Design

Introduction

It was clear during the feasibility studies and preliminary design work in the early 1980's that integrating a modern tramway system into a dense urban area, such as Sheffield, would be no easy task. Given the limitation of acceptable walk links to a fixed rail system, none of the former rail routes into the City Centre were suitable for Supertram alignment as they generally avoided residential areas. Avoiding any major demolition of property, the final preferred alignment was predominantly on-street in both segregated and street running form. Only phase 1, between Meadowhall and the City Centre, is fully segregated over its 7 km length with only four signalised road crossings. Use was made of 3 km of existing railway alignment, the formation being shared with a remaining single track freight line. Of the total 29 km system length, the remaining 22 km generally relates to adjacent highways, being either fully street running or segregated in the Central reserve, a wide highway verge or on adjacent undeveloped land. It is the design of this section which has provided the largest learning curve for all parties involved in the design process and is the subject of this paper.

Basic Design Consideration

From the earliest feasibility studies, certain requirements were defined as essential to meet the objective of providing a high public transport system:

- Reliable
- Regular services
- Easy accessibility
- Good comparative journey times

These were the key aims if Supertram was to provide the high quality travel experience which would attract motorists from their cars and ease urban congestion in Sheffield well into the next century.

In themselves these aims were laudable, however, the practicalities of achieving them and integrating the tramway into the overall environment were not so easy. The numerous stakeholders in the project from Her Majesty's Railway Inspectorate and the Highway Authority to individual property owners adjacent to the alignment, all had an input to the design process and brought their own requirements. This in itself created the need for a complex set of procedures and consultations over four years.

The key parameters of the on-street design related to:

- the design specification of the tram vehicle and the maximising of the tramway accessibility
- the right of way and the need to integrate the swept path into the local traffic system with no detrimental effect on safety and minimal impact on local access road capacity

Additionally, environmental issues played a significant role in many areas, especially during public consultation. However as in all transport projects, safety considerations had first priority.

The Design Process

For such a complex process a project team was formed at an early stage involving the key stakeholders. This included representatives from the South Yorkshire Supertram Ltd (SYSL), its project managers and consultants, South Yorkshire Passenger Transport Executive (SYPTE), the City Council as Highway and Planning authority, and where appropriate Her Majesty's Railway Inspectorate and the police. This group overviewed the design process with the day to day actions being managed by the project managers, Turner and Townsend.

Initially a Swept Path Alignment, (SPA), was developed based on the original Parliamentary preliminary design layout and the tram vehicle characteristics to establish basic on-street clearances. The vehicle was 35m long, 2.65m wide and articulated into three sections allowing it to traverse a minimum horizontal radius of 25 m and a vertical radius of 1.65 m.

The development of the SPA enabled an assessment to be made of the ability to provide adjacent facilities for the traffic, for example parking, loading and bus bays, right turning lanes, adequate footway widths and act as a basis for investigating the impact on junction design. This established an initial alignment and defined the tramway, highway, traffic control and accommodation works required.

Using CAD facilities, the swept path was developed by Highway consultants, Design and Building Services, into a Dynamic Kinetic Envelope, (DKE), which modelled the maximum throw of the tram vehicle in transit to establish more realistically the clearances from street furniture and facilities. This defined the basic operational horizontal and vertical highway alignment.

Under the design and build contract, the design was then passed to the infrastructure contractor, Balfour Beatty Power Construction, whose consultants, Sir Owen Williams and Partners, considered the railway alignment and its interface with the highway. Frequently this was an interative process with the highway consultants to establish the best compromise design. Particularly when there was a conflict in horizontal or vertical alignment between rail and road requirements on a street cross section of limited width where less than 300m might be the difference between parking provision or not.

These detailed design plans at a 1/500 scale were then the basis for final engineering construction drawings containing everything from setting out strings to complex paving details with different materials.

Consulting on the design

Integrating with the design procedure were consultations with Sheffield City Council, as Highway and Planning Authority. On the basis of legal undertakings with SYPTE, the City Council had the right to be consulted on all aspects of the design. A protocol was agreed where designated officers covering transportation, traffic and urban planning disciplines joined project working groups to provide a viewpoint as design concepts were developed. In addition a formal procedure was agreed whereby designs were processed through the City Council's Committee system, phase by phase, including public consultation. A three stage process was adopted following agreement in principle with Council Officers:

- **Stage 1** Approval of draft detailed design as a basis for public consultation.
- **Stage 2** Report back from consultation and agreement in principle to the main design aspects.
- **Stage 3** Consideration of and agreement to final detailed design issues e.g. paving materials and landscaping.

As this procedure is as much political as professional in nature it has worked remarkably well.

A major input to this process has been a series of major public consultation exercised promoted and managed by SYSL. Initially the occupiers and owners of each property adjacent to the tramway were approached to establish details of their parking, loading and access arrangements e.g. was there a disabled person with special needs to provide, as far as possible, suitable facilities clear of the swept path.

As the draft detailed design became available for each of the 8 phases, public exhibitions and meetings were organised, supported by extensive publicity, to ensure local residents and businesses had chance to air their views. They were generally well attended and the normal concerns raised related to satisfactory parking, loading and bus bay provisions, loss of existing trees and hedges, pedestrian facilities and location of tram-stops. At times significant political pressure was applied to SYSL who normally responded by modifying designs if these changes did not radically effect safety, tram run times, flexibility of operation or budgeted costs. The consultation exercise took some four years to complete and involved extensive staff time and resources, particularly for the client, with some 400 meetings with local resident and business groups.

Aspects of Design

The design process has meant the interfacing of a multitude of traffic, highway and railway engineering aspects together with environmental considerations and the expectations of the local community. In general there has been no ideal design solution in any location but a least worst compromise. However, advantage has been taken of available technology and the ability to develop novel proposals by pooling the professional knowledge of the project team.

Traffic Control

The strategy adopted to maximise priority for Supertram relies on the use of transponders on the trams to establish demands with the LRT/Road traffic controller via VIS loops. By setting an appropriate code on his inboard computer, the driver can input demands at signalled junctions and also set the power points to the correct route setting. The control software is normally configured to maximise right of way for the tram but this is subject to the avoidance of unreasonable queuing for other traffic especially at peak hours.

Impact on Local Access

The major concern expressed by the public throughout the project has been their aspirations for maximising the availability of parking and loading. In urban Sheffield there has always been a degree of access restraint through waiting and loading restrictions particularly on the major road network and in the City Centre. As for much of its on-street route the tramway is kerb running, the parking of vehicles within the swept path is not acceptable and will be strictly enforced through traffic regulation orders and the tramway bye-laws

Great effort has been expended to create acceptable parking and loading bays clear of the tram tracks without compromising the minimum 1.8 metre footway width. Widths of bays thus vary from 2m, for cars only, to 2.5m for HGV's and much ingenuity has been used to fit these facilities into streets of restricted width.

Interface with Other Traffic

Particular attention has been focused on minimising the interaction between the tram and other traffic. At both priority and signalised junctions, where there is significant turning traffic, separate lanes have been provided to protect tram movements or minimise delays to through movements from queuing vehicles.

Wherever possible, the swept path has been segregated in the central reserve, such as at Netherthorpe Road or Ridgeway Road (inbound) or within a wide highway verge as on Donetsk Way and Eckington Way at Mosborough. All movements on and off highway are under traffic signal control. Significant thought has been given to road signing and lining, especially where the tramway layout is unusual and there is potential for accidents during the formative operation period. Differential surface colouring, extensive confirmatory signage and lining and improved lighting has been adopted to clarify acceptable traffic movement practice.

Pedestrian Facilities

In view of potential road safety problems of cars overtaking trams on single carriageway roads, especially at tram-stops, central islands have been constructed to prevent these manoeuvres. In many locations these are integrated with new or replacement pedestrian crossing facilities, especially adjacent to tram-stops and major signalised junctions. The project has upgraded pedestrian access on many parts of the alignment.

Modal Transfer

There are currently major modal interchange facilities at Meadowhall (bus, tram, rail, and car) and similar developments by SYPTE are in hand at Sheffield Station (bus, tram, and rail) together with the planning of a number of park and ride sites. However, on-street the project has sought to encourage interchange and feeder bus routes by positioning bus lay-bys adjacent to tram-stops wherever possible. In the age of deregulation, this provides the system with the maximum flexibility for the future.

Access to the System

Pedestrian access to tram-stops has been intensively researched to ensure maximum case of access irrespective of passenger disabilities. Ergonomic studies by Cranfield Institute of Technology have established the layout features of the stops including two new types of tactile paving to locate the tram doors and define the platform edge, shallow approach ramps and differential coloured paving to indicate safe and unsafe areas. This has set standard tram-stop layout to be adopted throughout the system but has created slight specific problems on-street due to lack of road width or adverse impacts on the threshold of adjacent premises. In these cases specific solutions, such as lowering the highway rather than building up the platform on the foot-way, have been adopted.

Environmental Considerations

A limited budget of £2.5 million has been allowed by the Department of Transport for hard and soft landscaping to compliment the engineering works. Although seen as inadequate by the City Council and the general public, the expenditure has been prioritised in consultation with the Planning Authority for maximum effect.

The City Council, the Cathedral Authorities and the business community have seized this initiative to provide extra funding to expand the environmental benefits of an enhanced streetscape by redesigning Castle Square and Cathedral Square.

In a suburban environment, enhancement normally takes the form of soft landscaping but care is always needed to avoid sight line problems and adverse effects on the maintenance of the overhead current system. The importance of environmental issues were predominantly recognised on Ridgeway Road, part of the outer ring road, where the out of city track has been constructed in the outer lane of a dual carriageway after a careful risk assessment to avoid removing a large avenue of mature trees.