology that makes the Xchange work

Real-time passenger information (RTPI) and dynamic bus stop allocations are the key enabling technologies that make the Xchange work.

RTPI gives passengers the confidence to read or visit the shops and food court while waiting for their bus. This confidence is important as the lounge capacity relies on some passengers waiting outside the lounges in the food court or shops. If RTPI information is distributed throughout the retail environment, passengers will be given real choices that will allow them to delay their arrival at the Xchange until the last possible moment.

Dynamic bus stop allocation assigns buses to stops and announces the stop location to passengers up to 1 minute before the bus arrives at the stop. Early announcements speed loading by over 40 seconds per trip, which increases the capacity of the platform by up to 20%. Dynamic stop allocation allows greater use of stops, with B platform supporting 14 routes with up to 48 services per hour, with a service frequency of less than 20 minutes per route. In any other terminus in the world this would require a dedicated stop per service.

Press Release
Canterbury buses carry 13.1 million passengers
1 August 2002

The record books will have to be rewritten after more than 13.1 million passengers were carried by Canterbury buses over the last year – boosted by patronage rising 22.6 per cent.

The last time bus services transported more passengers was in 1988. Not since 1932 (31 per cent) and 1907 (107 per cent) has better growth been achieved.

Officially, 13,151,684 passenger trips were made in Canterbury (greater Christchurch and Timaru) during the 2001 to 2002 financial year, ending June. The result is 1.8 million trips (16.2 per cent) above that targeted by Environment Canterbury.

Environment Canterbury's Public Passenger Transport Portfolio Committee Chair, Cr Diana Shand says many factors have contributed to an outstanding result for Canterbury. "It's part of a long campaign that began building in 1998 when super low floor buses were introduced followed by the arrival of express routes, the Orbiter and the Bus Exchange. What we have seen over the last few years is people recognising that buses are reliable, good value and an efficient way of getting to a destination. We do not plan to stop here and rest on our laurels – already Environment Canterbury has begun surveys looking into how we can make even greater improvements."

The golden era of Christchurch's public transport peaked at 32 million passengers per year in the mid-1940s when fewer people owned their own car and public transport was the main mode of travel. The latest result is all the more impressive because many households have two or more cars in the garage today, says Cr Shand.

Success stories include a 30 per cent increase in patronage after a review of bus services in the north east of Christchurch. A review of south Christchurch is now underway. A survey found that 79 per cent of Christchurch users and 95 per cent of Timaru users rated the level of bus service as very good or excellent.

For further information please contact: Cr Diana Shand, Public Passenger Transport Portfolio Committee Chair, Environment Canterbury, ph (03) 365 0546 or Wayne Holton-Jeffreys, Passenger Services Manager, Environment Canterbury, ph (03) 365 3828.

From: Environment Canterbury News (http://www.ecan.govt.nz/) 1 August 2002

Referees

David Hinman, Central City Policy Leader
Christchurch City Council
phone +64 – 3 – 941 – 8804
email dave.hinman@ccc.govt.nz

Wayne Holton-Jeffreys, Passenger Services Manager
Environment Canterbury
phone +64 – 3 – 365 – 3828
email Wayne.Holton-Jeffreys@ecan.govt.nz

MRK-0075(rep)
Issue date: 12 September 2002

About the authors

Robert Burke, Managing Director, Connexionz

Robert started Connexionz in 1998 to develop tracking systems for transport operators. Connexionz started by tracking buses to provide management information to operators, and in early 2000 started experimenting with Real Time Passenger Information (RTPI).

When Christchurch City tendered for an RTPI system in 2000, Connexionz started to focus exclusively on RTPI. They were awarded the Christchurch contract, and have since obtained a further 4 contracts. With innovative products like the battery-powered Bus Finder street sign and bus interchange management solutions Connexionz has established itself as a credible supplier of RTPI systems.

phone +64 3 339-4536
email robert.burke@connexionz.co.nz

Brian Smith, Parsons Brinckerhoff

Brian Smith is a Principal Transport Planner with Parsons Brinckerhoff (formerly PPK). He is an intermodal specialist with national and international experience in planning and design of public transport interchanges. He has been involved in some of the most significant bus and bus/rail interchange developments in Australia and New Zealand.

Brian is also an accomplished bus network planner.

phone +61 2 9736 9780
email bsmith@pb.com.au

Control Sheet

Document Title	Review
Central Square - New Bus Facility	Originator: Richard Crappsley, Steer Davies Gleave
Document Type	**Other Contributors**
Final Report of Stage 2	AECOM
Client Contract/Project No.	**SDG Project/Proposal No.** / **Reviewed by**
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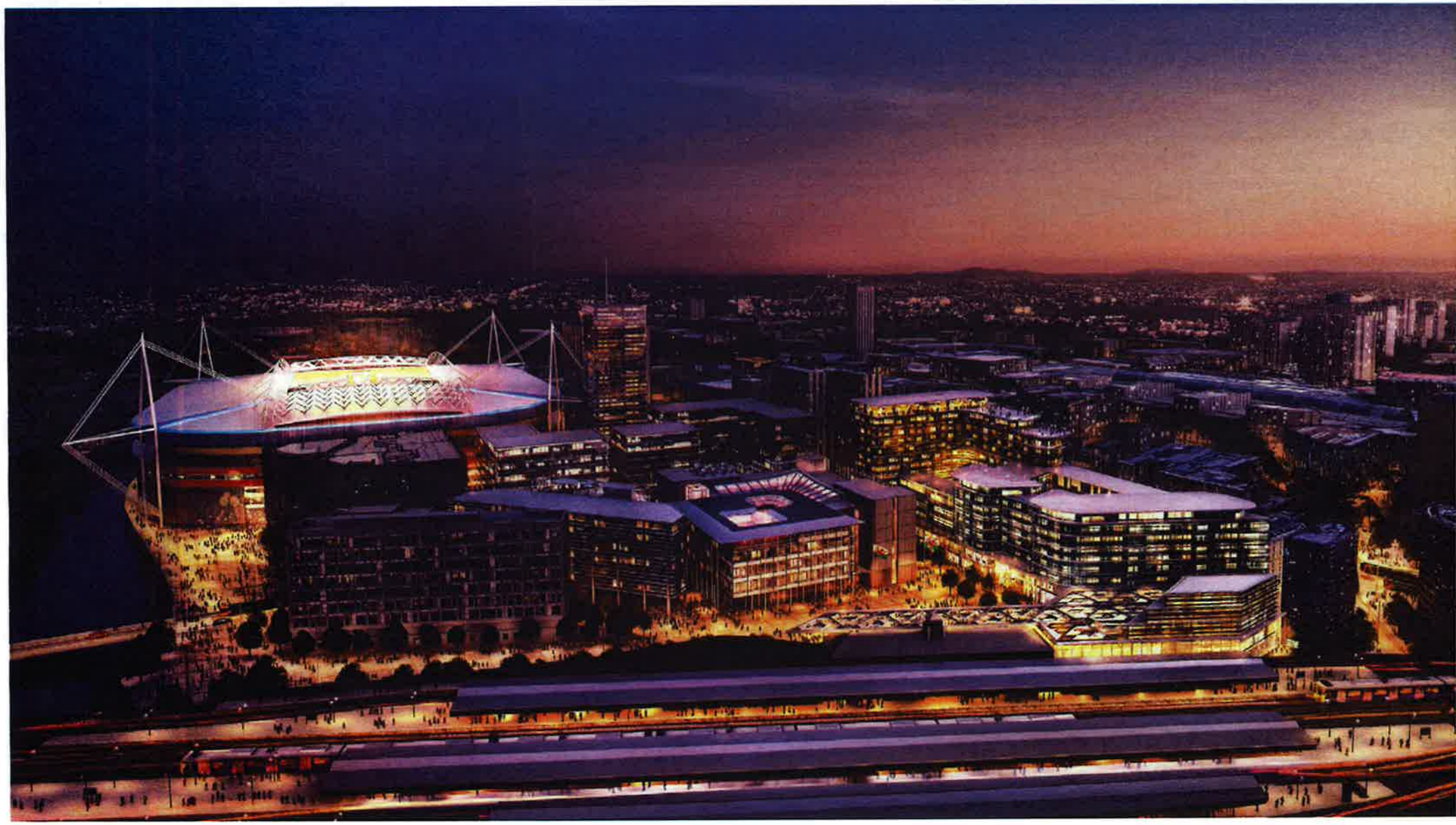


Provide a public **transport gateway** of a **high aesthetic** and **functional quality**, which is commensurate to **Cardiff's status as a European capital city**

Cardiff City Council
Cardiff Local Department Plan 2006 - 2026 Deposit Plan p.147

Buildings don't arise out of thin air.
They are generated by needs, the needs of users.

Research
Executive Summary

Research
Executive Summary

Foster + Partners has always been guided by a belief that the quality of our surroundings has a direct influence on the quality of our lives, whether that is in the workplace, at home or in the public realm. Allied to that is an acknowledgement that architecture is generated by the needs of people – both material and spiritual – and a concern for the physical context and the culture and climate of place. Excellence of design and its successful execution are central to our approach.

We believe the best architecture comes from a synthesis of all the elements that separately comprise and inform the character of a building: the structure that holds it up; the services that allow it to function; its ecology; the quality of natural light; the symbolism of the form; the relationship of the building to the skyline or the streetscape; the way one moves through or around it; and ultimately its ability to lift the spirits. This holistic approach is coupled with a strong commitment to those who commission and use our buildings.

A high degree of personal service, together with respect for the precious resources of cost and time, characterises our client relationships. The scale, diversity and global reach of our projects was unimaginable 40 years ago, yet many of the issues that excited us in the early days continue to inform what we do today. Environmental awareness has always been integral to the practice's culture. We have consistently sought to devise design solutions that use renewable energy sources and reduce carbon emissions.

We work in a spirit of enquiry, challenging preconceptions and testing conventions. The process of 'reinvention' distinguishes much of our work – past and present – and rests on a duty to design well and to design responsibly, whether that is at the scale of an airport or a door handle.

The design of Cardiff Central Square interchange is generated by the needs of users. For some it represents an essential part of their daily life; for others it's a once-in-a-lifetime holiday experience. Every day, thousands of feet and tyres pass through this one space. The challenge lies in understanding who (and how many) will use this space and what their needs will be; tying these together to form an efficient service and an inspiring destination.

For regular users, the design is streamlined for maximum journey efficiency. And for first-time visitors, Cardiff Central provides a welcome to the city: easy access to information, amenities and travel options. As a place of work, Cardiff Central provides a pleasant environment and essential facilities for the hundreds of drivers and operational staff. A functional, high-quality transport interchange to optimise operational efficiency, drive revenue and maximise customer satisfaction.

Commuters tend to prioritise convenience and connectivity; business travellers demand comfort and efficiency; leisure travellers require accessibility and amenities; non-travellers, such as meet-and-greeters, demand a secure and attractive environment.

A public transport hub that priorities access for all, including wheelchair users, young families and those with luggage.

Our design process has been one which has embraced numerous site visits, model making, sketching, interviewing, 3D design and research, the rigor with which we have approached the project has been demonstrated in the end result.

Integrated transport hub

- Easy interchange of passengers between national, regional and local rail and bus services
- Clear signage and way finding
- Real time information screens
- Central information point and ticket office
- Level access
- Clean, reliable and convenient travel experience
- 24/7 access
- Operational on international rugby match days and other events at the Millennium Stadium

Mixed-use building

- Hotel
- Office spaces
- Retail spaces
- Restaurants and food hall with premier views over new Central Square
- New cycle hub with safe and secure storage facilities for bicycles
- Amenities for travellers such as food and beverage convenience stores and restaurants
- Mix of uses ensures a lively and vibrant atmosphere at all times of day and night

Design for people

- Responding to local needs of users and city in general
- Easy accessibility on foot and by bike
- Satisfies access needs of all users
- High quality passenger facilities including seating, central information point, public toilet facilities
- High quality staff amenities
- Enclosed and heated waiting areas for bus station users to
- Wait, rest and enjoy

Response to context

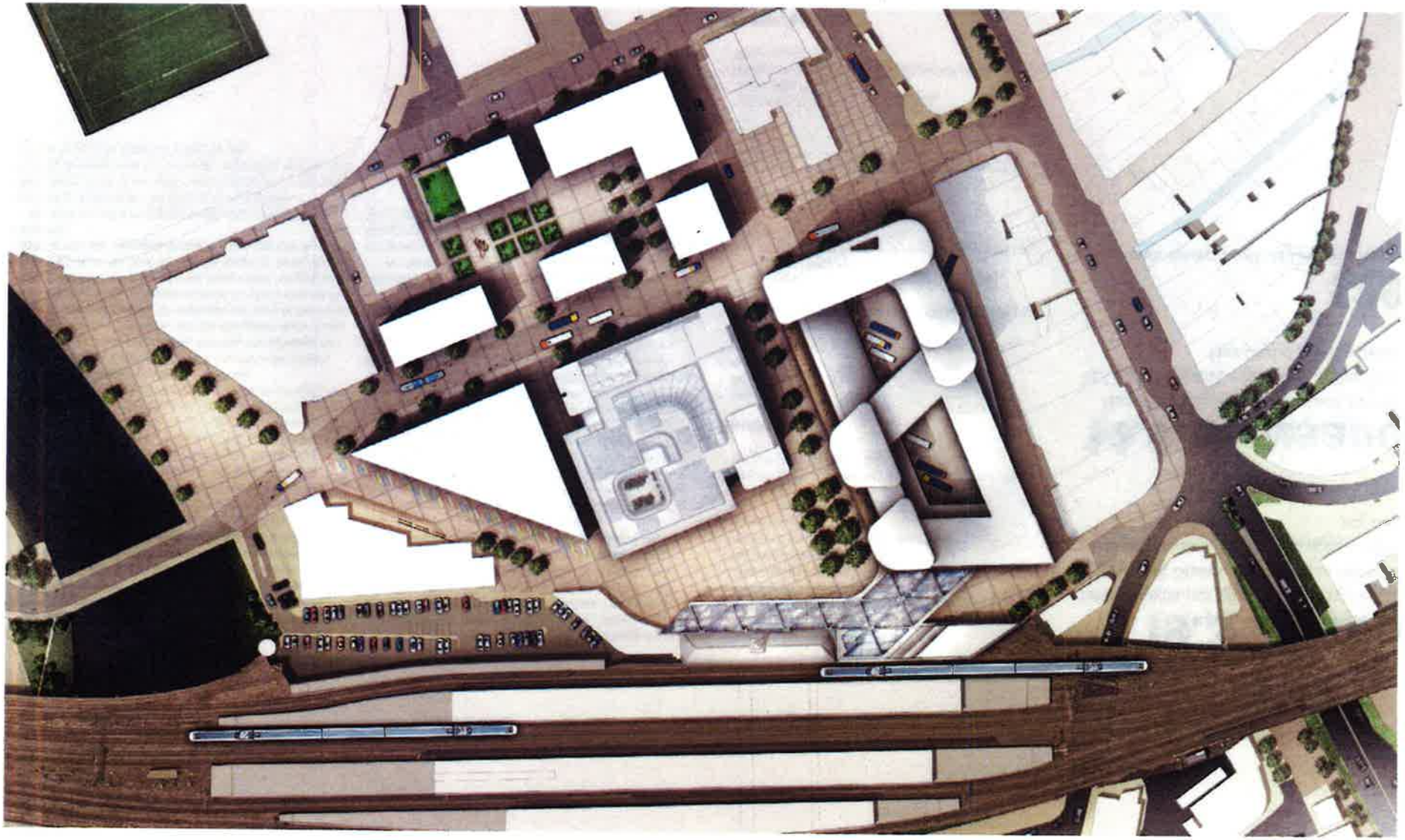
- Enclosed building with natural supervision increases levels of security
- Integration with development in surrounding urban areas
- Convenient and efficient accessibility to city centre and other parts of Cardiff and Wales
- Provision of high quality, well-designed public transport hub which is appropriate for Cardiff's status as a capital city
- Contributes to an attractive, legible and vibrant urban environment
- Flexible design for future

19.3 million
Entries/exits per year by 2023 at Cardiff Central Rail Station according to Network Rail estimates (which averages 52,876 per day)

14.6 thousand
Bus and coach journeys made per day at Cardiff Central, according to the 2014 Bus Station Consultation

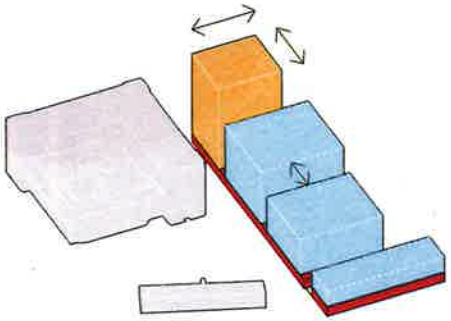
500
Bus drivers work at Cardiff Central

The Proposed Masterplan



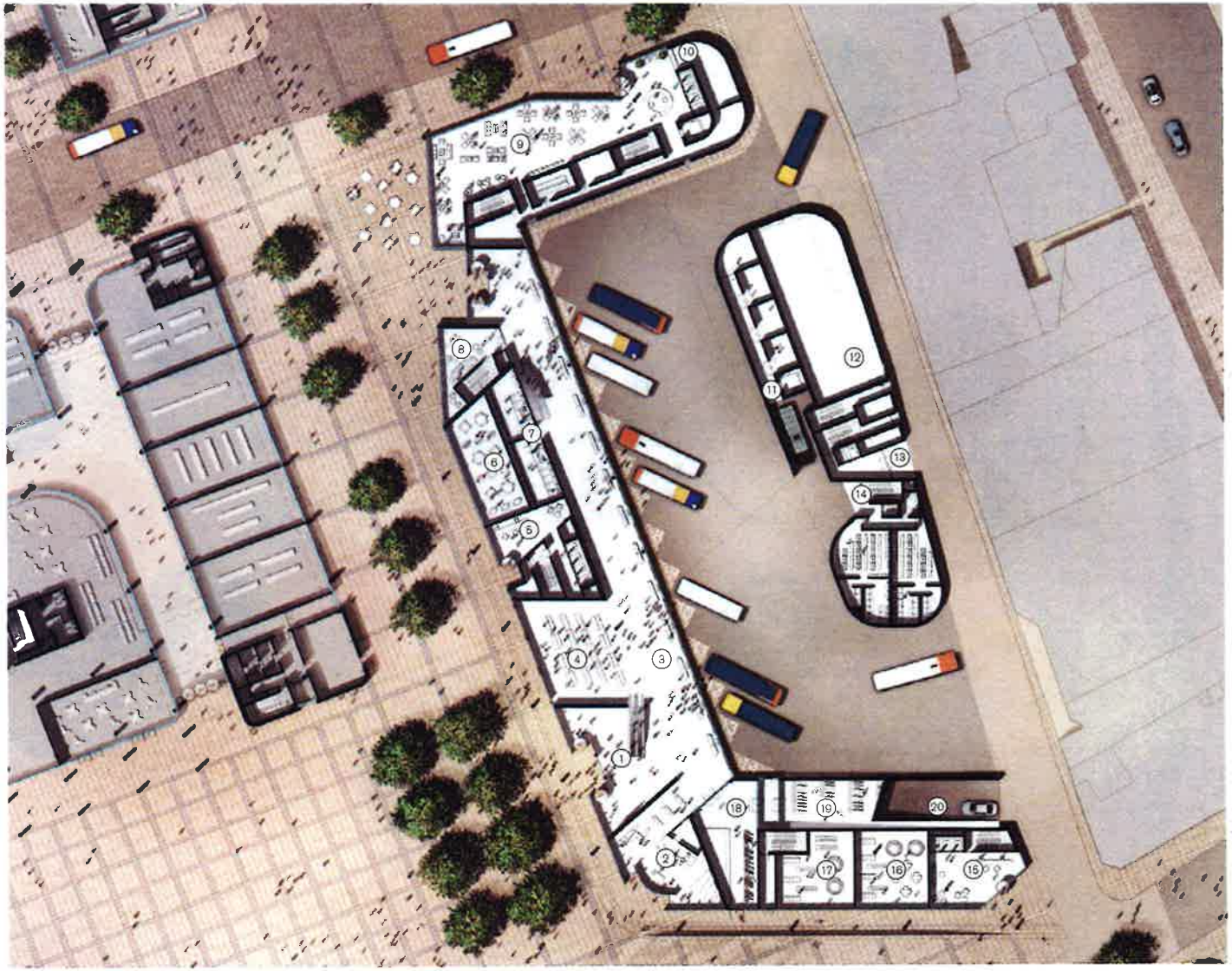
Central Square Interchange

Research
The Site



The original master plan proposed a succession of blocks declining in size and scale from the north to the south. The new proposal builds upon this first idea initially wraps around the bus stands to create a permeable city block before covering over the whole and forming the Interchange. The massing of the new block follows the first principles as illustrated above but connects the mass, and in doing so slims the width of the floor plates to a more efficient size and practical dimension.

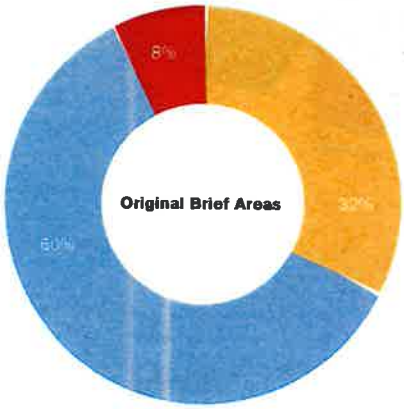
1. Main entrance
2. Information Centre
3. Concourse
4. Market stalls
5. Office lobby 1
6. Cafe 1
7. Toilets
8. Cafe 2
9. Hotel Lobby
10. Hotel reception
11. Loading bay
12. Substation
13. Residential Entrance
14. Bus staff facilities
15. Office lobby 2
16. Retail unit 1
17. Retail unit 2
18. Bicycle hub
19. Bicycle storage
20. Car Park Pamp

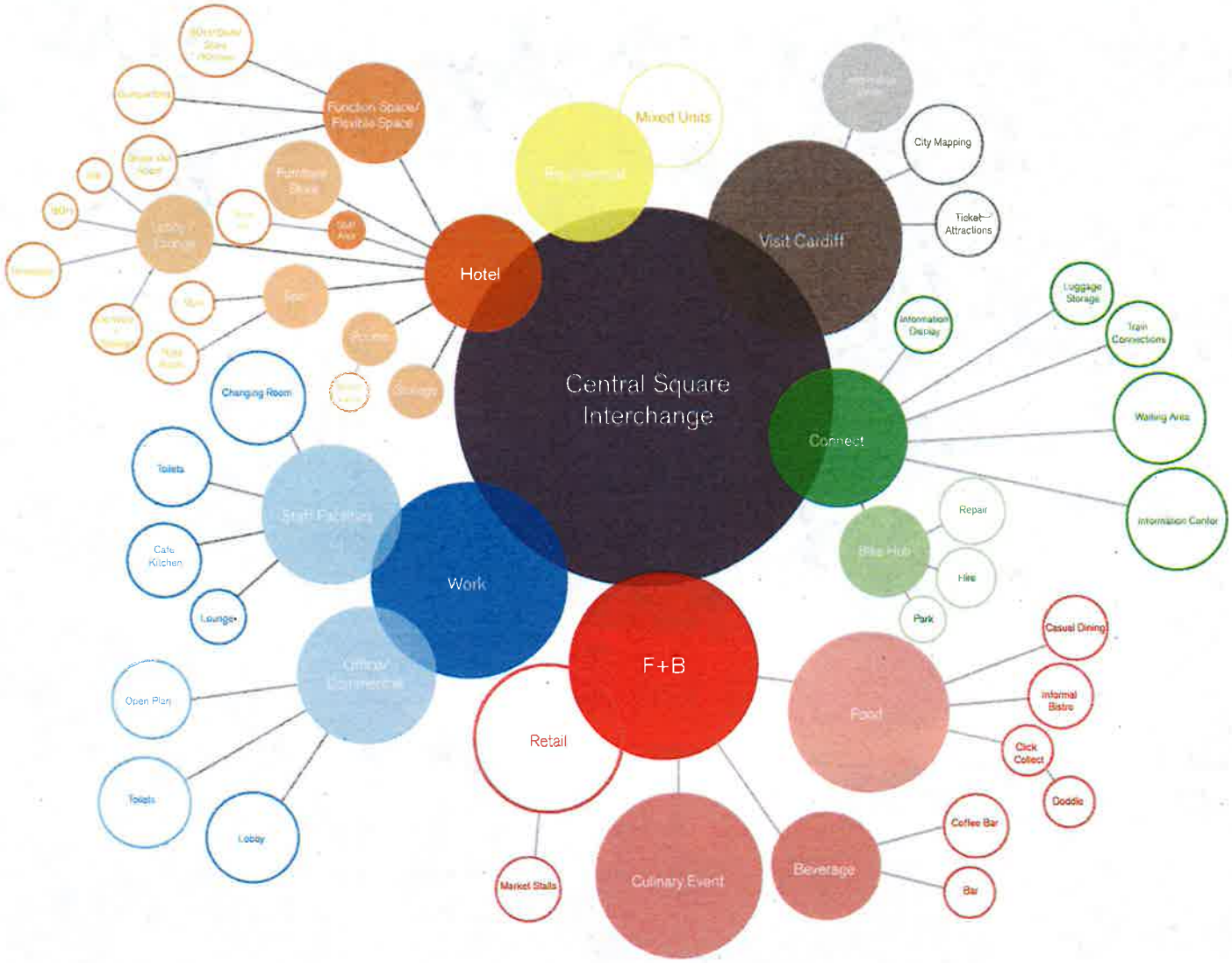


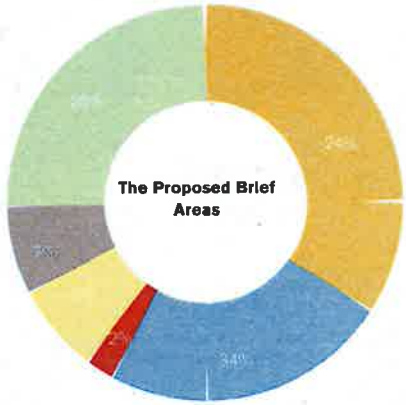
The Brief

A client brief begins the design process, but within the concept design time we also investigate the requirements and desires of the myriad of users that will occupy or we attract to the proposal. This information adds depth to the brief and aids the design process.

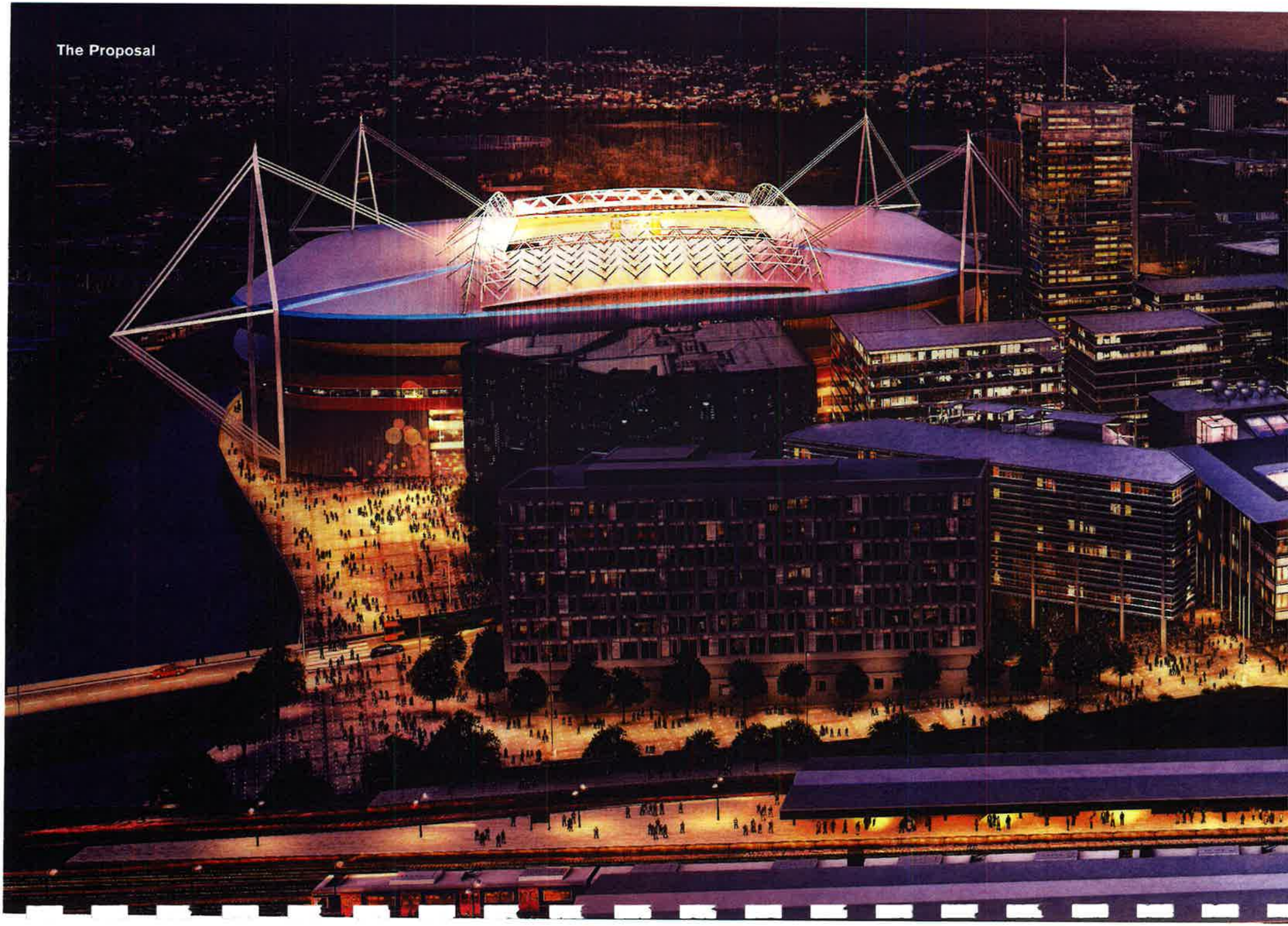
Central Square, and the environment that the masterplan aspires to create all form part of the new brief for the Interchange building. The growth of Cardiff and the future plans from the City Council are woven into the scheme from the outset. The diagram to the right visibly demonstrates how these users and their requirements become the central brief for the project

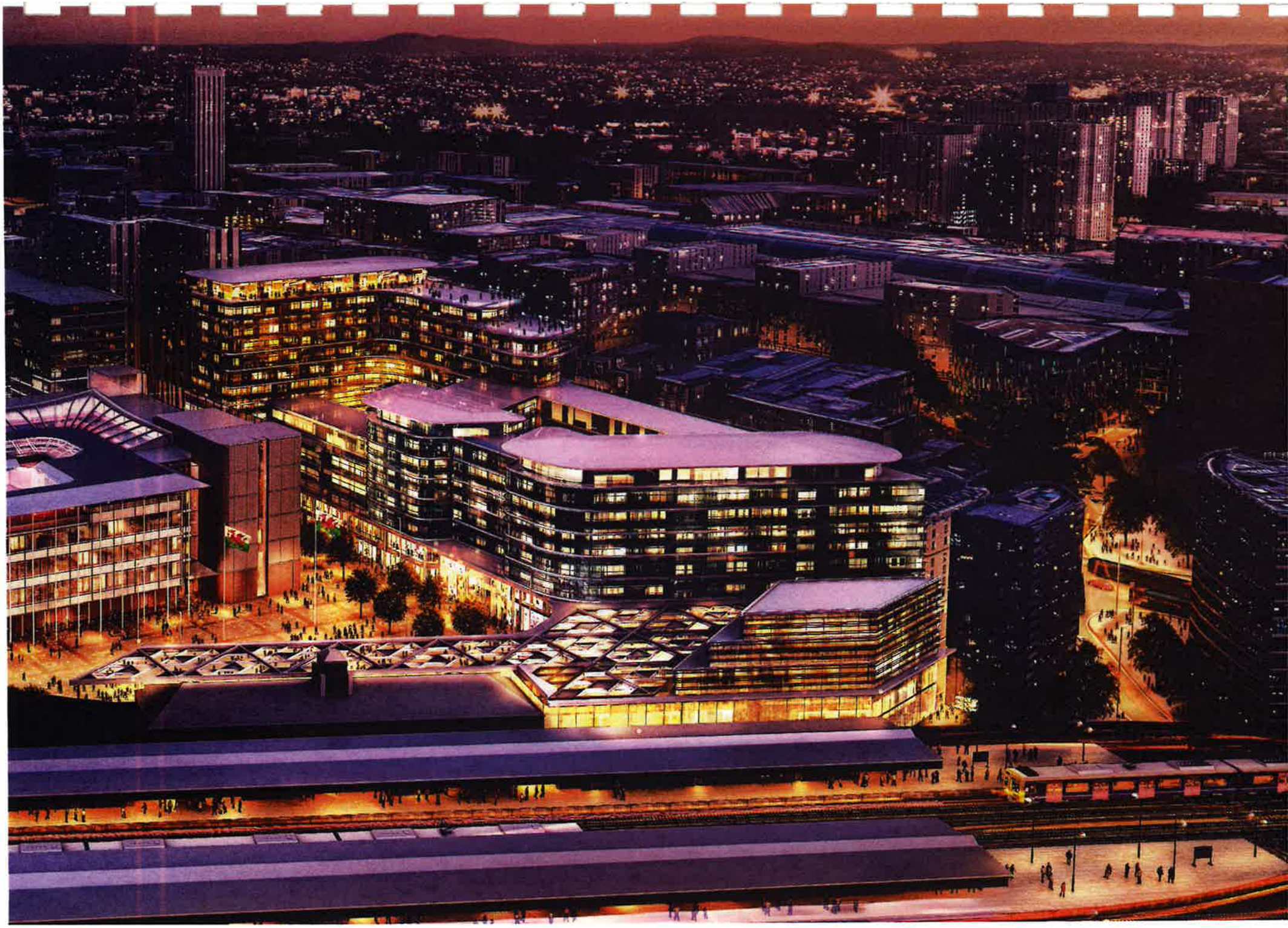






Central Square Interchange

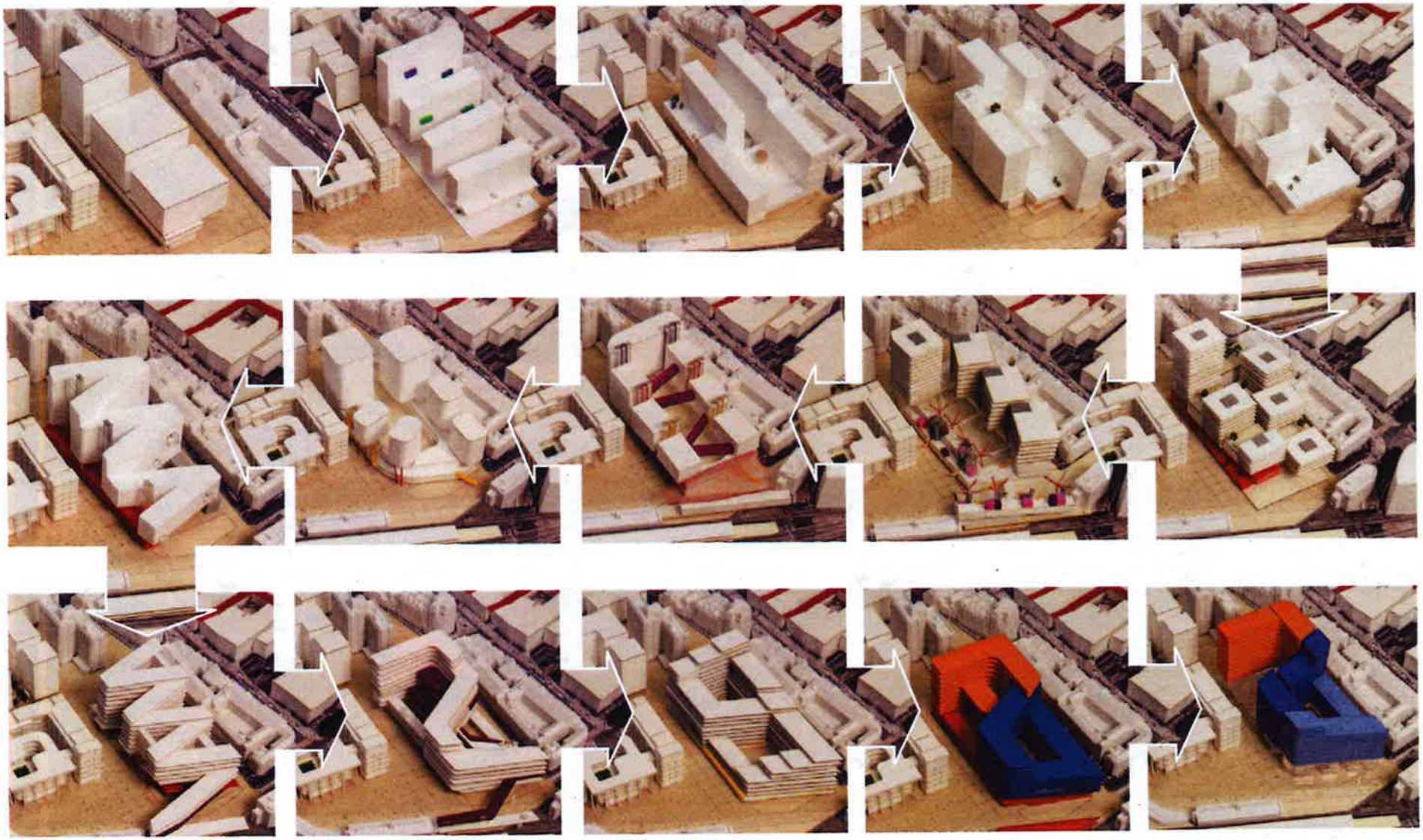




The **new Transport Hub** will provide **a world class gateway into the city**, interlinking travel by train and bus, as well as providing pick up and drop off areas ensuring easy access for cyclists, taxis and pedestrians. This is an exciting development and a key priority for this Council which will significantly improve journey times; make public transport more viable and a more enjoyable experience for all.

Cllr Phil Bale, Leader of Cardiff City Council
http://www.cardiffnewsroom.co.uk/index.php/archive/97-revealed-new-bus-station-earmarked-for-north-of-the-railway-line

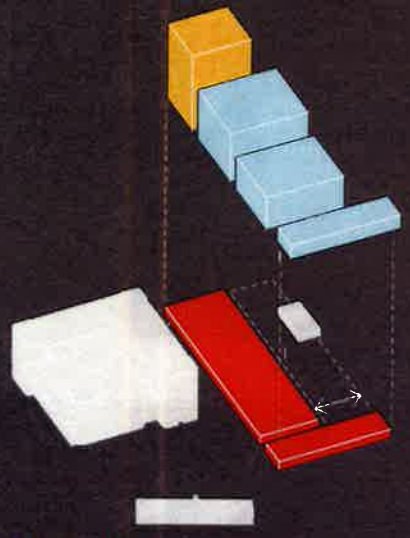
Design
Model Development



Central Square Interchange

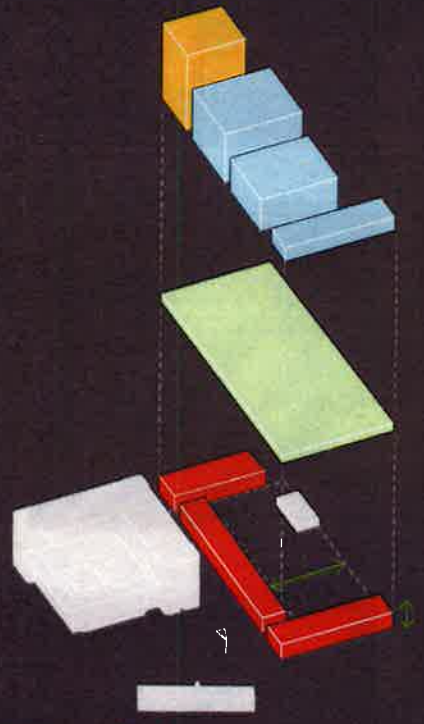
Design

Forming the Interchange



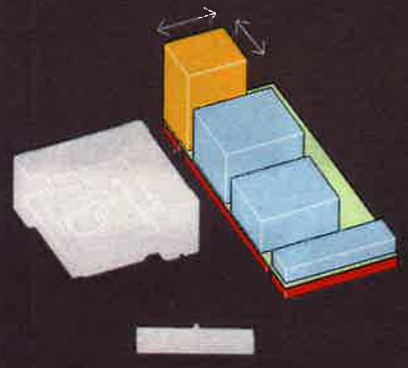
1 Original Proposal

- Small width of bus station



2 Efficient Bus Layout

- Unify roof = creating destination point
- Introducing efficient bus station layout



3 Urban Form

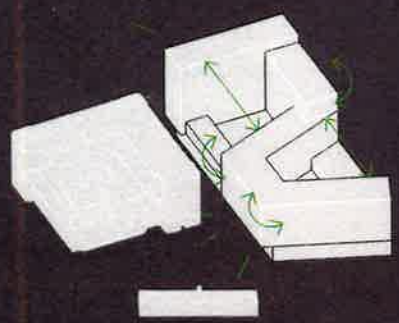
- Too dense
- Deep floorplate
- Central core
- Cover the interchange with new unifying roof to enable new functions on top

4 Hotel Brief

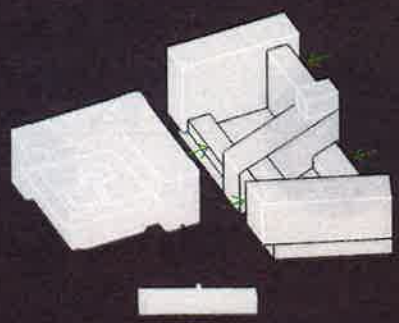
- Efficient width of the floorplate
- Appropriate facade orientation

Design

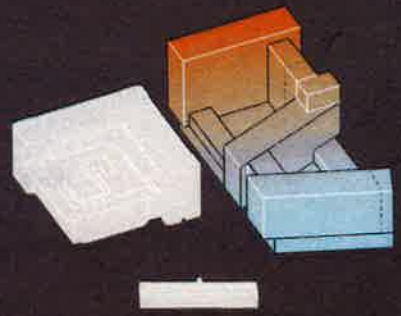
Forming the Interchange



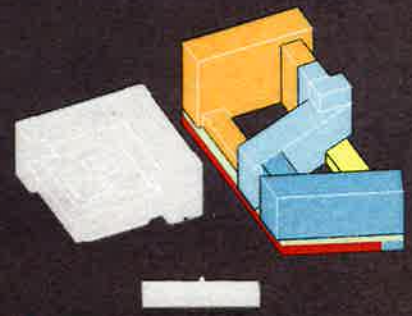
- Respecting Wood Street
- Creating an edge to a square
- Providing efficient distance between volumes



- Visibility of the entrance
- Increase permeability



- Can be split as per function requirements



- Functional split

Hotel Interchange Residential F+B Office

Design
Function

Design Function - Principles

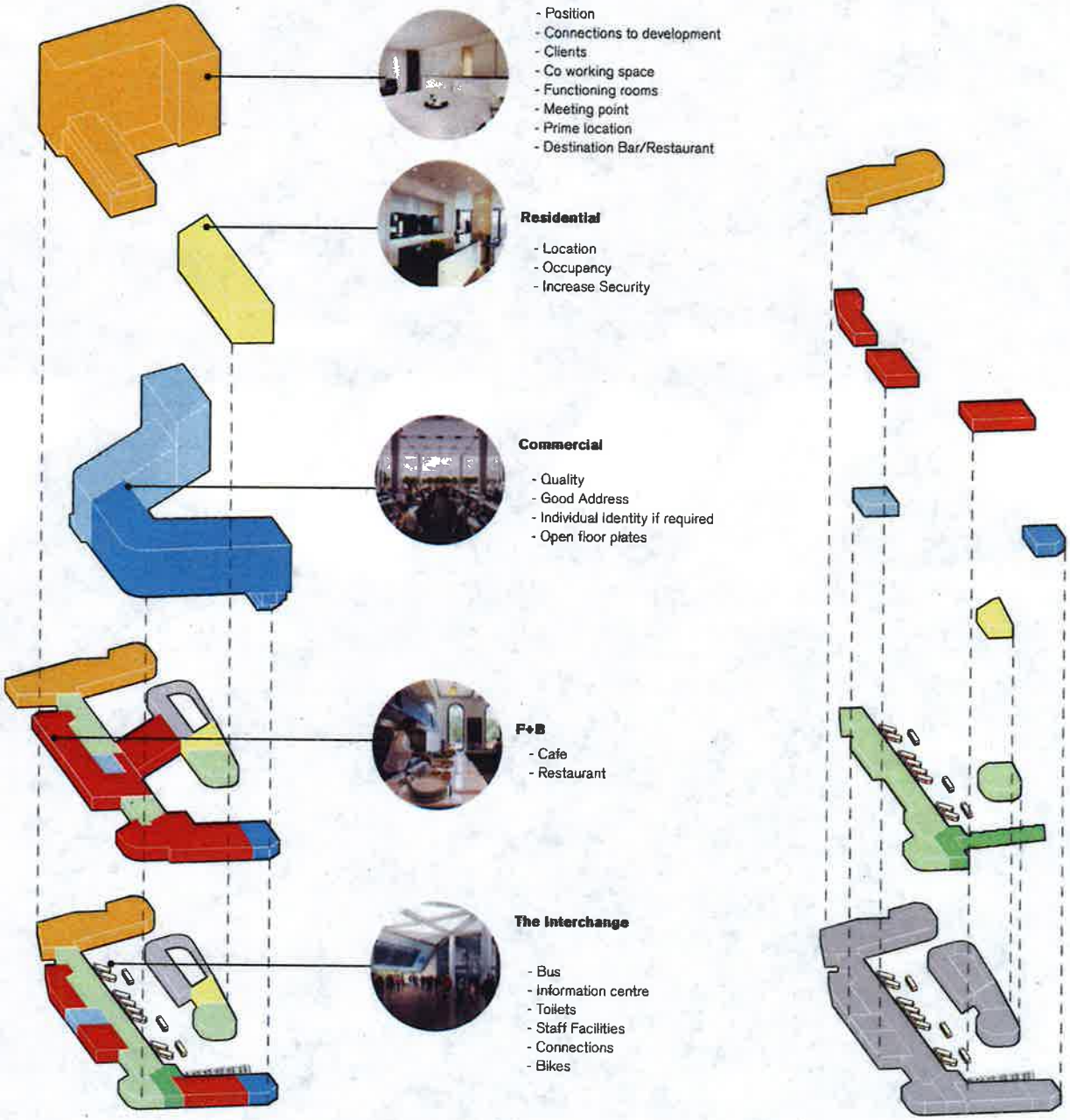
The site has a rich mix of uses and a very broad mix of users. In effect, we are creating a micro-city; with public spaces, transport hub, residential spaces, offices, hotel and retail. The challenge lies in designing a space that is both a gateway to the city and a highly functional interchange; fitting in with the urban grain whilst fulfilling a number of demanding operational requirements.

The importance of creating a new civic building that becomes a welcome addition to the public life of Cardiff was one of the most important factors in the design process.

The team made a number of key structural decisions at an early stage in the project in order to meet the challenge of creating a new civic building with the need for commercial functionality. A series of design sessions with foam and cardboard led to the creative solution of the unifying roof - a structural deck at the second floor level that acts as a layer between the public functions at ground and first, and the commercial functions above.

Drawing clear connections between ground and first floors has been central to the design process. The necessity of ground floor addresses for the hotel, office spaces and the residential portion of the scheme naturally puts pressure on the footprint area. We have designed split-level spaces which maximise spatial efficiency and tie the two levels together. Knitting together all the functions has created a ground floor plate that is multi-functional and will have a 24hr life.

The addition of a first floor connection to Plot 13B becomes a viable part of the scheme, whilst not hindering the development of the building as a 'standalone' development if required.



Hotel

- Position
- Connections to development
- Clients
- Co working space
- Functioning rooms
- Meeting point
- Prime location
- Destination Bar/Restaurant

Residential

- Location
- Occupancy
- Increase Security

Commercial

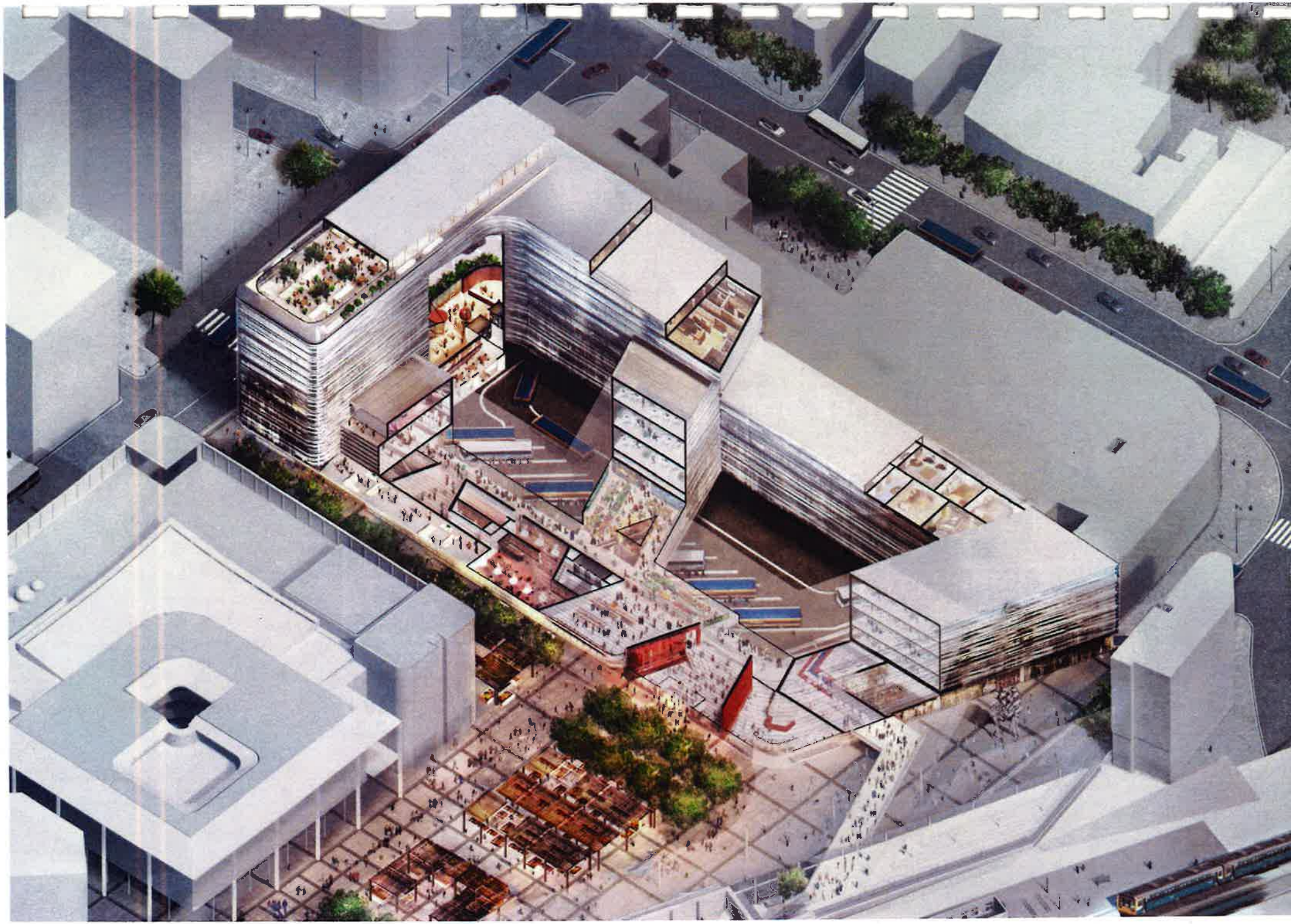
- Quality
- Good Address
- Individual Identity if required
- Open floor plates

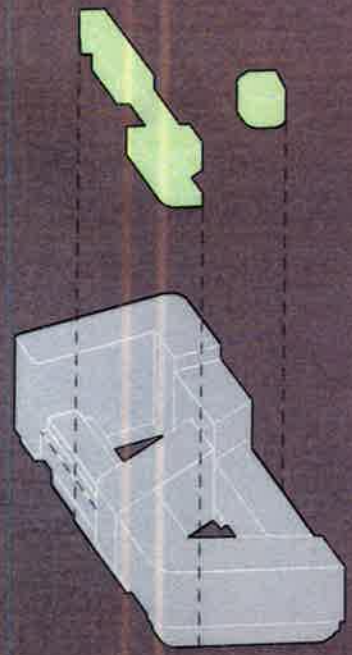
F+B

- Cafe
- Restaurant

The Interchange

- Bus
- Information centre
- Toilets
- Staff Facilities
- Connections
- Bikes



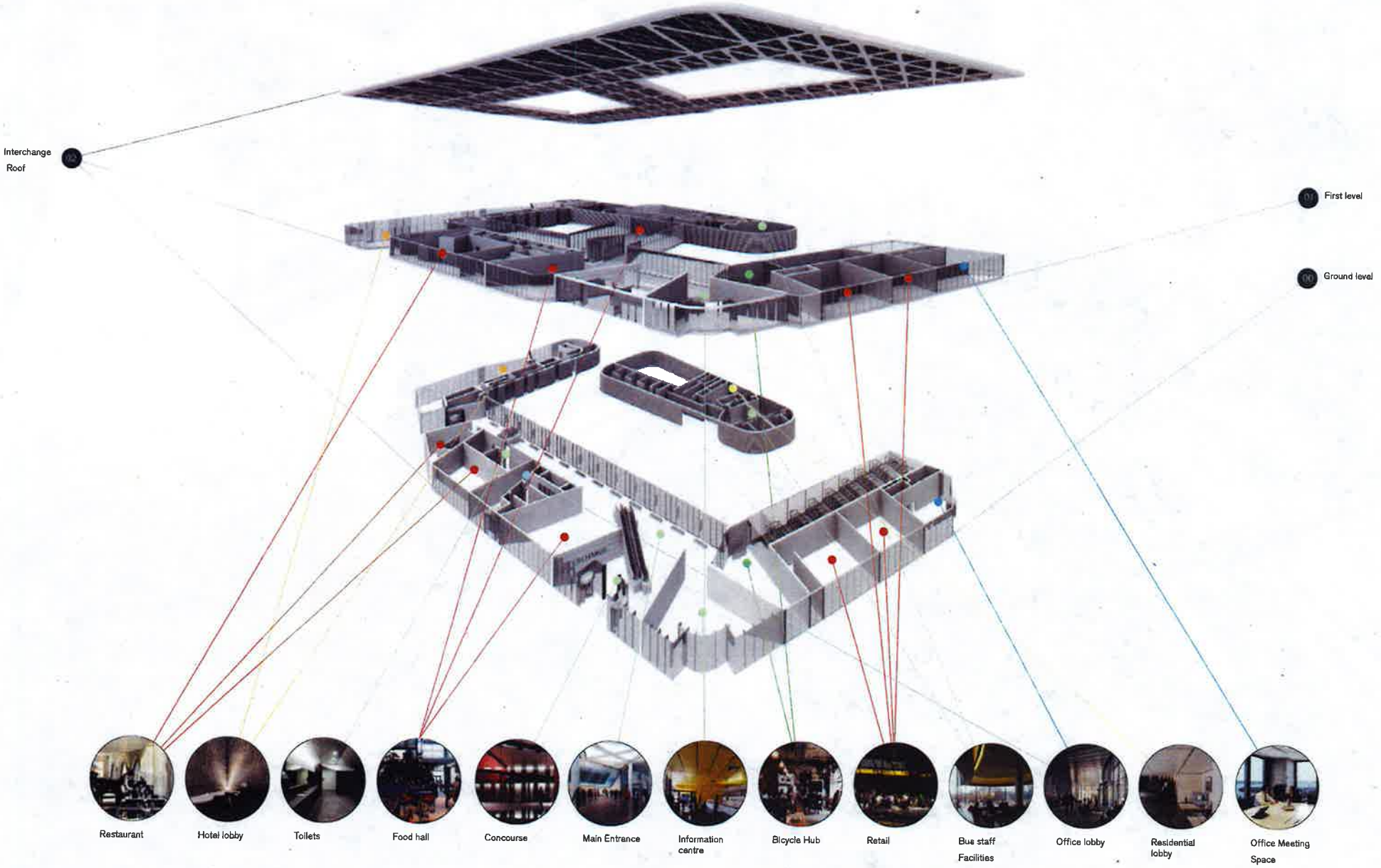


Information + Interchange + Investment + Imagination = Integration

The other basic factor in providing an enjoyable traveller experience is easy. Easy is probably the most significant objective in integrated public transport.

Professor Stuart Cole CBE
Emeritus Professor of Transport, Wales Transport Research Centre, University of Glamorgan
Briefing Paper for National Assembly for Wales Enterprise and Business Committee Integrated Public Transport Inquiry November 2012

Design
Interchange



Design
The Interchange

Bus Station
The current situation at the bus station is clearly very negative, the new proposal contains a number of vital parts of design which will create a more successful and secure space for all the users. The indoor waiting area and concourse is a major part of creating a more inviting environment. Psychologically entering a building is a very different experience to waiting in a windy and open sided bus shelter and public behaviour patterns will be expected to change due to this and the increased surveillance that is possible in the well-lit and warm concourse.

Passenger Experience
Cardiff Central is the first point of contact for many visitors. This is more than a bus station; it's a welcoming advertisement for Cardiff, Wales and the UK. Providing a centralised, visible information centre creates a welcoming first impression for visitors and leads to greater efficiency from both the visitor and the operational sides of the equation. Designing an interchange for Cardiff involves making the experience as easy as possible for users. Recent surveys conducted in order to find out what areas were of most importance to the public concluded the following:

Staffed Presence
93.5% rated as important or very important

Seated Waiting Area
95% rated as important or very important

Real time Information displays
96.5% rated as important or very important

Toilets
Public toilets are a much needed facility in the area. The current situation is appalling and contributes negatively to the first impression of Cardiff. A new Interchange will require a level of public toilets, the number of which will be determined at the next stage.

Staff Facilities
The current staff facilities for the drivers, management, and organisational team behind all of the bus and coach operations out of the current bus station are a disparate and disconnected collection of buildings. The toilets, rest areas and central office are not all in the same building. Bring all of the various functions and requirements together in one new hub, and placing it within the heart of the Interchange will bring improved efficiency, well rested and happy drivers and increase security within the Interchange as there will be a 24hr staffed presence at the station.

Bike Hub
The inclusion of a bike hub within the Interchange adds an important new dimension to a public interchange building. A 24hr access secure bike park with associated bike repair shop and mini café will create a new hub not only for the daily commuters who can leave their bicycle to be fixed after they have boarded the train, but also for general cyclists within the Cardiff area.

Design
Information Centre and Ticket Hall

Current Situation

With over 1 million arrivals at Cardiff Central Station every year the site is at a key point for the multitude of visitors that arrive by rail and coach in to the heart of the city. However the current location of the key visitor and travel information points detached from the arrival and departure point does not aid smooth travel or a legible visitor hub.

Making the user experience as easy as possible

Providing a centralised, visible information centre creates a welcoming first impression for visitors and leads to greater efficiency for all. Cardiff Interchange must deliver an experience that is as easy as possible for users: whether a first-time or frequent user.

Visitors, particularly those coming from overseas, need to know more than simply how to undertake the first stage of their journey. They need to know how to travel beyond any given intermediate transfer point and on to their chosen destination.

Professor Stuart Cole
Welsh Transport Centre

A central information point for all travel services

The range of service providers at Cardiff Central is broad. This is an inter modal transport hub, with multiple service operators for each transport type. One point of enquiry for both city, station and travel contributes to the seamless integration of these essential services. Co-locating them at the point of departure or arrival streamlines the visitor experience.

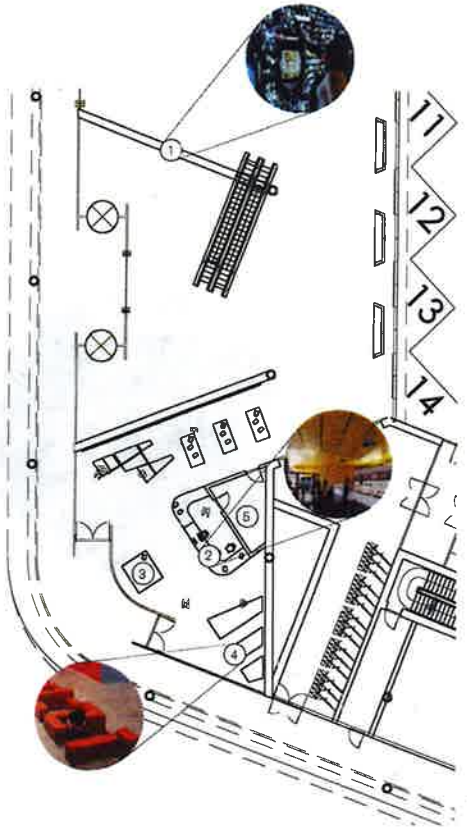
A gateway to the city

Cardiff Central is the first point of contact for many visitors. This is more than a bus station; it's a welcoming advertisement for Cardiff, Wales and the UK. What are the primary requirements of people when they arrive in the city? What information might be helpful in between journeys? How can we enhance the image of the city?

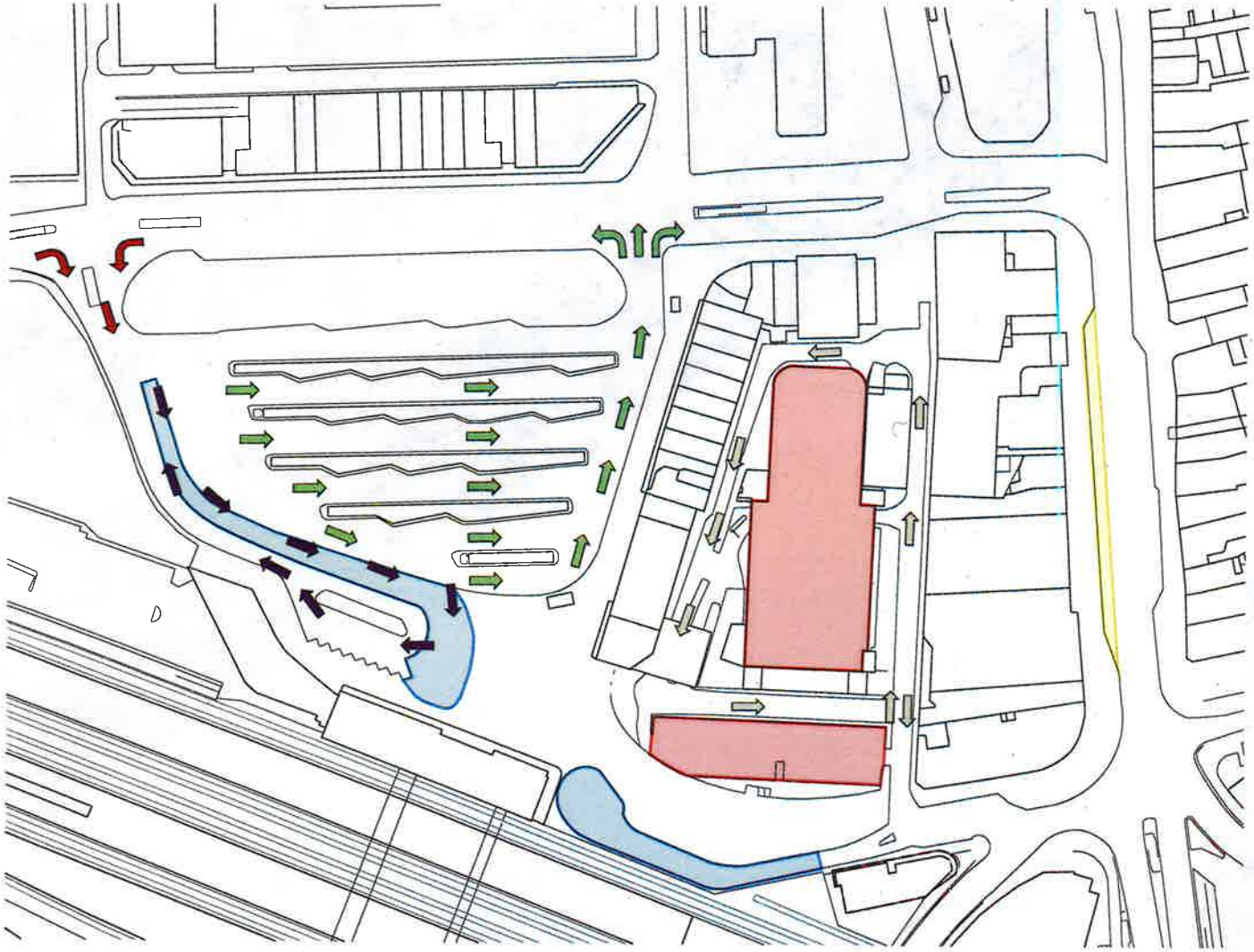
What about the impact of digital services?

Establishing a healthy balance between 'people' services and 'digital' services is essential to catering to the needs of all users now and in the future. In the design of the Information Centre, we have considered research that indicates a staffed presence is key for users; according to the 2014 Bus Consultation, 93.5% of respondents rated this as important or very important. We have also taken into account services such as self-service ticket machines, the iff app and Traveline Cymru which offer additional means of accessing information both in and out of the interchange.

1. Feature Information Wall
2. Information Feature Desk
3. Presentation Table
4. Seating
5. Storage Room




On Time
On Time
No 24
12
PASTA
PASTA



Existing Situation

At present, buses, taxis and cars enter Cardiff Square from Wood Street, with buses turning left into the bus station and taxis and cars proceeding to the taxi rank and short stay parking area.

Conflict occurs between taxis and buses when taxis queue to access the rank and block the entry to the bus station. Congestion occurs within the taxi rank and short stay parking area due to vehicles accessing the area resulting in conflict with buses, as once this area reaches capacity, cars and taxis queue along the same section of road as buses accessing the bus station.

Buses exit the bus station to the east, from a bus only exit arm of a signal controlled junction with Wood Street and Havelock Street. The various movements performed by taxis, cars and buses are shown in Appendix A.

Great Western Lane is a one way access road, accessible from Saunders Road to the south. The lane is used to access the NCP Wood Street car park and by servicing vehicles accessing rear of units facing onto St Mary Street, Wood Street and Cardiff Central Square.

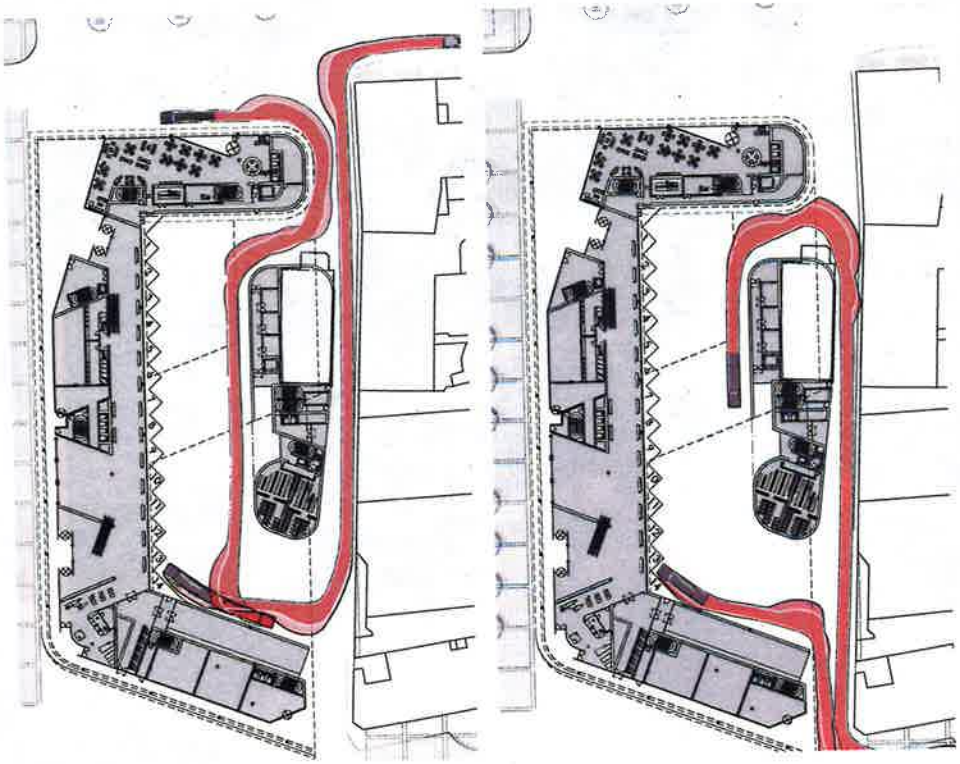
At present, there is no vehicular link between Great Western Lane and Wood Street.

Along the section of Great Western Lane running to the rear of the buildings fronting onto St Mary Street, there are loading bays used for servicing these units. The bars, clubs and pubs along St Mary Street have fire exits onto Great Western Lane.

Key

- Current one way servicing route along Great Western Lane
- Current bus routing accessing and egressing the station
- Route shared by buses, taxis and cars
- Route shared by taxis and cars
- Taxi Rank
- Car Parking
- Loading Bay

Design
Bus



Normal Day

Match Day

Proposals

'Normal Conditions' Operations

The proposals for Cardiff Central Square include the relocation of bus station to the east of the existing site, to occupy the current location of the NCP Wood Street car park on Great Western Lane. The bus station will continue to be accessed from Wood Street, but the location of the access will shift eastwards, with a new junction linking Great Western Lane to Wood Street across the existing pedestrianised area. The use of Great Western Way assumes it is public highway.

Under normal operations, the access will be two-way, allowing buses to enter and exit via the same junction onto Wood Street. Any junction will need to accommodate the physical geometry to allow bus operations and appropriate signal phasing to permit access and egress to the bus station.

Access to the proposed car parking within the development will continue to be made from Saunders Road / Great Western Lane. The movements associated with the operation of the proposed bus station are shown in Appendix B.

It is proposed that servicing of units along St Mary Street will utilise the existing loading bays situated along the frontage of St Mary Street. In order to maintain the usage of the emergency exits onto the eastern side of Great Western Lane, it is recommended that footways are widened to accommodate this and avoid conflict between pedestrian activity and buses.

'Event Conditions' Operations

On days when there are large events at the Cardiff Millennium Stadium, it is understood that Wood Street and St Mary Street will be pedestrianised to accommodate the crowd flows and management. Under these conditions, buses will not be able to access the bus station through the Wood Street junction. It is proposed that buses will enter and exit the bus station via Saunders Road, the current and proposed access to the on-site car park.

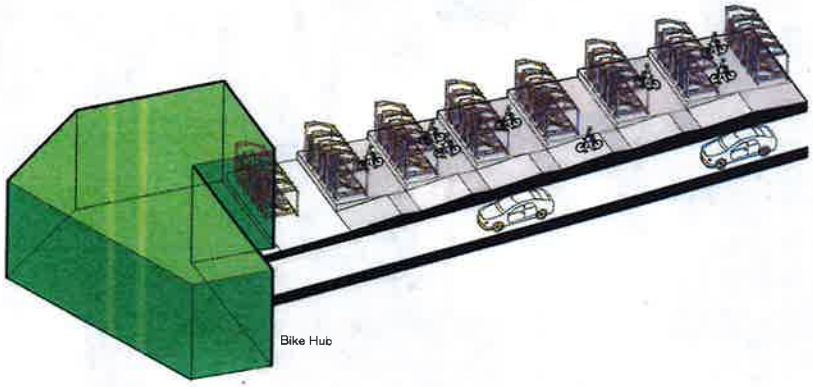
There are some implications in buses utilising this junction under its existing arrangement. Appendix C shows a standard rigid bus manoeuvring this junction, with clear pinch points identifiable as the width of Saunders Road and the access to Great Western Lane.

To allow for the operation of buses through this junction, it is proposed that signals will control the movement of the buses and also the cars entering and exiting via the car park ramp. Detailed assessment of the signal phases is required but it is anticipated that the operation will firstly allow cars and buses to enter Great Western Lane, with cars turning left to access the ramp and buses proceeding to the bus bays. The second signal phase will then allow cars to exit the car park, with vehicles queuing at the signal on the ramp. The final phase will control the buses exiting the bus station, positioned so not to conflict with movement of cars exiting the car park ramp.

The western extent of Saunders Road is primarily used by taxis, accessing the rank to the east of Cardiff Central railway station. Under the proposed arrangement, this rank will be relocated, so will not be in conflict with cars and buses accessing Great Western Lane from Saunders Road.

In addition, the realignment of the radii of the left turn from Great Western Lane onto Saunders Road would be required to allow buses to perform this manoeuvre, as the current arrangement requires a bus to swing across the path of oncoming traffic.


10
Cardiff bus
bws Caerdydd



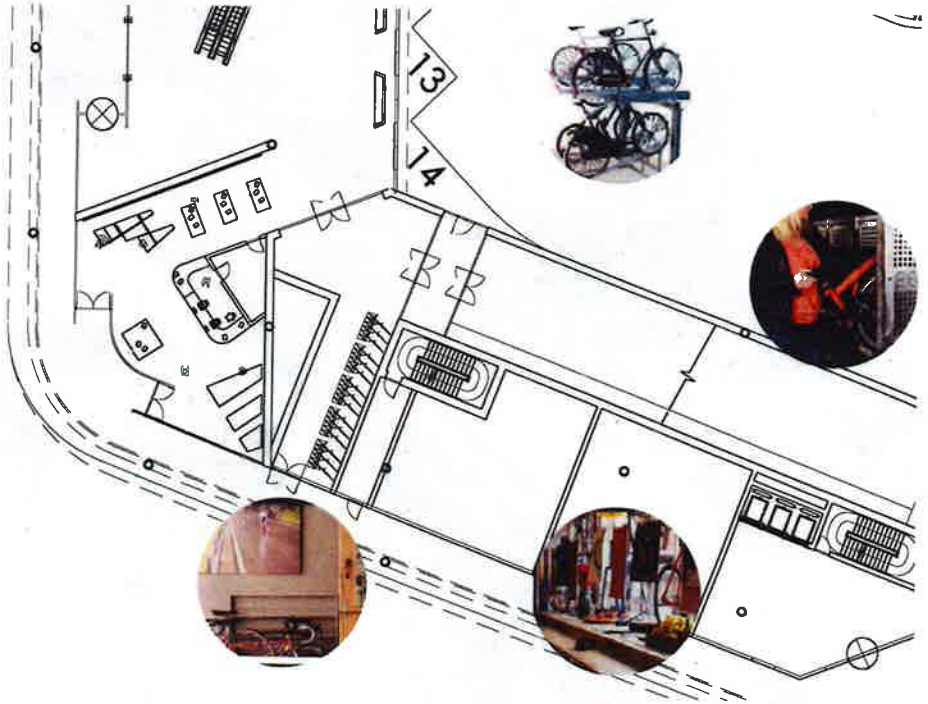
Bike Hub

The Cycle Hub

As part of an integrated transport strategy, we are proposing a new cycle hub is located at the within the Interchange building. The hub will provide secure bike parking and repair services, directly connecting on routes to the Bus Station and Cardiff Central Station. Cyclists enter from Saunders road and proceed through the hub and up a ramp with two-tier bike racks for over two hundred bicycles. This utilises the space above the car ramp leading to the basement. The user can lock up their bicycle using individual access codes and then walk under shelter to the bus concourse or through the interchange to Cardiff Central Station. Visitors to Cardiff could come through the interchange and potentially hire a bicycle before exploring the city.

If the cyclist needs repairs to their bicycle then the repair shop will take the bike, fix the machine and then use the secure lock up to store the owners pride and joy. Sending them an access code for the 24hr door and the bike lock on the stand means that even if the owner is late back and arrives at the Interchange after the shop and cafe have closed they are able to gain access and retrieve their cycle.

The objective of the cycle hub would be to not only provide cycle facilities for locals and visitors, but to create a place that promotes sustainable transport in the city. Workshops, seminars and creating a friendly place for advice about cycling will help increase the number of people using bikes to get around




14

Design
Staff Facilities

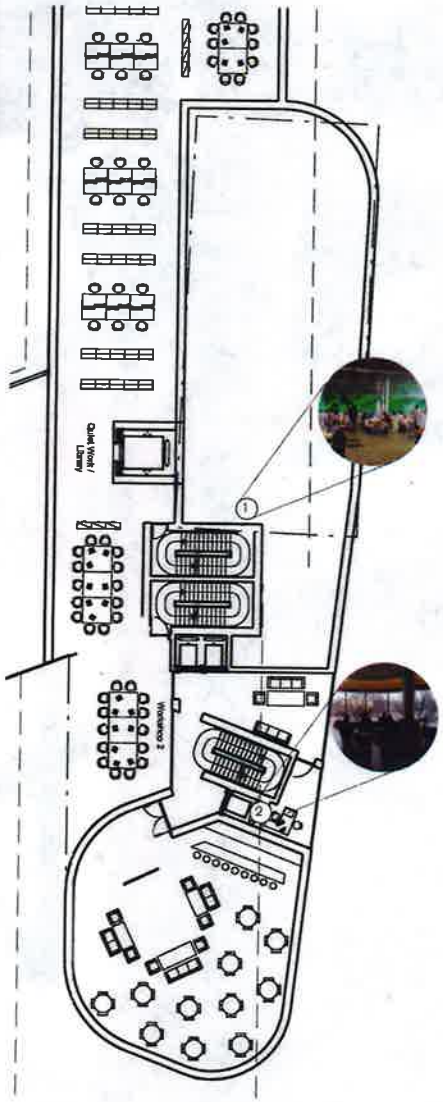
Bringing all of the various functions together in one new hub will improve efficiency, positivity and security; centralising the 24-hour presence at the heart of the interchange. The current staff facilities for the drivers, management, and organisational team behind all of the bus and coach operations out of the current bus station are a disparate and disconnected collection of buildings. The toilets, rest areas and central office are not all in the same building. Bring all of the various functions and requirements together in one new hub, and placing it within the heart of the Interchange will bring improved efficiency, well rested and happy drivers and increase security within the Interchange as there will be a 24hr staffed presence at the station.

In addition to the Control Room, washroom and break out spaces are designed to provide a pleasant environment for the hundreds of staff who consider Cardiff Central Square their place of work. A warm, dry and private space with greatly enhanced facilities, located on the site for enhanced convenience and a greater sense of place.

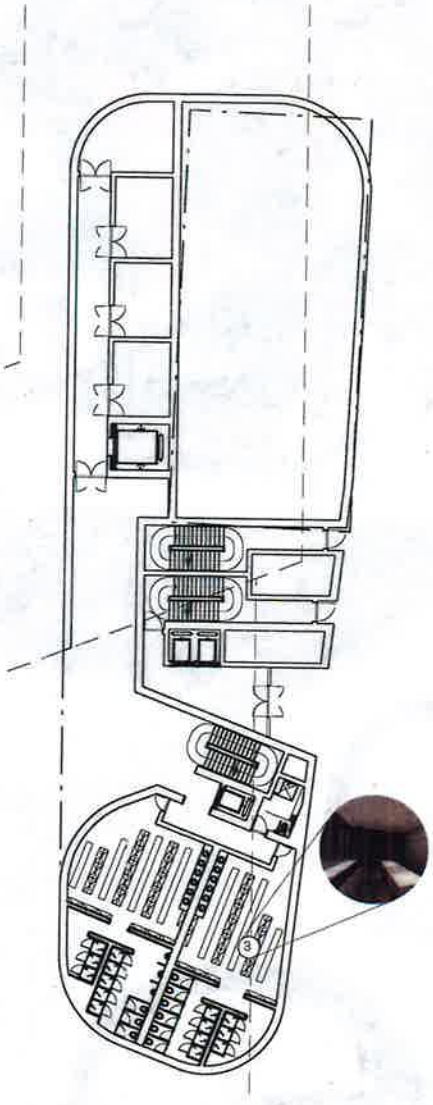
"There are 30 of us here right now, but you're not seeing the full story. There are more than 500 bus drivers in total and there are 100 or so in the area at any one time"

Bus driver, interview

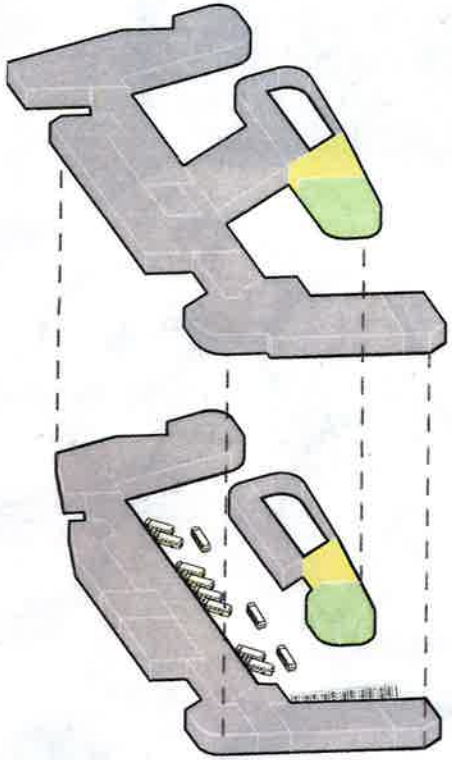
First Floor

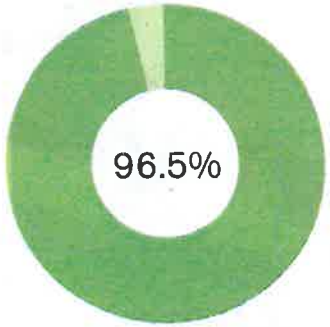


Ground Floor



1. Kitchen/Cafe
2. Lounge
3. Changing Rooms





Accessible, functional design

Situating the toilets adjacent to the concourse makes them convenient for users and easily visible, enabling natural surveillance (to lessen crime, vandalism and unwanted behaviour). Accessibility is a key issue: located on the ground floor, users with mobility problems, buggies or luggage in tow are able to easily access toilets. Cubicles are designed to be spacious enough to accommodate luggage. There is a range of toilet options to meet the needs of multiple users.

You can judge a nation by its toilets

Make a positive impression of Cardiff, Wales and the UK

Economic: attracts footfall and custom

Encourage people to visit, stay longer and spend more money. Vital tc attract custom (according to a survey of retailers and developers)

Environmental: creates sustainable cities

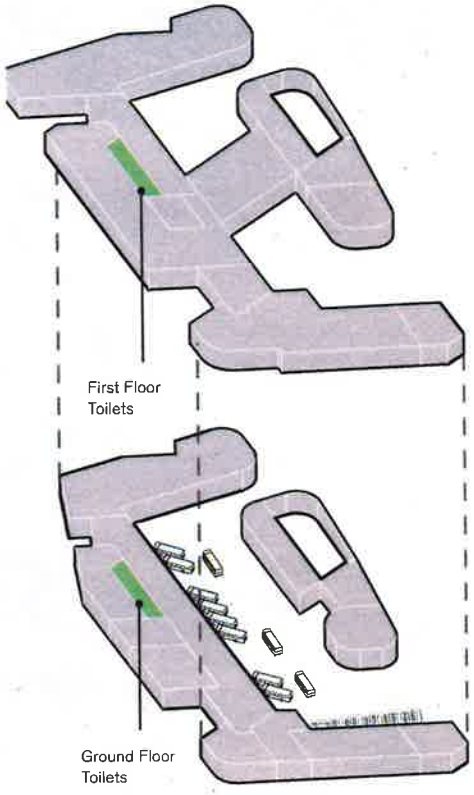
People are more likely to leave their cars at home if public toilets are accessible within walking distance from their destination

Social

Benefits all of society by enabling increased mobility of users especially with adequate provision of accessible toilets

What do users want?

96.5% rated public toilets important or very important (78.3% rated very important) according to the 2014 Bus Consultation.



Public toilets are a much needed facility in the area. The current situation is appalling and contributes negatively to the first impression of Cardiff. A new Interchange will require a level of public toilets, the number of which will be determined at the next stage. Railway stations and central area car parks, for example, are likely to be the main gateways to a city for large numbers of commuters, tourist, shoppers and other visitors and so a high level of public toilet provision is needed. However, local area toilets can be important to significant number of residents. For example, many older people might take a bus to their local shopping centre and need a toilet there, even though they might not have travelled very far, because of the infrequency of bus services and because of the urinary problems that can be associated with old age.

British Standard BS6465:4

Case Study

World Square for All

The 'World Squares for All' masterplan area of Central London is familiar the world over. It contains a World Heritage Site – the Palace of Westminster and Westminster Abbey – and such national emblems as Nelson's Column and the Cenotaph. Yet when this exercise began, its two major civic spaces, Trafalgar Square and Parliament Square, were effectively reduced to traffic gyratories and the area as a whole was largely hostile to pedestrians. The aim was to improve visitor facilities and pedestrian access while enhancing the settings of the buildings, monuments and spaces.

The first phase of the masterplan to be implemented focused on Trafalgar Square. As part of a comprehensive programme of detailed improvements, the northern side of the square in front of the National Gallery was closed to traffic and a wide pedestrian plaza created, which connects via a flight of steps to the central part of the square. Although in architectural terms it is a fairly discreet intervention, its effect has been radical, transforming the experience of the square for visitors and with none of the traffic chaos predicted by the critics. One of the very subtle new features contained within the square is a discrete entrance to a new set of public toilets. The importance of the toilets within the wider masterplan and within the area as whole was considered to be a vital part for the success of the project.


WHOLE FOODS

Design
Retail

It's all about convenience. People don't have a lot of time to spend on shopping. People can pick up their shopping on their way home and in big cities they have everything, coffee shops and restaurants, all in one place

Maureen Hinton, Analyst at Retail Consultancy Conlumino
(Source: The Guardian, June 2014)

Appealing to the broad range of user needs and as part of the strategy to maintain high levels of activity around the clock, Cardiff Central Square has a choice of shops, cafes and restaurants.

Maximum footfall

Retail units are located for maximum footfall along Marland Street Saundes Street.
Access from the platform

Convenience for commuters

The retail strategy for Cardiff Central is to complement existing city shopping areas, with a focus on convenience. Commuters who are short on time demand services that fit around their busy life styles. The focus is therefore on providing retail services such as Doddle, the Network Rail click-and-collect service.

A destination in itself

Increasing dwelling times encourages the sense that this is a destination, not just a place to pass through. More than just an interchange, Cardiff Central Square's range of cafes and restaurants provide travellers with a greater choice. They also draw in non-travelling visitors; at Euston station in London, for example, one fifth of visitors to the station are not travelling.

Appealing to the broad range of user needs and as part of the strategy to maintain high levels of activity around the clock, the Interchange building and Cardiff Central Square have a wide choice of shops, cafes and restaurants. A busy atmosphere creates a vibrant building that attracts customers, increases public transport usage and adds a piece of urban fabric.

Maximum footfall and circulation

The retail units are located for maximum footfall past shops. Shops are visible to customers both on Marland Street and from inside the interchange building for waiting bus users. Shops can be accessed almost immediately from the platforms. Platform and bus visibility encourage browsing in shops whilst waiting as approaching buses can be quickly seen and boarded. A single waiting area concentrates internal circulation.

Convenience for commuters

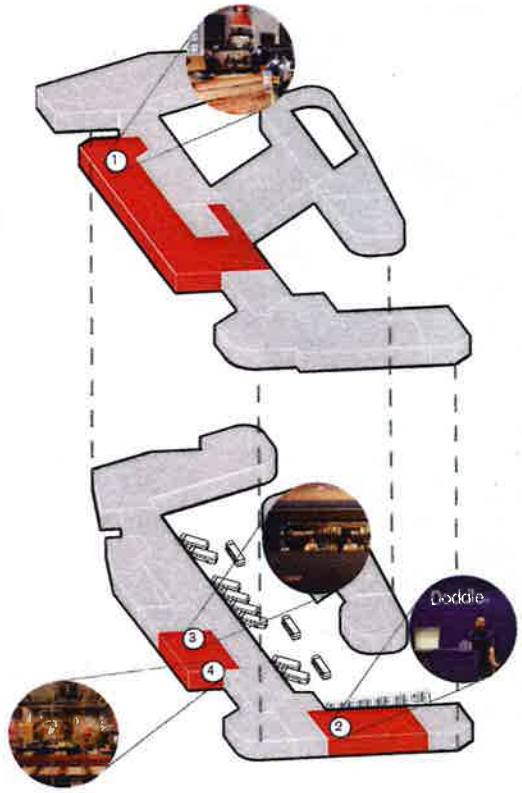
The retail strategy for Cardiff Central is to complement existing city shopping areas, with a focus on convenience. Commuters who are short on time demand services that fit around their busy life styles. The focus is therefore on providing retail services such as Doddle, the Network Rail click-and-collect service. Moreover, it provides key opportunities for everyday shopping needs such as pharmacies and dry cleaners.

1. Coffee Bar

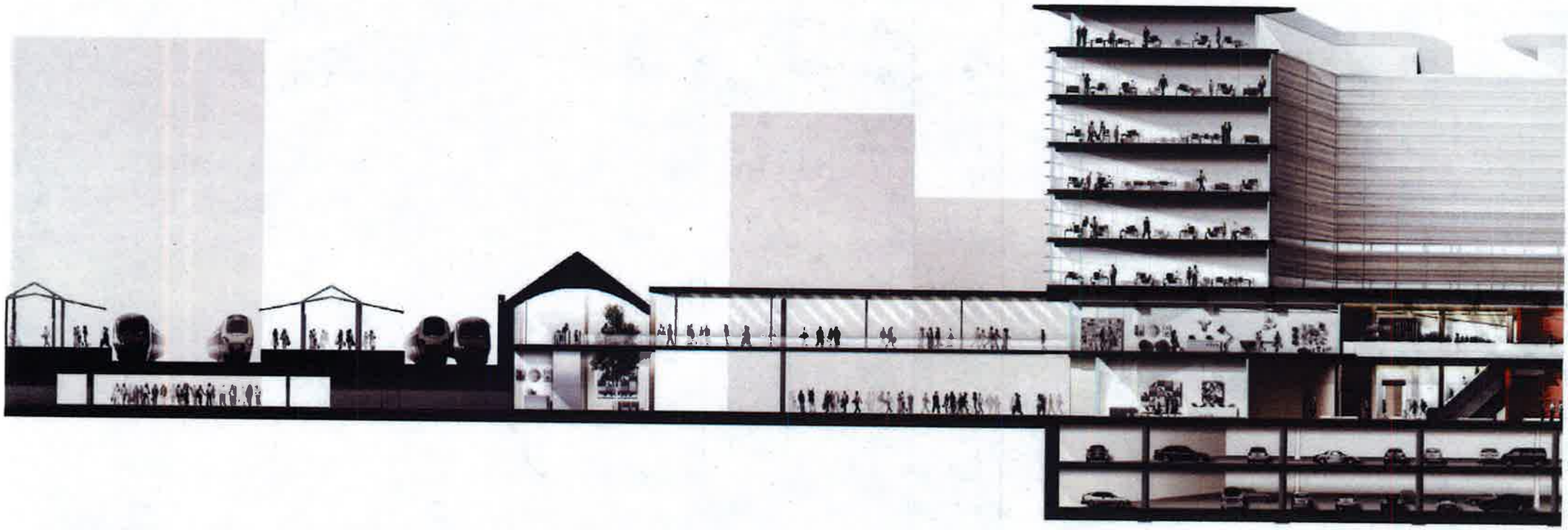
Between 30% and 50% of a station's trading space will be taken up by food and drink outlets
(Source: The Guardian, June 2014)

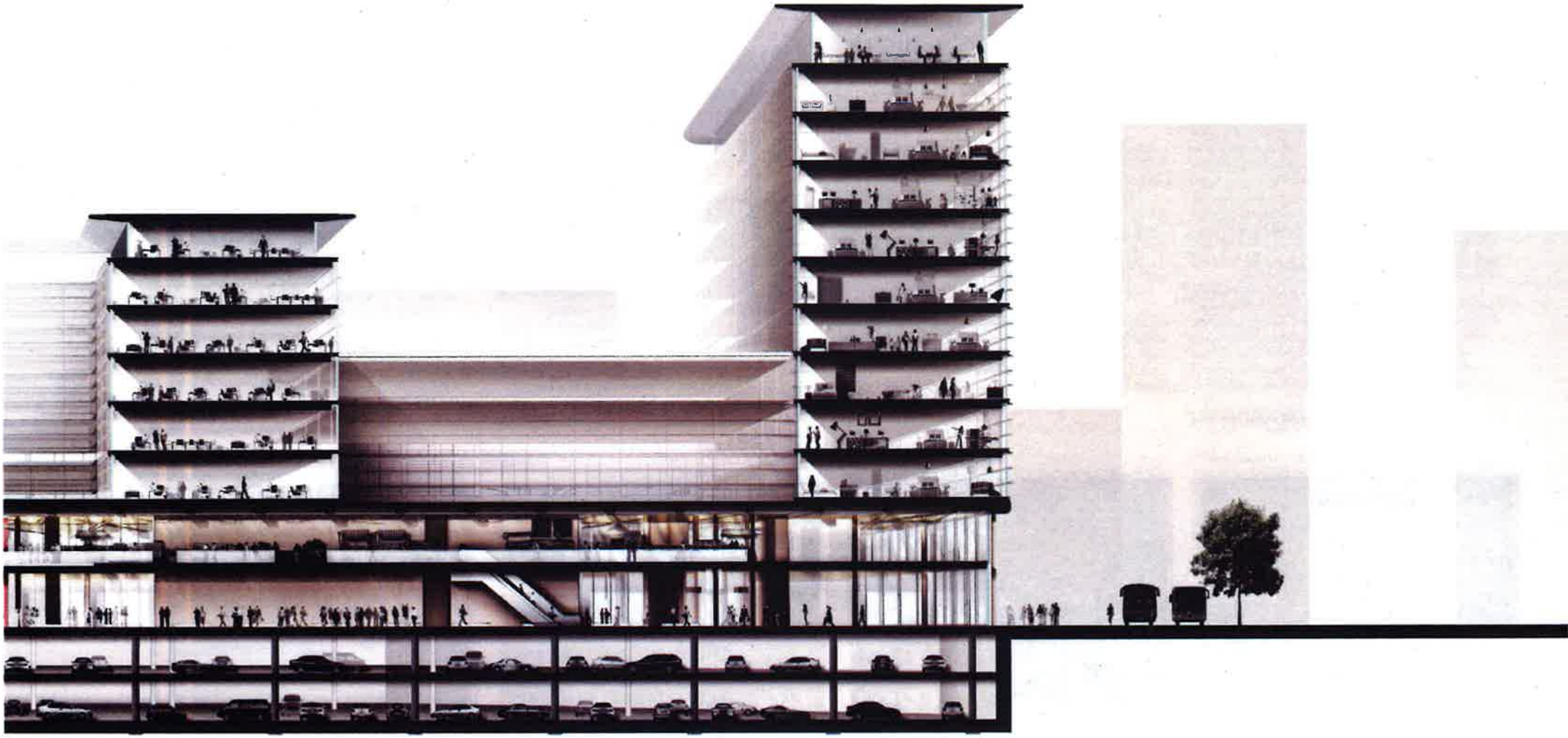
2. Click - Collect

Network Rail click-and-collect service 'Doddle' at 300 stations
59% of British consumers use click-and-collect services
(Source: The Guardian, June 2014)



Design
Section





Central Square Interchange

Design

Role an Interchange can Play in the Urban Enviroment

Stansted Airport

Welcome

Stansted Airport has become a model for airport design worldwide due to its energy efficiency, advances in technology and easy-to-use design. It welcomes visitors from all over the world to London, greeting them with a world-class travel experience.

The development is the opportunity to redesign Cardiff's Welcome to the World. Capital Square and the new interchange are Cardiff's urban front door where the Capital City welcomes its visitors from all over the world. Consequently, the proposed interchange will greet its inhabitants and guests with a modern, high quality and sustainable transport interchange and hub. This does not only mean providing and convenient access to other parts of Cardiff and Wales but also establishing an urban area and part of which Cardiff can be proud.

Bilbao Metro

Set scene

Like a transport interchange, a metro system demonstrates the impact that the built environment can have on the quality of our everyday lives. The glassy entrance canopies have become synonymous with Bilbao and set the scene for the active cultural life happening around the city.

Similarly, the interchange will set the scene for discovering Wales, its culture, history and language. Cardiff is, of course, one of the UK's largest cities and benefits from great connectivity to the rest of the country. The interchange bridges the transformations happening right in the urban heart of Wales with its surrounding areas and the rest of Wales. It serves as the point of connection that sets the scene and expectations for the range of unique attractions and opportunities that Cardiff and Wales have on offer.

North Greenwich Interchange

Arrival and departure

The North Greenwich Transport Interchange is a key element of London's transport strategy and a gateway to the city. It is an arrival and departure point, especially for commuters from the South-east of England, but also for visitors and Londoners alike to discover the North Greenwich peninsular, including the Millennium Dome.

In Cardiff, the interchange will serve as the urban focal point and point of connection for a diversity of users and their specific routes. Nonetheless, all have in common that they either arrive or depart from the interchange. Visitors arrive from the airport or the train station and discover Cardiff and explore other places in Wales from the interchange. Commuters arrive from parts of Cardiff and surrounding areas on their everyday route to work and back home. Regional transport links provide a chance to share in the cultural, social and economic opportunities that the Capital City offers for the wider region.

Dresden Station

Hub and focus point

Dresden's main railway terminus is a large transport hub that has played an important part in the cities industrial and economic growth over the last hundred years. The F+P redevelopment of Dresden Hauptbahnhof built on this significant role and restored the clarity of the original design that is needed to serve its function as an urban focus point and transport hub for the future.

Transport shapes its urban context and environment. The basic significance of a transport hub lies in ensuring the safe and convenient provision of transport options and multi-modal interchanges as well as a place where people can make informed transport choices. On top of that, interchange facilities link public transport services to the urban network and public realm. A fully integrated transport hub is also integrated in its surrounding urban environment, enhancing the public realm, streetscapes through which it passes. A transport hub in this sense is an integrated focus point that adds real value carries significance and enormous potential for the city of Cardiff and the nation.

Design

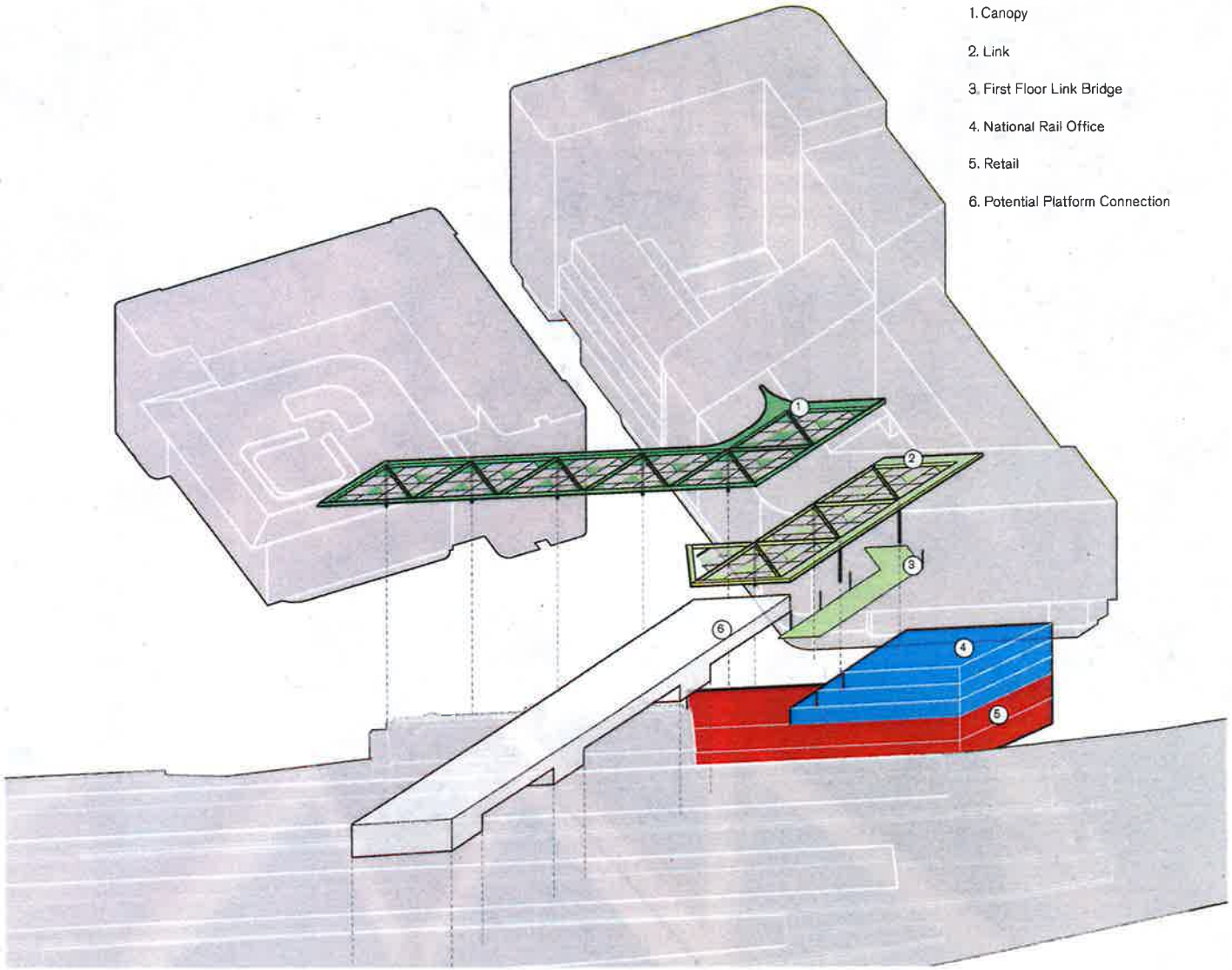
Role of Network Rail - Opportunity of Plot 13B

Plot 13B

The connection of plot 13B to the Interchange building has a grounding in historic Cardiff where covered pedestrian routes are commonplace and considered to be key parts of the urban fabric of the city. Without distracting from the listed façade of the station a glazed canopy physically linking the two buildings would form a protected route from the station into the interchange.

The scheme concept design also includes an opportunity to connect through to the first floor of the interchange – either simply through the existing blank eastern façade of the station, opening up the wall and linking through to a double height glazed courtyard with a new F+B offer at ground floor and escalators leading the users up to the first floor and out on to a new bridge linking to the market stall retail section of the Interchange. With the introduction of the double height courtyard space next to the station it would be possible, and potentially preferable to link across all the platforms at high level. This would create a well-connected Interchange with the option of creating a tickets access route at first floor level between the two buildings and down on to the platforms.

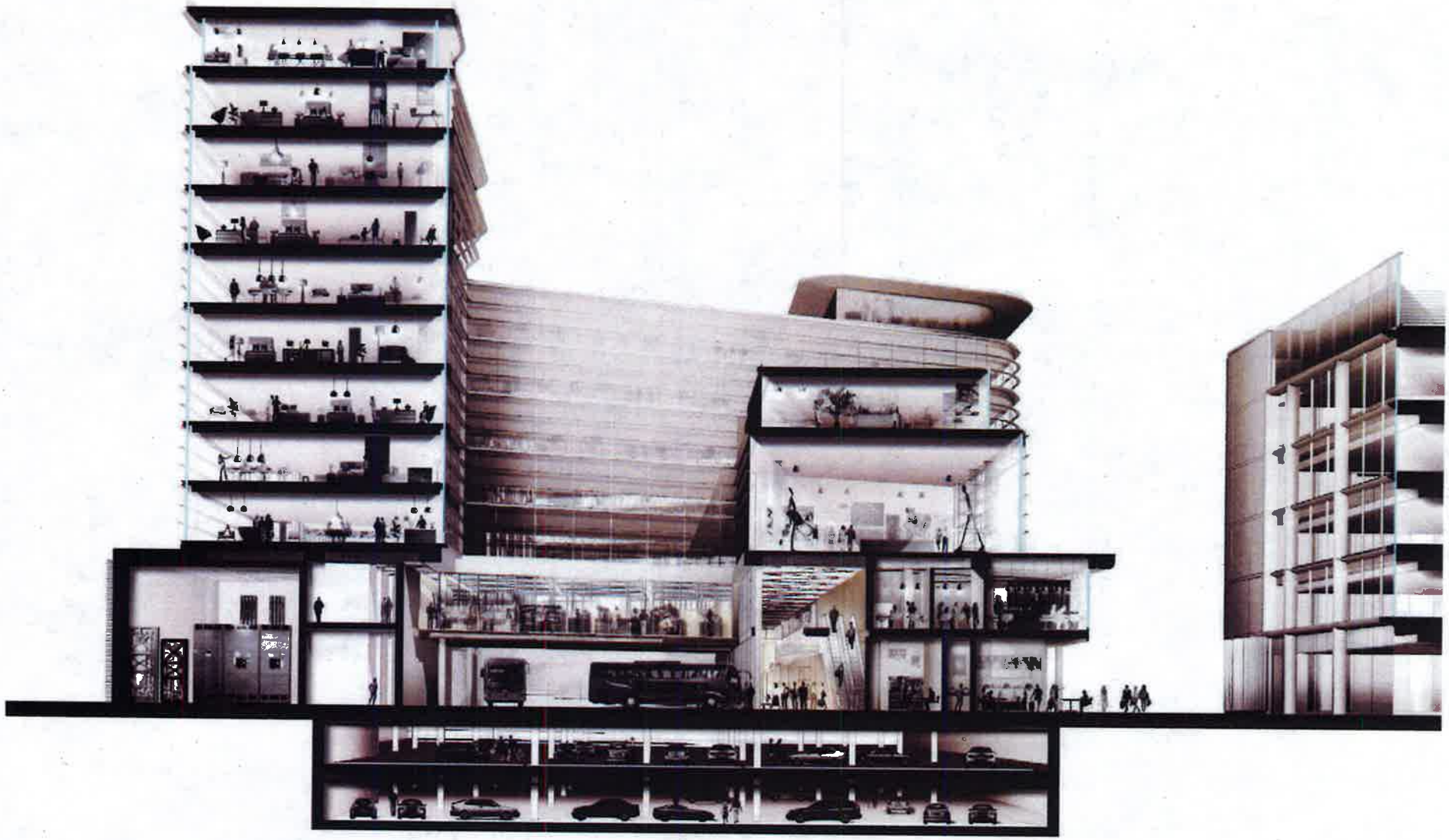
The double height connection space between the commercial offices, F+B, Station and Interchange is a fulcrum point which brings together all of the elements of the scheme into one space. The glazed roof and structure reflecting the triangular forms of the soffit in the Interchange and the first floor bridge would enable a link to the current platforms that would be more suitable to a European Capital City than the existing below ground tunnel. The visual interconnection between spaces is important, and light and space are common themes to create successful public buildings.



1. Canopy
2. Link
3. First Floor Link Bridge
4. National Rail Office
5. Retail
6. Potential Platform Connection

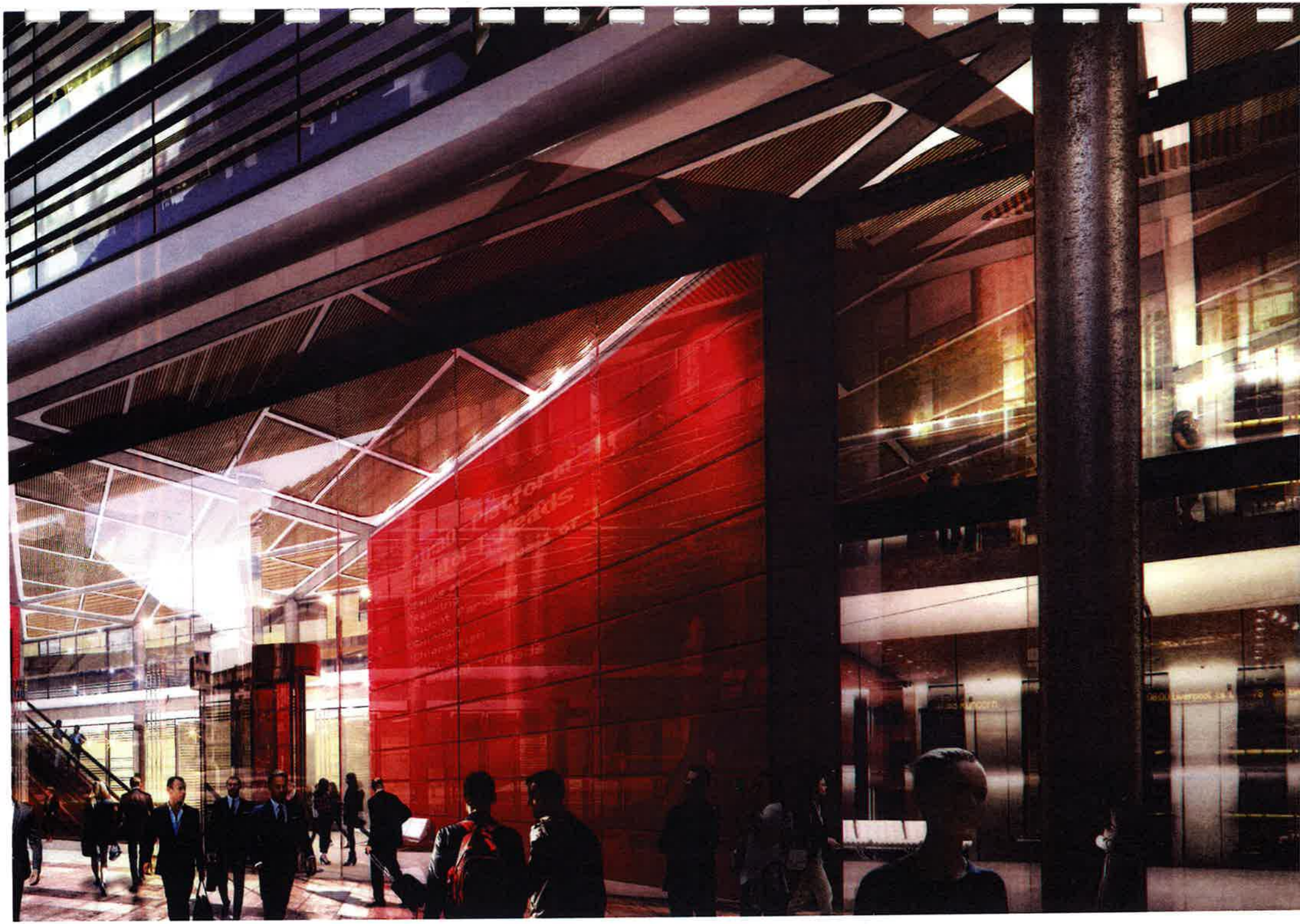

elcome to Cardiff

Design
Section

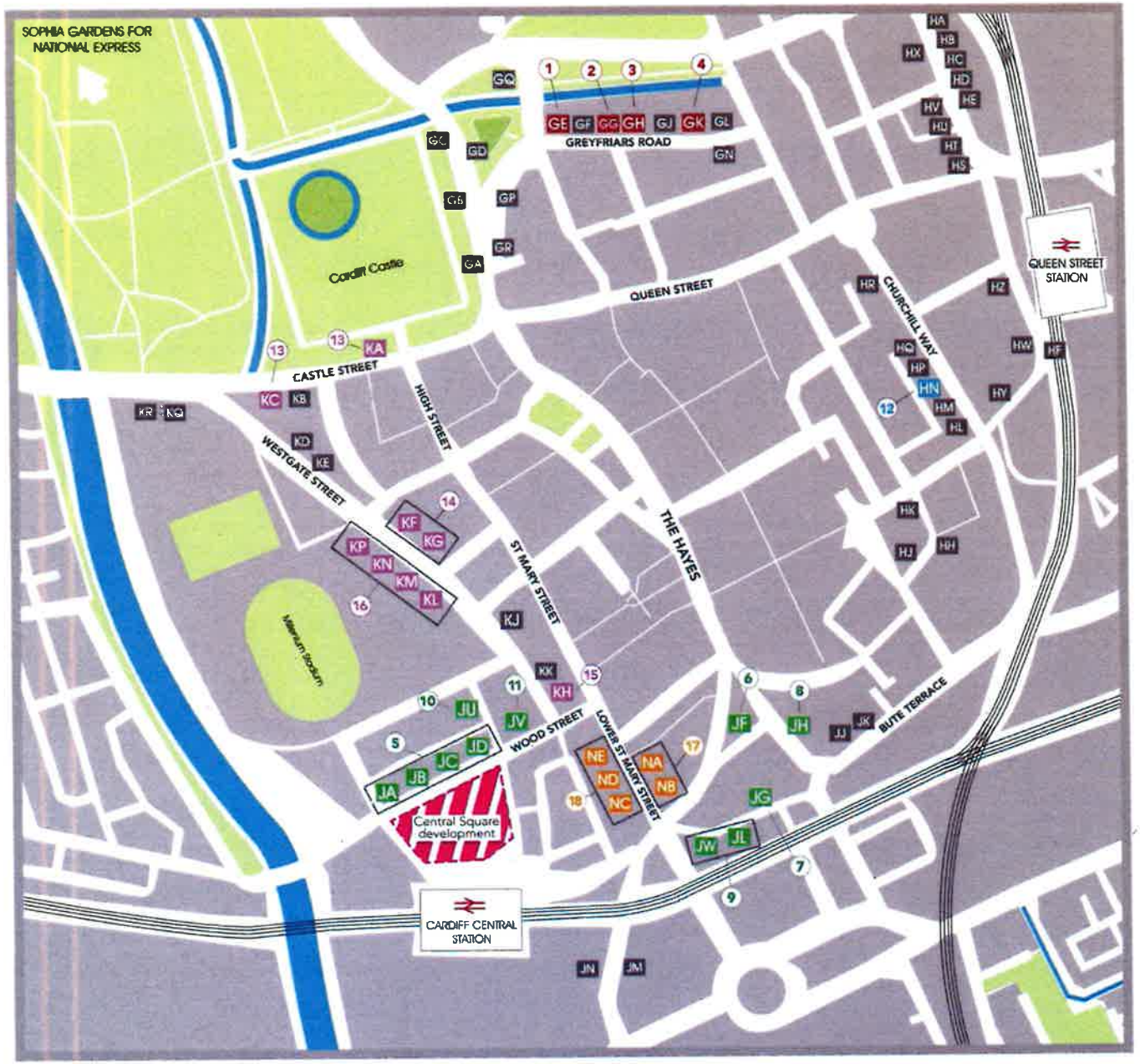


Central Square Interchange


INTERCHA



Appendix 3



1	TONYPANDY	GL 122
2	NEWPORT	GG X30
3	BEDDAU X16	GH X16, 400
4	LLANISHEN	GK 51, 53, 86
5	PENARTH BARRY UHW 95 CARDIFF MET X2 X70	JA 100 JB X2, X70 JC 95NB, M3 JD 4, 92, 93, 94
6	SPORTS VILLAGE 1/2 P&R SOUTH P&R WEST	JF 1, 2, 7, 9A, P&R WEST, P&R SOUTH
7	6 CATHAYS CYNCOED PONTPRENNAU PENGAM GREEN	JG 6NB, 52, 57, 58
8	THORNHILL CYNCOED PENGAM GREEN	JH 11, 28, 28A, 28B, 54
9	X91 NEWPORT 95 BARRY AIRPORT	JL 30, X91, 95SB, 95A, X30, 304 JW T9
10	THORNHILL	JU 27
11	PENGAM GREEN	JV 11
12	P&R EAST CARDIFF GATE	HN X59
13	NATIONAL EXPRESS	KA KC NATIONAL EXPRESS
14	GABALFA UHW CARDIFF BAY SPORTS VILLAGE	KF 8, 9 KG 35, 36, 38, 38A
15	ST MELLONS LLANRUMNEY PLASMAWR PONTPRENNAU	KH 44, 45, 49, 50, 57, 58,10
16	BARRY CAERAU DANESCOURT ELY LLANDAF PENTREBANE RADYR UHW 64/65	KL 17, 18 KM 13, 15, 96, 96A KN 32, 61, 64, 65, 32A, 320 KP 25, 62, 63, 66
17	RHIWBINA WHITCHURCH 6 CARDIFF BAY	NA 6SB NB 21, 21A, 23, 24, 24A
18	STAGECOACH (NOT 122)	NC ND NE 26, 124, 132, 136, X3, X4, T4, A, B, X, 701