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EDINBURGH TRAM NETWORK

Network Effects

Revision 1: January 2004

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Edinburgh Tram

Network Effects: Report on Work Package 1 - Lines 1 & 2

Revision 1: January 2004

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1	incorporation of demand & revenue sensitivity test as appendix D		30/1/04

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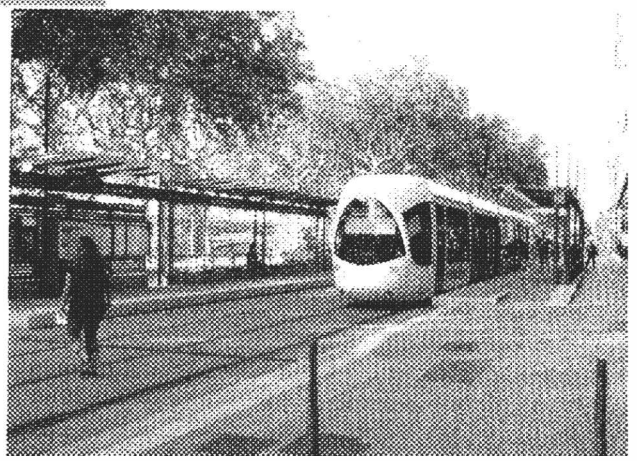
EXECUTIVE SUMMARY



Executive Summary

Background and Objectives

A key component of the strategy of public transport investment in Edinburgh being sponsored by City of Edinburgh Council (the Council) is the development of a network of modern trams. The tram system is being developed in stages and will focus on the major city transport corridors.

Parliamentary Bills for Edinburgh Tram Lines 1 and 2 are to be submitted to the Scottish Parliament as separate Bills. Therefore the STAG Appraisals and Preliminary Financial Cases for both lines represent the revenues, costs and wider benefits associated with constructing and operating each line in isolation. It is recognised, through, that there will be implications on costs, revenues and the wider benefits if both lines were to operate together as a network.

Initial pre-feasibility work was reported in January 2003 and the Council charged Transport Initiatives Edinburgh (**tie**) with the delivery of Bills to be considered by the Scottish Parliament by the end of 2003. The submissions would focus on the individual lines identified in the original feasibility study as providing the best opportunity for delivering a robust business case. These were:

- Line 1: a circular route linking the city centre with Leith, Ocean Terminal, Granton and Ravelston; and
- Line 2: a route linking St Andrew Square with the Airport and Newbridge via Haymarket, Murrayfield, Edinburgh Park and The Gyle.

Consultant teams were appointed to assist **tie** in progressing the STAG Appraisals and associated preliminary Financial Cases to the Scottish Executive and Private Bill submissions to Parliament, and these have been developing the necessary detail accordingly.

A separate appointment was made by **tie** for Faber Maunsell (with Semaly) to undertake a Network Effects Study. Work Package 1 of this Study focussed on combining Lines 1 and 2. The aim was to compliment the key strands of work being undertaken by the Line 1 and 2 teams and to identify what the issues and benefits would be in operating the two lines together. Therefore the objectives of the Network Effects Study were to:

- identify the implications on costs and benefits arising from operating Line 1 and Line 2 together as a network;
- ensure that the identification and development of the cost, revenue and wider benefits remained consistent with the assumptions and methodologies being employed by **tie** and their consultants on Line 1 and Line 2;
- develop and analyse logical scenarios for operating the tram network under different service operation conditions that might present themselves during the development of Line 1 and Line 2; and
- determine and develop a robust evaluation of the identified network scenarios that remains consistent with Line 1 and Line 2 and provides cost information suitable for use by **tie's** financial consultants in the development of an associated Preliminary Financial Case.

Therefore, related to these overall objectives, the aim of this Report is to:

- demonstrate that Line 1 and Line 2 can function as a network;
- estimate revenue and benefits associated with an optimum network service configuration;
- demonstrate that if Line and Line 2 proceed, that any changes to their STAG appraisals are highlighted that the Parliamentary Bills are unaffected and that the consultation exercise is still valid;
- reconcile costs and revenues to previous estimates used for Line 1and Line 2; and
- report assumptions made and risks identified.

This report outlines how the 'network effects ' for combining Lines 1 and 2 were developed into two different scenarios, for which the implication son infrastructure provision, operational requirements, farebox revenue and the wider economic benefits were then identified to produce cost: benefit ratios. The report should be viewed as a supporting document to be considered alongside the separate Line 1 and Line 2 Bill submissions. It is not the intention to submit a separate Bill for the tram network and therefore no full STAG analysis has been completed for this.

Nevertheless, analysis of the networks was brought together using the same evaluation techniques as those being used within the Line 1 and Line 2 appraisals.

Study Approach

The methodologies applied in the network effect study mirrored those employed by both the Line 1 and Line 2 study teams, thus ensuring consistency and enabling comparisons to be made.

All cost assumptions were taken from the Line 1 and Line 2 teams. Savings in capital costs through economies of scale were identified where possible, as were savings in operating costs, which were mainly related to the fixed staff elements such as maintenance and headquarters staff. Associated savings in lifecycle costs were also identified. Any additional infrastructure required in order to ensure the robust operation of the network, with suitable flexibility, was identified.

The focus for assessing the environmental impacts has rested with the individual Line teams, through their requirement to produce an Environmental Appraisal as part of the overall STAG submissions. Part of both the Line 1 and Line 2 Environmental Appraisal is a chapter on the 'cumulative effects' of operating Line 1 and Line 2 together and, therefore, the agreed approach with **tie** was to focus on the production of these within the Line teams, assuming the 'Base case' network option identified within this Report.

The demand and revenue modelling work was done under the guidance of **tie's** Modelling & Appraisal Working Group (M&AWG), which meets regularly to ensure consistency of approach between the consultants responsible for Lines 1 and 2. Demand modelling and car/public transport mode choice modelling was done using the Land Use and Transport Interaction (LUTI) model developed and run by consultants MVA on behalf of The Council. This produced highway and public transport (PT) demand matrices for use in the detailed assignment models (DAM models).

The appraisal techniques used within the network effects study focussed on three formats:
- production of a standard TEE (Transport Economic Efficiency) analysis;
- generation of cost: benefit ratios; and
- financial data (capital costs, lifecycle costs, operating costs, farebox revenues).

The first two essentially incorporated the latter and also took into account wider economic benefits such as time savings to users and non users, in accordance with normal practice.

in summary:
- a robust appraisal process has been carried out with support from the individual Line technical advisors;
- new journey opportunities and economies of scale are reflected in the Preliminary Financial Case and overall financial and economic appraisal.

Option Identification

The approach adopted to define the Line 1/Line 2 network options involved:

a/ identification of the 'Base Case' option; and

b/ identification of the best 'Investment Enhancement' option, through the detailed appraisal and review of various possible service patterns.

The Base Case option was defined as Line 1 and Line 2 running together as specified by the individual Line Teams. The specification of this option allowed for the identification of the potential savings that would occur bringing the two Lines together.

Therefore the Base Case comprised of:

- Line 1: 8 trams per hour in each direction; and
- Line 2: 6 trams per hour in each direction between Airport and Picardy Place;
  6 trams per hour in each direction between Newbridge and Ingliston Park & Ride

Whilst the Base Case option could be described as fairly self-explanatory the Investment Enhancement option required the undertaking of a two stage appraisal process. In considering what the best 'investment enhancement' option might represent, it was clear that there were a large number of possible service pattern options – differing combinations of service configurations and frequencies. In most cases, these options would require additional investment, but would facilitate additional network-related benefits, as well as providing additional benefits to the individual lines (improved capacity where require, etc). Therefore an initial option appraisal was undertaken which sieved through the potential options using the following criteria:

- fit to Edinburgh LTS;
- passenger convenience;
- operational practicality and constraints;
- demand patterns;
- additional infrastructure requirements;
- tram-km (operating cost indicator); and
- future interaction with Line 3.

From this initial appraisal (which used a weighted ranking scoring system), five shortlisted options for further analysis were identified. These focussed on service frequency changes on Line 2 and/or extending some Line 2 trams beyond the city centre along the east side of Line 1 to terminate at Ocean terminal.

The more detailed work focussing on these shortlisted options used high level costs and revenues that were available at the time of appraisal in order to identify a best investment enhancement option. This was defined as:

- Line 1: 8 trams per hour in each direction; and
- Line 2: 4 trams per hour in each direction between Airport and Ocean Terminal via Princes St
  3 trams per hour in each direction between Airport and Picardy Place
  7 trams per hour in each direction between Newbridge and Ingliston Park & Ride

in summary:

- the network will provide increased operational flexibility and has the potential to allow sensible and coherent integration with Line 3.

Economic Appraisal

An appraisal taking into account the wider benefits and costs associated with the Base Case option produced a benefit:cost ratio (BCR) of 1.62. The BCR calculated for the Investment Enhancement option was 1.51. The reason this is lower than the Base Case BCR is that it reflects the fact that the overall increase in costs (especially those associated with operating five additional trams and increased tram km) outweighs the additional benefits.

By comparison, the separate Line 1 BCR is 1.51, whilst the separate Line 2 BCR is 1.38. Analysis of the wider economic benefits, and in particular the travel time savings, identified that the Base Case network generates an extra 8% of benefits compared to the sum of Line 1 and Line 2 as individual Lines. Therefore, it is clear that the network impact leads to a stronger economic case than that for the individual Lines.

in summary:
- the network configuration presents stronger economic cases than the individual Lines, including significant additional wider benefits relating to travel time benefits.

Revenue and Cost Appraisal

Table 1 summarises the key components of the Base Case option.

Table 1: The Base Case Option Cost/Revenue Summary

£m	2011	2026	Total over Scheme Life
Total Capital Costs, £m			£565.34m
Total Lifecycle Costs £m			£88.65m
Total operating Costs, £m	£10.78m	£11.62m	£344.62m
Total Revenue, £m	£10.99m	£16.56m	£440.92m
Total Operating Surplus, £m	£0.21m	£4.94m	£96.30m

Totals are undiscounted/2003 prices
'scheme life' consists of the 30 year operating period (2009 to 2038) plus the construction period (2006 to 2009) capital costs include 31% optimism bias

The Base Case would cost £565m to construct, which represents a saving compared to Line 1 plus Line 2. Principally the capital and lifecycle cost savings are associated with the reduction of one tram from the combined tram fleet, plus the rationalisation of heavy maintenance infrastructure between the two depots required to house and maintain the whole ram fleet. A number of key additional infrastructure items were identified for network effects. These focussed on the need for additional turnback/layover facilities in order to separate Line 2 trams from impeding Line 1 trams. In addition, a more complex delta junction at Roseburn was identified in order to achieve better operational flexibility.

The total revenue over the scheme life exceeds the sum of the operating costs and lifecycle costs.

Table 2 summarises the key components of the Investment Enhancement option.

Table 2: The Investment Enhancement Option Cost/Revenue Summary

£m	2011	2026	Total over Scheme Life
Total Capital Costs, £m			£576.48m
Total Lifecycle Costs £m			£92.36m
Total operating Costs, £m	£11.82m	£12.74m	£377.90m
Total Revenue, £m	£13.11m	£18.27m	£496.54m
Total Operating Surplus, £m	£1.29m	£5.53m	£118.64m

Totals are undiscounted
'scheme life' consists of the 30 year operating period (2009 to 2038), plus the construction period (2006 to 2009)
Capital costs include 31% optimism bias

Compared the Base Case, the additional capital investment involved is some £11m, which represents the additional trams required to operate the enhanced service (Line 2 to increased to 7 tph), plus the additional layover/tumback facilities required at Ocean Terminal (extension of Line 2 to Ocean terminal). Revenues and operating costs increase, with the overall effect being that the operating surplus increases by 23% compared to the Base case. The total revenue over the scheme life exceeds the sum of the operating costs and lifecycle costs.

Table 3 sets out the comparison of the two network options to the results for Line 1 and Line 2.

Table 3: Network Options Comparison to Individual Lines

Costs and Revenues for Tram	Total over Scheme Life			
	Line 1	Line 2	Base Case	Investment Enhancement
Capital Costs	£287m	£336m	£565m	£576m
Lifecycle Costs	£45m	£52m	£89m	£92m
Operating Costs	£175m	£190m	£345m	£378m
Revenue	£256m	£230m	£441m	£497m
Operating Surplus	£81m	£40m	£96m	£119m
BCR to Government	1.51	1.38	1.62	1.51

2003 prices / undiscounted
'scheme life' consists of the 30 year operating period (2009 to 2038), plus the construction period (2006 to 2009)
Capital costs include 31% optimism bias
Note that Line 1 + Line 2 costs and revenues can't simply be added together, due to the double counting that would entail relating to the shared section of joint running in the city centre

Table 3 demonstrates that both the network options enhance the case for Line 1 and Line 2 in both financial and economic terms. The operating surplus in both cases is sufficient to cover ongoing lifecycle costs, something that is not achieved by Line. The Base Case illustrates the savings in costs that can be achieved. The revenue in the Base Case appears lower than Line 1 plus Line 2, but this reflects the element of double counting that occurs when Line 1 and Line 2 revenue is simply added together and this is outweighing the increase in patronage and revenue that is actually occurring when the two Lines are combined.

Sensitivity analysis on the revenues for both network options was undertaken, which focussed on a trip suppression exercise to match demand more closely to the anticipated supply in the peak hours. This analysis confirmed that overall revenue would reduce by between 3% and 4.5% as a result. This exercise is outlined in greater detail in Appendix D.

in summary

- fundamentally, Line 1 and Line 2 can be configured into an operating network with demonstrable savings in capital, operating and lifecycle costs and increased revenue without service re-configuration;
- the Base network can be further enhanced through service re-configuration with consequent need for additional capital investment to further increase the operating surplus and revenue of the scheme.
- additional infrastructure requirements and depot configurations have been examined and costed.
- the network can be constructed in a 41 month period including optimism bias.
- the base Case network can be delivered for £565m, including optimism bias, which represents a saving of £58m on the sum of the capital costs for the individual lines.
- the revenue of the network can be optimised through service re-configuration to increase by nearly £2m per annum, an increase of 10% on the base Case network options.
- the Base Case and Investment enhancement networks generate sufficient surplus to cover operating costs and ongoing lifecycle costs.

Conclusions

The opportunities associated with developing the Edinburgh Tram Network have been developed in some detail and demonstrated to be robust and complementary to the separate Line 1 and Line 2 Bill submissions. Two network options were identified that were developed to meet different objectives:

- a 'Base Case Option' that reflects the separate Line Bills being submitted to the Scottish Parliament and can demonstrate some potential areas for cost savings and additional revenue generation;
- an 'Investment Enhancement option' that reflects what might be achieved through further investment and service re-configuration which generates additional benefits.

Both options demonstrated a stronger economic case for a network solution rather than individual lines and recorded good benefit to cost ratios that compared favourable with the separate Line 1 and Line 2 results.

In summary, this Report has demonstrated that:

1. A robust appraisal process has been carried out with support from the individual Line technical advisors;
2. New journey opportunities and economies of scale are reflected in the Preliminary Financial Case and overall financial and economic appraisal;
3. The network will provide increased operational flexibility and has the potential to allow sensible and coherent integration with Line 3;
4. The network configurations present stronger economic cases than the individual Lines, including significant additional wider benefits relating to travel time benefits;
5. Fundamentally, Line 1 and Line 2 can be configured into an operating network with demonstrable savings in captain, operating and lifecycle costs and increased revenue without service re-configuration;
6. This (Base) network can be further enhanced through service re-configuration with consequent need for additional capital investment to further increase the operating surplus and revenue of the scheme;
7. Additional infrastructure requirements and depot configurations have been examined and costed;
8. The network can be constructed in a 41 month period including optimism bias;

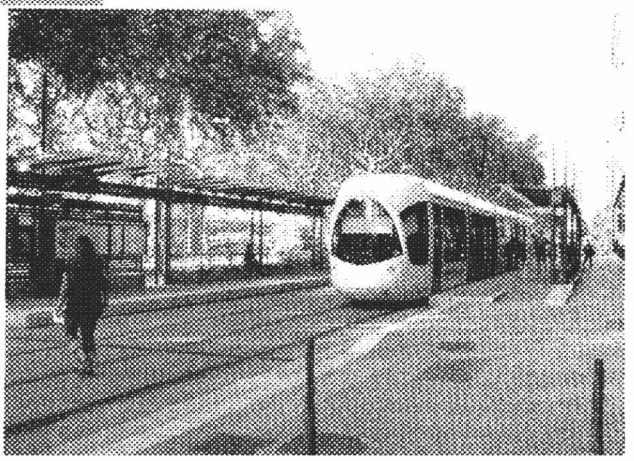
9. The Base Case network can be delivered for £565m including optimism bias, which represents a saving of £58m on the sum of the capital costs for the individual lines;
10. The revenue of the network can be optimised through service re-configuration to increase by nearly £2m per annum, an increase of 10% on the Base Case network option; and
11. The Base Case and Investment Enhancement networks generate sufficient surplus to cover operating costs and ongoing lifecycle costs.

In addition, the Report concludes that:

- it is easier to market and brand an extensive (network) system than a system limited to a single line/locality. As well as being likely to result in higher patronage, greater public acceptance could lead to additional benefits, including:
    - minimise objections during the planning stage;
    - aid the rapid ramp-up to full ridership in the early years of operation;
    - lead to greater awareness of the overall public transport operation within the City;
- the STAG appraisals for the individual lines are not impacted by the findings of this Report;
- the Parliamentary Bills will cater for the individual lines, 'Base Case' network and 'Investment Enhanced' network;
- no further consultation would be required;
- development of the network and associated fares strategy will be ongoing through the DPOF (operator) process. The Report has raised a number of issues with regard to demand modelling assumptions and the matching of capacity to forecast demand levels. These issues will be consider by **tie** and are likely to be addressed with the appointed operator in due course; and
- no significant new risks have been identified as a result of this exercise.

Contents List

1 INTRODUCTION



1 Introduction

1.1 Aim and Scope of Report

The City of Edinburgh Council (the Council) is examining ways of providing the city with the transport infrastructure necessary to promote and support a growing local economy and create a healthy, safe and sustainable environment. This is part of a £1.5 billion new Transport Initiative that the Council is working in co-operation with other local authorities in South East Scotland to deliver.

As a key component of the strategy of public transport investment in Edinburgh, the Council is proposing to develop a network of modern trams. The tram system is being developed in stages and will focus on the major city transport corridors.

Parliamentary Bills for Edinburgh Tram Lines 1 and 2 are to be submitted to the Scottish Parliament as separate Bills. Therefore the STAG Appraisals and Preliminary Financial Cases for both lines represent the revenues, costs and wider benefits associated with constructing and operating each line in isolation. It is recognised, though, that there will be implications on costs, revenues and the wider benefits if both lines were to operate together as a network. For example, the scale and scope of the tram depots being proposed for each line could alter, new direct journey opportunities by tram could be offered, tram service frequencies on certain sections of route could be increased, etc. It is therefore the aim of this report to set out what the implications on costs, revenues and the wider benefits might be if the two lines were operated together as a network for Edinburgh.

In considering the benefits of operating a light rail system that includes more than one line, it is important to recognise that these benefits can occur at a number of levels, namely:

- profitability;
- wider economic benefits;
- flexibility; and
- perception.

While all of these will tend to impact positively on the viability of the system as a whole, it should be noted that only those benefits relating to profitability and the wider economic impacts are directly quantifiable in terms of cost savings, revenue benefits, time savings, etc. For example, economies of scale might result in lower overhead costs such as staffing and depot costs, while improved travel opportunities are likely to increase patronage and, therefore, revenue and also increase the likelihood of mode switching from car.

However, the benefits resulting from flexibility are of equal important, although their effect on the viability of the system are harder to quantify. For example, as well as their quantifiable effect on revenue, different configurations of cross-city service provision may allow greater flexibility in terms of tram operation (timetable optimisation, closure of Princes St, minimising tram use of congested shared track sections, allowance for staff changeovers etc.)

Also important is the issue of the public's perception of the system. It is easier to market an extensive system covering large parts of the city than a system that is limited to a single locality. As well as being likely to result in higher patronage, greater public acceptance could lead to a number of additional benefits, not least the possibility that it will minimise objections during the planning stage and will aid the rapid ramp-up to full ridership in the early years of operation. Public acceptance of the system could also have wider benefits for Edinburgh, such as greater awareness of overall public transport operation within the city.

It should also be noted that, as the full network options are developed, there might be scenarios whereby some additional capital cost is incurred in order to facilitate particular 'network' – related operational movements. This obviously, would be a particular 'downside' effect in terms of cost, but might facilitate various 'upside' benefits related to additional patronage and revenue and improved operational flexibility and robustness.

This Report was commissioned by **tie** and is intended as a submission to the Council and Scottish Executive. It should be viewed as a supporting document to be considered alongside the separate Line 1 and Line 2 Bill submissions and therefore the analysis of the potential impacts of the network were required to be brought together using the same evaluation techniques as those being used within the Line 1 and Line 2 appraisals. This Report will outline how the 'network effects' for combining Lines 1 and 2 were developed into two different scenarios, for which the implications on infrastructure provision, operational requirements, farebox revenue and the wider economic benefits were then identified and brought together using the standard Transport Economic Efficiency (TEE) approach and to produce cost:benefit ratios.

The aim of this Report is therefore to:

- demonstrate that Line 1 and Line 2 can function as a network;
- estimate revenue and benefits associated with an optimum network service configuration;
- demonstrate that if Line 1and Line 2 proceed, that any changes to their STAG appraisals are highlighted, that the Parliamentary Bills are unaffected and that the consultation exercise is still valid;
- reconcile costs and revenues to previous estimates used for Line 1 and Line 2; and
- report assumptions made and any risks identified.

This Network Effects Study Report should be read in conjunction with the Network Effects Business Case.

1.2 Study Background and Objectives

A Feasibility Study into the potential for introducing tram routes across Edinburgh was completed and reported by consultants in January 2003. This study used a two phase approach. The first phase comprised a comparison of corridors and their appraisal against preliminary criteria based on STAG1 requirements. This comparison led to recommended schemes for more detailed assessment at Phase 2, which formed the basis of the recommendations on priorities for LRT implementation. The consultants recommended that the North Edinburgh Loop (ie: Line 1) be accorded the highest priority, and that both the West (ie: Line 2) and the South East (ie: Line 3) tram lines should be high priority schemes (with a 'strong case' for considering the West route before the South East route).

Following on from this initial work, the Council charged Transport initiatives Edinburgh (**tie**) with the delivery of Bills to be submitted to the Scottish Parliament by the end of 2003. The submissions would focus on the separate lines identified in the original feasibility study as providing the best opportunity for delivering a robust business case. These were:

- Line 1: a circular route linking the city centre with Leith, ocean terminal, Granton and Ravelston; and
- Line 2; a route linking St Andrew Square with the Airport and Newbridge via Haymarket, Murrayfield, Edinburgh Park and The Gyle.

A third tram line linking the city centre and the south west wedge of the city was also identified for further progression towards a Bill, but was not part of the original package to be submitted by the end of 2003.

Consultant teams were appointed to assist **tie** in progressing the STAG Appraisals and associated preliminary Financial Cases to the Scottish Executive and Private Bill submissions to Parliament and these have been developing the necessary detail accordingly. Consultation with the public and key stakeholders has been an important aspect of the process, which has been facilitated by the consultant teams in close liaison with **tie**.

A separate appointment was made by **tie** for their technical consultant FaberMaunsell (with Semaly) to undertake a 'Network Effects' Study, The aim of this study was to compliment the key strands of work being undertaken by the Line 1 and 2 teams, to identify what the issues and benefits would be in operating the two lines together. Therefore the objectives of the Network Effects Study were to:

- identify the implications on costs and benefits arising from operating Line 1 and Line 2 together as a network;
- ensure that the identification and development of the cost, revenue and wider benefits remained consistent with the assumptions and methodologies being employed by **tie** and their consultants on Line 1 and Line 2;
- develop and analyse logical scenarios for operating the tram network under different service operation conditions that might present themselves during the development of Line 1 and Line 2; and
- determine and develop a robust evaluation of the identified network scenarios that remains consistent with Line 1 and Line 2 and provides cost information suitable for use by **tie's** financial consultants in the development of an associated Preliminary Financial Case.

1.3 Study Approach

As highlighted above, both the Line 1 and Line 2 teams have been developing their business cases and submission of Bills to the Scottish parliament during 2003. The network effects study has undertaken a number of key t asks in parallel to the Line 1 and Line 2 technical studies that has ultimately resulted in the presentation of two network effects scenarios for consideration.

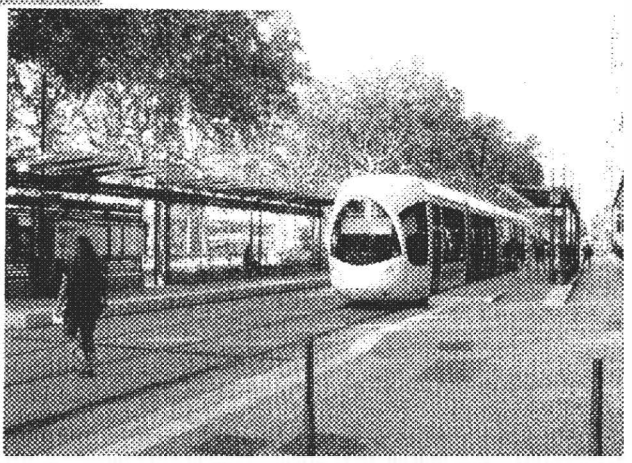
Chapters 2 and 3 set out the summary appraisals of Line 1 and Line 2 in isolation. These have been taken from the respective STAG Executive Summaries. The anticipated performance of these lines in isolation is set out for comparison with the network effect scenarios that are presented further on within this report. These also set the context for the study. Given this, the overall approach adopted by the network effects team is then explained in Chapter 4.

There were a large number of potential scenarios for combining lines 1 and 2 together, based on different combinations of service configurations and service frequencies. These, therefore, needed to be reduced to a more manageable number of potential options. Chapter 5 sets out how the Option Appraisal process was undertaken, starting with an initial option sieving process that shortlisted options for further assessment. From the more detailed work focussing on these shortlisted options, a best 'investment enhancement option' was identified.

This 'investment enhancement option' and the 'base case' option (Line 1 plus Line 2) were then subject to a detailed patronage, revenue, wider benefits and costs assessment that ultimately produced benefit:cost results that could be compared directly with those for Line 1 and Line 2. The results are presented in Chapter 6.

Chapter 7 discussed additional issues relating to the potential impact of combining Lines 1 and 2, including wider economic benefits, consultation and construction programme impacts. Chapter 8 sets out the conclusions.

2 LINE 1 APPRAISAL



2 Line 1 Appraisal

2.1 Introduction

This chapter summarises the STAG appraisal of Line 1 of Edinburgh tram network, the Northern Loop, linking, the City Centre with Granton, Newhaven and Leith, passing through the Waterfront development area and then along the line of the former Roseburn Railway to Haymarket, undertaken and led by Mott McDonald and reported in November 2003. This line is expected to provide a number of positive benefits for the area, including economic regeneration and improved accessibility.

2.2 Problems and Opportunities in North Edinburgh

North Edinburgh has demonstrable social deprivation and in economic terms, performs below average when compared with the rest of the City. Unemployment is higher than the City average while skills and qualifications are below average. There is a high dependency on public transport, yet poor accessibility is highlighted as one of the key obstacles to residents gaining employment opportunities.

Studies examining the North Edinburgh public transport network have highlighted its apparent incoherence and the degree to which congestion affects journey times, punctuality and regularity. North Edinburgh's road network already experiences peak hour congestion and has a significant rat-running problem. Previous studies have already highlighted the potential of new and improved bus links. Connections to potential employment opportunities in Leith and the West of Edinburgh are inadequate creating social exclusion problems.

The Waterfront Masterplan is predicated on the provision of high quality public transport. Studies that have preceded this one have already highlighted that additional capacity will be required to that available at present and moreover, as well as additional capacity the development related public transport element will only occur if there is a step-change in the quality of public transport.

2.3 Option Generation, Sifting and Development

The appraisal of the three route scenarios (Scenario 1 – Granton to Haymarket; Scenario 2 – Granton to St Andrews Square via Haymarket; Scenario 3 – The Northern Loop) was made within the context of technical, operational, patronage, cost and integration issues. The demand model was used to forecast patronage and revenue for the three route scenarios and for the two technology options considered. This process resulted in the preferred Option being the full loop using tram technology.

Following completion of the Outline Business Case, the Council concluded that the Northern Loop should be progressed in line with their local transport strategy.

2.4 Consultation

The consultation process informed major stakeholders and the residents of Edinburgh about the proposals to introduce trams to Edinburgh, and it has provided the opportunity to comment in a variety of way. The results of the consultation show that there is support in Edinburgh for the tram, although this is punctuated by a range of concerns relating in the main to the impact trams will have on properties in close proximity to the route and the requirement for CPOs in certain areas.

The consultation process resulted in Princes Street being chosen over George Road and the former railway solum being chosen over Telford Road, completing the selection of the preferred route.

2.5 Scheme Description

2.5.1 Route

The preferred route comprises:

- 15.6 km of Double Track infrastructure (single track at St Andrews Square);
- 51% off street; and
- 22 proposed stop locations.

Wherever possible a segregated alignment has been proposed (where the tram operates on dedicated tramway or tram road) such that the system can maintain speed and frequency and reliability of service without interference to and from other traffic. The alignment is effectively double track, clockwise and anti-clockwise running, throughout its length, with the exception of the one way loop at St Andrews Square (approximately 520m long).

2.5.2 Tram Specification

It is assumed that the trams will be semi-low floor or total low floor vehicles. This implies a floor height of between 300 and 400mm. This type of vehicle has been adopted in order to ensure that the alignment characteristics will cater for most currently available rolling stock.

2.5.3 Construction

The construction of Line 1 is programmed to commence in mid 2006 with an estimated construction period of 41 months, including optimum bias.

2.5.4 Capital Costs

Capital cost are estimated at £287m including optimism bias set at a base point of Quarter 2 2003. Costs have been derived from a comprehensive database compiled from analyses of costs for the infrastructure works of completed and proposed LRT schemes throughout the UK, currently advised priced from vehicle manufacturers and preliminary diversionary works estimates obtained from utilities companies. The resulting estimates take account of the prevailing factors influencing this particular scheme including location, relative complexity, environment and anticipated programme.

Lifecycle costs of £44.6m, allocated over years when particular costs are planned/anticipated.

2.5.5 Operations

The single overarching objective from the operational viewpoint is to minimise journey times, so as to maximise the attractiveness of the service and minimise operating costs and rolling stock resources. The key is to achieve free flow wherever possible so that the running speed is the maximum safe speed for any particular type of environment.

The frequency will be 8 trams per hour (ie a headway of 7.5 minutes).

The annual Line 1 operating cost is £5.82 million, excluding operator margin estimated at 12%.

2.6 STAG2 Appraisal

2.6.1 Environment

The majority of the tram route follows existing roads and the additional noise generated by tram movement is not expected to give rise to significant noise impacts in these areas. On the road network traffic changes resulting from the tram's operation will give rise to noise increases in some areas and noise decreases in others, but most changes will be small. Overall the effect of the scheme is predicted to be neutral on the road network.

The proposed Edinburgh Tram Line 1 is predicted to have a moderate positive impact on air quality in Edinburgh in 2011. In 2026 the impact on air quality is predicted to be minor positive. There is no net change in CO_2 emissions in 2011 as a result of the tram. In 2026 there is a net predicted decrease in CO_2 emissions.

Overall the scheme is expected to have a minor negative impact on surface water quality and drainage in the short term during construction.

Impacts to soils along the route are likely to be generic to construction activity including erosion, disaggregation, compaction and pollution. Assuming that good practice measures are adopted during construction of the tram, no significant impacts on geological resources are predicted. Land take associated with the development of Edinburgh tram Line 1 will not involve loss of any agricultural land.

Mitigation measures will be implemented to reduce biodiversity impacts to the minimum necessary for the safe completion of the works.

Although the scheme provides opportunities for enhancing the local landscape in certain areas, other adverse impacts would occur at varying degrees in different locations of the route. Key landscape impacts, relate, in the main to the necessity for Overhead Line extension Support.

The sensitivity of the receptors of visual impact varies according to their activity and expectations. There will be visual impacts on virtually all the properties and roads along the tram route, on public open spaces and recreational sites such as Princess Street Gardens, St Andrew Square and the Roseburn cycle route, and from important tourist viewpoints such as Princes Street and Edinburgh Castle.

There are no agricultural issues associated with the proposal.

The vast majority of sites impacted upon by the implementation of Line 1 in terms of cultural heritage have a suggested Level 1 mitigation response (detailed photographic record). Thirteen sites are recommended for Level 2 mitigation (detailed standing building survey). This higher level of survey has been suggested due to the physical impact on such sites expected as a result of engineering works. Level 3 mitigation (watching brief) is suggested for five sites. Two sites have been recommended for Level 4 mitigation (detailed standing building survey and salvage), both at Haymarket.

2.6.2 Safety

Accidents

A reduction in private vehicle traffic (in terms of veh-km removed from the road network) has promoted an annual saving in the number of accidents in the road network at 74 in 2011 and 439 in 2026, considering all severity levels. The majority of accidents are accounted for in terms of damage to property. The number of fatalities prevented by the implementation of the scheme would be negligible.

The total savings as a result of reduced traffic on the road network has been calculated at £302,400 per year for 2011, and £2.4 million per year for 2026.

Security
While all stops will be designed to high standards, the more remote ones may require mitigation facilities designed to ensure that they offer as great level of security as possible (including any street lighting or furniture to ensure safe approach to the stations). The stations have tended to be located in more accessible locations, therefore where the level of activity is greater and security higher. Although the stations will be unstaffed, they will be monitored by CCTV, while all vehicles will provide high levels of security with the presence of conductors.

2.6.3 Integration

Transport Integration
Co-ordinated and integrated transport services with convenient, simplified (and possibly through) ticketing can contribute to mote "seamless" journeys across the public transport network. Travel cards, season tickets, concession passes and probably the integrated "The One" ticket system will be available at other locations.

The attractiveness of the public transport system as a whole in Edinburgh can be enhanced with the implementation of Line 1 by the existence and quality of infrastructure facilities at stations, maximising bus and rail interchange with the tram and real-time passenger information at all stations.

Land-Use Transportation Integration
Improvements in public transport brought about by Line 1 are expected to meet or support most local, regional and national policy objectives, in particular those related to sustainable travel (with increased use of public transport and reduced dependence on the car), regeneration and improving access 9especially for those dependent on public transport).

Policy Integration
Edinburgh Line 1 will contribute to wider Government Policies covering disability, health, rural affairs and social exclusion.

2.6.4 Accessibility and Social Inclusion
Community accessibility has been measured to key local services and destinations. Public transport travel time has been estimated both for the "without" and "with" the scheme scenarios.

The distribution of accessibility impacts is relevant in that it identifies the extent to which the scheme benefits social groups or geographic locations most in need of access by public transport to essential activities.

2.6.5 Economy
The cost to Government sets out the net cost of a proposal from the public sector's point of view, which can then be compared with the overall benefits of the scheme covering all five of the main objectives (environment, safety, economy, integration and accessibility). The economic impact of Line 1 is determined by calculating the monetised benefits of the scheme in terms of safety and economy and then comparing with the cost to Government. A BCR of 1.51 was calculated, which indicates, on this basis, that the scheme represents good value for money. Sensitivities around this Central Case demonstrate the robustness of the case for Line 1, coupled with the benefits to the non-monetary objectives, a strong case for Line 1 has been made.

Economic Activity and Location Impacts
The aim of Economic Activity and Location Impact (EALI) analysis is to quantify the impacts of a proposed scheme on the economy at a local or regional level and at the level of Scotland as a whole.

At the regeneration level, the team will provide a strategic transport link - the benefits at the level of the regeneration areas depend upon how residents of these areas are enabled to access the jobs in the North Edinburgh sites. Base on the proximity and travel to work characteristics of people living in the regeneration areas, it is reasonable to expect that a proportion of total new jobs would be taken up by these residents as a result of better accessibility and that this would amount to between 70 and 200 jobs. Some allowance needs to be made for displacement, which is assumed to be around 50%. Accordingly the net impact ranges from 35 to 100 jobs at the regeneration area level (note that these impacts are over and above the construction and operation of the tram).

The new developments will attract a significant number of service sector based businesses, which will result in a large number of low skilled jobs being created. It is likely that these jobs may be filled by residents living in deprived areas in North Edinburgh. The tram will be pivotal in providing public transport access to these jobs for thee individuals.

2.7 Risk and Uncertainty

One of the critical success factors for Edinburgh tram is the identification and mitigation of the risks inherent in a project of this nature. In order to manage risk in a structured manner, **tie** has appointed a full-time Risk Manager to develop and apply a framework of risk analysis and evaluation to assist in decision-making, and identified the following prime objectives:

- mitigate all identified risks to a 'medium' significance or less;
- pass all identified risks to the best parties capable of managing the risk;
- a culture of risk awareness (not risk averse) and management be created;
- delivery within budget and on time;
- provide a fully functioning operational service; and
- obtain support from all key stakeholders.

tie has developed clear and active processes to prevent and mitigate project risks in accordance with industry best practice. The tie Board takes ultimate responsibility for risk, with responsibility delegated to the Project Direction.

2.8 Monitoring and Evaluation

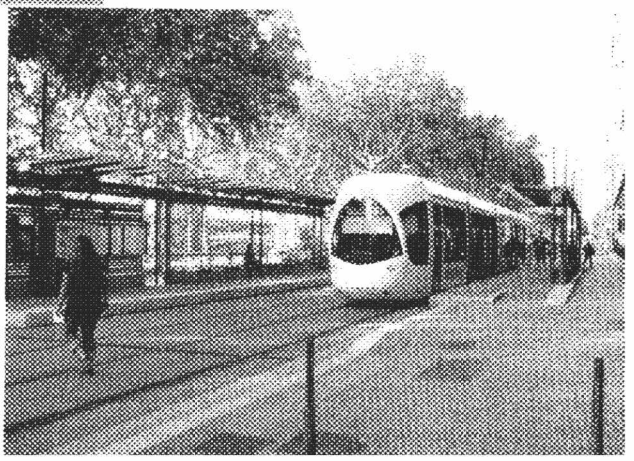
There are five phases of the project which require consideration during the monitoring and evaluation process, namely:

- scheme development;
- infrastructure procurement;
- construction;
- testing and commissioning; and
- operations.

The STAG requirements for monitoring and evaluation are principally associated with the operational phase, following scheme implementation. However, it is also necessary to assess and re-appraise the project during phases prior to implementation.

tie has been, is and will continue to take steps to validate and evaluate the scheme (both before and after implementation) and to monitor its performance in the operational phase.

3 LINE 2 APPRAISAL



3 Line 2 Appraisal

3.1 Introduction

This Chapter summarises the STAG appraisal that has been undertaken by FaberMaunsell and reported in November 2003 in developing a preferred route and operating system for the Edinburgh Tram Lines 2. During this time the engineering feasibility, environmental impact and revenue/patronage forecasting was undertaken for a variety of options seeking to provide a first class public transport system from the City Centre to the western edge of the city.

3.2 Problems and Opportunities

Edinburgh's economic success as a growing region for employment and increasing population has led to many pressures arising in it's transport networks. This together with increasing demands for new developments, particularly in the West Edinburgh area, will mean that this congestion is likely to increase further.

It has been estimated that traffic levels in Edinburgh will grow by 20% over the 20 years. Traffic delays, however, grow at a disproportionate rate and as a result the time lost in traffic due to congestion is expected to double. The most serious problems are expected in West Edinburgh, which has been shown to account for almost half of the additional congestion. There is a concern that the competitiveness and, thus, the dynamism of the Edinburgh and Lothian's economic will be reduced if the region's strengths are not further developed and this would have a negative impact upon Scotland as a whole. Traffic congestion is causing problems for all road users through delays to commercial vehicles, private car and bus. Traffic congestion can impeded effective business and discourage the location of new or expanding businesses in or near the city. As a consequence, congestion is harming the local economy and the environment.

3.3 Option Generation, Sifting and Development

A considerable body of work has already been completed to support the Integrated Transport Initiative. This includes **tie**'s report to the Scottish Executive in September 2002, which sought approval in principal to proceed with the ITI; and Arup's "Edinburgh LRT Masterplan Feasibility Study" submitted to the Council in January 2003. In essence, the work already undertaken within these reports has been presented to a sufficient level to satisfy the requirements of the STAG1 appraisal process. This is confirmed by the Executive's announcement in March 2003 to investment in principal for a tram network in Edinburgh.

From publication of the Preferred Route Corridor Report (February 2003), the design team continued work in refinement of the options by technical review, site visits and stakeholder consultation. This further work enabled the route options within the preferred corridor to be sifted, which reduced the options presented within the initial report. In other areas it was not possible to resolve all issues and it was felt that public consultation would assist in the appraisal. This work is referenced in the Addendum of the "Preferred Route Corridor Report".

The preferred route corridor that was taken forward to public consultation is the central corridor, which broadly follows the alignment of CERT.

3.4 Consultation

The consultation process has informed major stakeholders and the residents of Edinburgh about the proposals to introduce trams to Edinburgh, and it has provided the opportunity to comment in a variety of ways.

The results of the consultation show that there is broad support in Edinburgh for Line 2 and options for including in the preferred route were identified.

3.5 Scheme Description

The Preferred Route begins at St Andrew Square before travelling along Princes Street, Shandwick Place to Haymarket. It then runs parallel to the main Edinburgh to Glasgow Railway line, initially on the north side but crossing over the railway to run on the south side as fare as the new Edinburgh Park Rail Station.

From this point it crosses the rail line once more and runs northwards through the Edinburgh Park and Gyle Shopping Centre. After crossing the A8 to the east of Gogar roundabout the tram passes close to the new Royal Bank of Scotland headquarters (albeit on the north side of the A8) before reaching the new Park and Ride site at Eastfield Road. The line then swings northwards to Edinburgh Airport where it terminates.

A second branch line (the Newbridge spur) will run between the Eastfield Road Park and Ride stop westwards towards Ratho Station and the new developments at Newbridge where it will terminate.

The frequency of both the main line and the Newbridge Spur will see 6 trams running in each direction in each hour during the peak. Each tram will have a capacity of up to 300 passengers giving an overall capacity for the system of 1,800 passengers per hour in each direction. It is proposed that the Tram depot will be located at Gogar and there will be 17 stops located at the following locations:

Table 3.1: Line 2 Stops

Main Line	Newbridge Spur
St Andrews Square	
Princes Street	
Shandwick Place	
Haymarket	
Murrayfield	
Balgreen Road	
Saughton Road North	
South Gyle Access	
Edinburgh Park Station	
Edinburgh Park	
The Gyle	
Gogarburn	
Ingliston Park & Ride	Ingliston Park & Ride (interchange with the main line)
Airport	Ingliston West
	Ratho Station
	Newbridge South
	Newbridge North

Capital cost estimates for Edinburgh Tram Line Two have been prepared using a combination of benchmarking, previous experience and engineering judgement. The capital costs are estimated at £336.3m including 31% optimism bias based on 2Q 2003 prices.

Costs have been derived from a comprehensive database compiled from analyses of costs for the infrastructure works of completed and proposed LRT schemes throughout the UK, currently advised prices from vehicle manufacturers and preliminary diversionary works estimates obtained from utilities companies. The resulting estimates take account of the prevailing factors influencing this particular scheme including location, relative complexity, environment and anticipated programme.

Operating costs are expected to be around £5.7m per annum, excluding operator margin estimated at 12%.

3.6 STAG2 Appraisal

3.6.1 Environment

The assessment identifies a number of positive environmental benefits associated with tram Line 2. Air quality is predicted to improve as a result of a reduction in traffic flows, as will the main greenhouse has (CO2). Landscape and ecological benefits would occur along some segregated sections of the route where new planting would be undertaken. The tram would also have a number of negative impacts. The construction phase will result in short term localised disruption to residents and businesses. Vegetation including trees will be lost in several locations. Replacement planting is proposed in these areas.

The main operational impacts are associated with the presence of tram infrastructure within Edinburgh's World Heritage site, and in the greenbelt. Negative heritage, landscape and visual impacts are predicted within this sensitive area. Heritage impacts would also occur at Gogar and Huly Hill at Newbridge. Operational noise impacts would be negligible along much of the route but negative impacts are predicted at residential properties at Balbirnie Place, Baird Drive and Ratho Station. Mitigation measures would be implemented to reduce these impacts.

3.6.2 Safety

It is a requirement that any new proposal must been reviewed in relation to its anticipated impact on safety and security, and the frequency and severity of accidents. The personal security concerns of many individuals when using public transport will be dealt with through the design of mitigating facilities designed into the tram development. For example, Edinburgh Tram Line Two will have stops fitted with high quality lighting and close circuit television.

In terms of road user accidents it is not envisaged that there will be any significant changes in the number of road accidents occurring during the early years of operation.

3.6.3 Integration

The integration of Line 2 with transport, land-use and wider policies has been reviewed within this report. In terms of transport integration the tram route will provide rail interchange opportunities at Waverley, Haymarket and the new station at Edinburgh Park. Bus interchange opportunities will also be possible at the Gyle Shopping Centre and at other locations.

The tram route will connect well with the Park and Ride facilities at Ingliston, ensuring that an alternative choice can be provided for motorists.

The preferred route integrates well with land-use as it connects well with major employment, leisure and transport hubs thus contributing to sustainability and reducing the need to travel. In addition there is also greater scope for development opportunities resulting from the eventual routing of the tram route.

In terms of policy integration the tram has been shown to contribute to wider Government policies on Disability, Health and Social Exclusion.

3.6.4 Accessibility

The proposed tram line is expected to increase accessibility by public transport with key benefits realised by those who do not own a private car and the socially disadvantaged. There are a number of socially deprived ward in and around the proposed route of the tram in which the tram will provide increased accessibility to employment opportunities.

In terms of access to local services it is considered that, since the tram mainly runs off street, that it will have only minor adverse impacts on local accessibility.

3.6.5 Economy

As required by STAG, this report includes consideration of the economic welfare impacts of the proposal (Transport Economic Efficiency, TEE). This appraisal provides a review of what users are willing to p ay in order to use the tram line; the financial impact on private sector transport providers; and impacts arising from land use or other impacts of the tram line.

The Benefit Cost Ratio of the Preferred Route was calculated as 1.38. This means that the overall benefits of the scheme exceed the costs by 38% and therefore represents good value for money in economic terms.

In addition, an assessment has been made of the economic activity and location impacts (EALIs), including quantification of the impacts in terms of employment gains and losses, as well as income/ GDP. This has indicated that there will be a small net increase in the amount of residential, retail, office and industrial floorspace created as a result of the tram project but would have no impact on property rental values in those sectors.

3.7 Risk and Uncertainty

One of the critical success factors for Edinburgh tram is the identification and mitigation of the risks inherent in a project of this nature. In order to manage risk in a structured manner, **tie** has appointed a full-time Risk manager to develop and apply a framework of risk analysis and evaluation to assist in decision-making, and identified the following prime objectives:

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3.8 Monitoring and Evaluation

There are five phases of the project which require consideration during the monitoring and evaluation process, namely:

- scheme development;
- infrastructure procurement;
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The STAG requirements for monitoring and evaluation are principally associated with the operational phase, following scheme implementation. However, it is also necessary to assess and re-appraise the project during phases prior to implementation.

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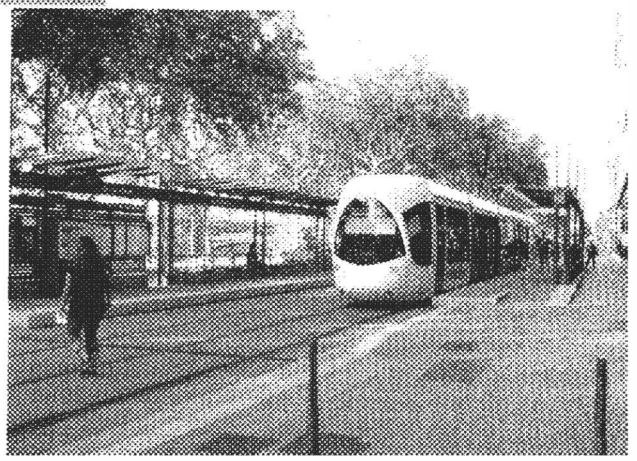
4 STUDY APPROACH



4 Study Approach

4.1 Introduction

The methodologies applied in the network effect study mirrored those employed by both the Line 1 and Line 2 study teams, thus ensuring consistency and enabling comparisons to be made. As the individual Line study teams progressed their designs, so the network effects team had to take on board any changes to their plans and assumptions and incorporate them into the network options being developed accordingly. Effective communication between the Line teams and the network effects team was maintained throughout.

A summary of the overall methodologies and underlying assumptions employed is set out below under the key topic headings.

4.2 Tram Operations

By running two tramlines as a network, certain operating efficiencies can be realised due to economies of scale. These savings include staff costs associated with day-to-day operations and routine maintenance of the infrastructure and vehicles can be reduced through combined operations.

Certain specific costs can be reduced by eliminating the 'double counting'' that would be present when Line 1 and Line 2 are considered individually. In particular, Line 1 and Line 2 share a common section of tram alignment between St Andrew Square and the Roseburn Junction to the west of Haymarket Station. Both the Line 1 and Line 2 teams considered the maintenance costs of the track and associated infrastructure for this 2.6km section. Under network operations, such maintenance would be considered only once.

Table 4.1: Operating Characteristics – Line 1, Line 2 & Network Common Section

	Length (km)	Peak headway (trams per hour)	Journey Time (minutes)
Line 1 Northern Loop	15.7	8	41
Line 2 St Andrew Square to Edinburgh Airport Ingliston to Newbridge	 13.6 4.2	 6 6	 31 9
Line 1 + Line 2 St Andrew Square to Roseburn Junction (Common Section*)	2.6	14	9
* common section is included in the lengths & journey times for Line 1 and Line 2 by themselves.			

Perhaps more significantly, fixed staff costs will be reduced under network operations. Several staff positions are needed for a tram system regardless of the size of the system. For instance, a tram network requires a senior management team, a human resources department, and accounting and payroll staff. The number of employees in these positions is not linearly related to the size of the tram fleet or its operating characteristics. By operating Lines 1 and 2 as a network, these sorts of positions can be consolidated to reduce the overall number of employees.

In several cases, the positions that can be consolidated are high-level with relatively higher salaries. Appendix A sets out the salary assumptions that were used for the operating cost estimates. Reducing the positions with higher salaries can have a noticeable impact on the annual operating costs of the combined network.

Not all staff positions can benefit from an 'economy of scale'. However, the majority of positions are linearly related to the amount of tram service provided. The more service provided to passengers – be it as separate tramlines or as a network – the more staff is required. Drivers are a key example of staff positions that cannot be reduced through network operations. Every tram requires a driver and if the service patterns of Lines 1 and 2 do not change, the number of drivers cannot be reduced.

The sections later in this report examine the operating cost impacts of running Lines 1 and 2 as an integrated network. Readers will notice changes possible for fixed staff costs under network operations, as well as the linear relationship of tram-variable costs (eg drivers) to service provisions.

4.3 Infrastructure

Although sharing a common section of track alignment between the city centre and Rosebum Junction, both Line 1 and Line 2 have been designed independently without consideration for running the two lines as a network. When network operations are considered for the two lines, several additional infrastructure elements would be necessary to avoid operating conflicts.

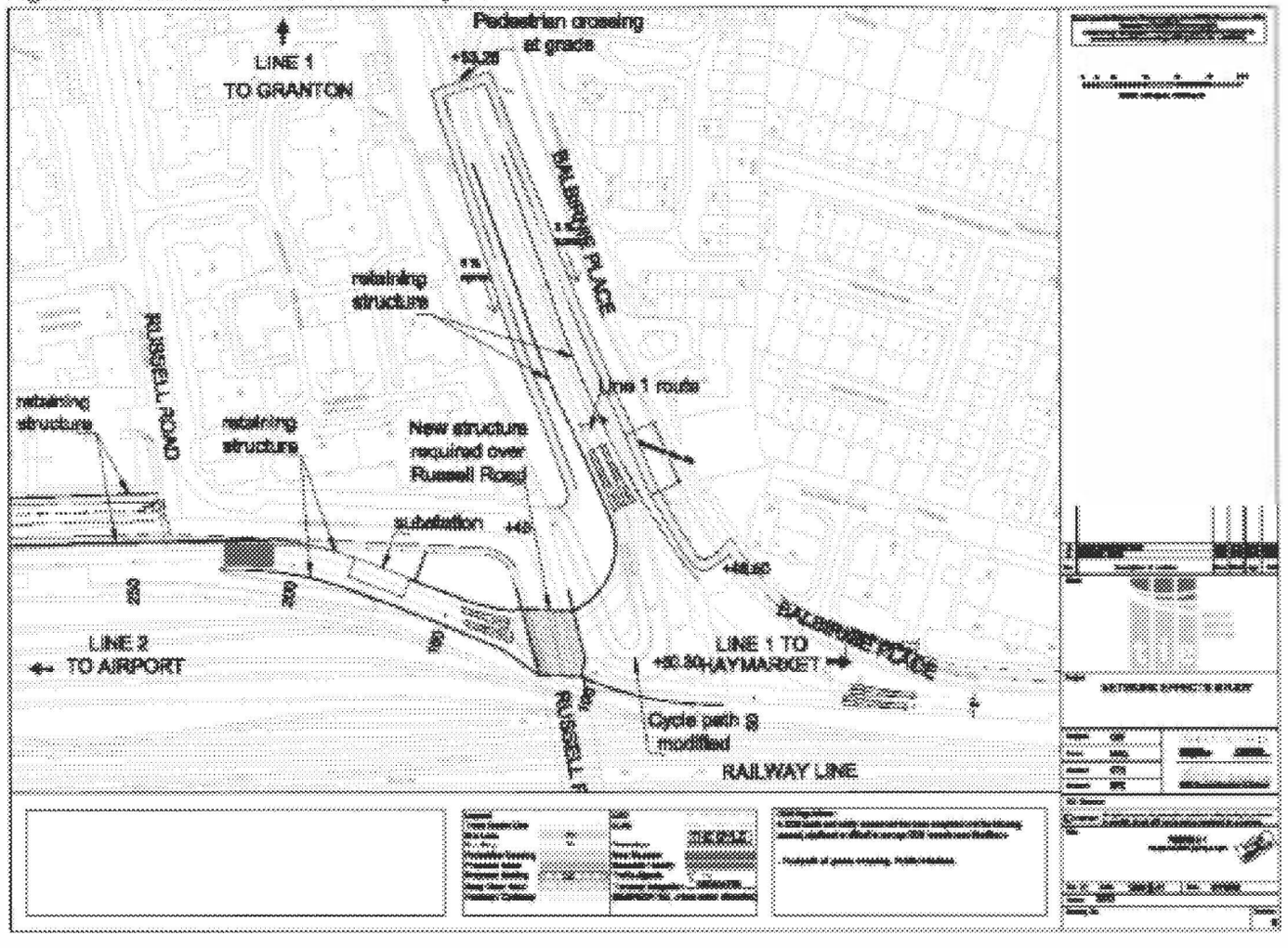
In particular, network operations scenarios need to allow the two lines to run unencumbered by each other. If, for whatever reason, a tram vehicle on Line 1 needs to pass a tram vehicle on Line 2, specific infrastructure is required to permit this movement.

One example of where such infrastructure would be needed is in the east end of the city centre. Line 1 would be operating a through service in St Andrew Square and Princes Street without any need to stop and recover time or tum around. Line 2 on the other hand has considered the east end of the city centre as its termination point, where it will reverse service and layover to recover its schedule. With Lines 1 and 2 currently anticipated to run with different service frequencies, Line 1 tram vehicles will need to pass waiting Line 2 tram vehicles. To do this, additional infrastructure would be needed. This was assumed to be located at Picardy Place, but is subject to further development by the Line 1 team.

Similarly, a layover/tumback facility at ocean Terminal would require additional infrastructure. It would allow Line 2 trams to terminate and layover to recover their schedule without impeding through movements on Line 1.

The alignments for Line 1 and Line 2 meet up at Rosebum Junction to the west of Haymarket Station. From the city centre, Line 1 continues to the northwest towards the Westem General Hospital and Granton, while Line 2 continues west to Murrayfield Stadium and the Edinburgh Airport. In their separate projects, Line 1 and Line 2 incorporated a common alignment from the city centre to Roseburn, but neither considered a tram junction where the trams connect because they were designed independently. Under network operations, a special all-way junction would be beneficial as it would facilitate movements throughout the tram system. Within network effects, an estimation for the construction of a three-way delta junction at this location was developed, based on the alignments and designs of Line 1 and Line 2 and is illustrated in Figure 4.1.

Figure 4.1: Roseburn Delta Junction Layout



Therefore, three pieces of additional infrastructure could be required to run Lines 1 and 2 as a network. Two of these pieces would allow Line 2 tram vehicles to turn around and layover outside of the path of Line 1 tram vehicles, thereby permitting passing. This infrastructure would be needed at Ocean Terminal (if Line 2 operates through Leith) and in the east end of the city centre. The third piece would be the all-way (delta) Roseburn Junction. The estimated costs for the turnaround facilities and the Roseburn Junction are summarised in table 4.2. In total, the estimated capital cost of the additional infrastructure is approximately £3.84m.

Table 4.2: Estimated Capital Costs

	Ocean Terminal Turnback/Layover	Turnback/Layover (Picardy Place)	Roseburn Delta Junction
Capital Cost	£707,400	£1,270, 700	£1,860,200

Includes optimism bias

4.4 Rolling Stock

Network operations have a limited impact on rolling stock. Because the number of rolling stock vehicles for the service is directly proportional to the amount of service provided, the only real changes in fleet size (and thus in operating, life cycle and capital cost) that results from network operations are associated with extra or spare vehicles.

The number of spare vehicles has been established (by the Line teams) at 10% of the in-service fleet size (with a minimum requirement of two tram vehicles for each line) to cover vehicle maintenance and breakdowns. When Lines 1 and 2 are considered independently, that results in a minimum combined spare vehicle requirement of four trams, which can result in more than 10% of the combined in-service fleet size. For example, if Lines 1 and 2 each have 10 in-service vehicles, they require four spare vehicle in total – 20% of the combined in-service fleet size.

Carrying the same approach (10% with a two spare minimum) forward into the Network Effects Study, savings in vehicles can result when the spare vehicle calculations are done on a single combined in-service fleet. In the above example with a combined in-service fleet of 20 trams, only two spare vehicles would be needed – saving of two trams. This saving is a direct result of network operations and, using this example, would translate into savings of £4.06m in capital costs and £2.23m in total lifecycle costs (over the scheme life), including optimism bias.

Network effects assumed the same technical specifications for trams as per the Line 1 and Line 2 teams; semi low-floor or low-floor and 40m in length. These would offer a total capacity of 300 passengers per tram.

4.5 Depots

Constructed individually, Line 1 and Line 2 would each require a depot to provide support and maintenance facilities for the routine and long-term operations of the tram fleet. When operated as a network, the depot facilities could be better configured to provide the same level of support and maintenance with a reduced amount of infrastructure and equipment.

Three possible depot scenarios were considered for network operations, based on the two sites already established within the individual line projects. The network effects study did not seek to identify further potential new depot sites, as both the Line 1 and Line 2 studies separately assessed all potential sites for depots on their line of route. The scenarios include the use of the Line 2 Gogar Depot as a single depot for the entire network fleet (Scenario A in Table 4.3), and two scenarios with a main depot and a line depot (one with a main depot at the Line 1 Leith docks depot (Scenario C) and one with a main depot at the Line 2 Gogar Depot (Scenario B). A fourth scenario, where the Leith Docks Depot would be a single depot, was considered not large enough to accommodate an integrated network fleet.

Not surprisingly, the scenario with the greatest potential for cost savings is the scenario with only one depot (Scenario A). However, the cost savings from the complete elimination of the Line 1 Leith Docks Depot would be negated to a certain degree by the requirement for additional facilities at the Line 2 Gogar Depot to accommodate a larger fleet. The estimated cost for this single depot scenario (not including land costs or site preparation) is approximately £18m including optimism bias (see Table 4.3).

This scenario, however, would push the depot to its maximum thresholds for both capacity and operations, which means that future expansion o the site would not be possible to, say, accommodate trams for further network extensions and/or service frequency enhancements. Also, the day-t-day operations of the site would be restricted by the amount of space for equipment and maintenance facilities. Because of this constraint, operating conditions (hours of operation, days of the week, etc) would need to be expanded in order to carry out the necessary work on the network fleet.

The other two depot scenarios (B and C) maintain depot facilities on both the Line 1 Leith Docks Depot and the Line 2 Gogar Depot sites. However, because one of the depots would provide only day-to-day maintenance facilities (such as vehicle washing machine, interior cleaning equipment, and minor repairs equipment for bulb replacement, fabric mending etc), that site would not require heavy maintenance equipment. Instead of needing this heavy maintenance equipment for both sites, only the main depot would have it, resulting in cost savings.

As well, certain administration and control room facilities would not need duplication. That would lead to a reduction in the amount of space needed for buildings, roads, and parking, among other items. Again, as in the scenario with only one depot, certain infrastructure would need expansion in the main depot to provide s lightly more capacity for any heavy maintenance required for the fleet. The estimated costs (excluding land costs and site preparation) are approximately £25m (including optimism bias, regardless of whether the Line 1 Leith Docks Depot (Scenario C) or the Line 2 Gogar Depot (Scenario B) is selected as the main depot.

From a depot operations point of view, either of the two-depot scenarios (B or C) would be acceptable. A single-depot scenario does not permit enough operational flexibility on the site to, firstly, perform maintenance and to, secondly, expand the fleet. The combination of main and line depots provides flexibility and reduces the overall infrastructure and equipment necessary. The selection of the site for the main depot could end up being more of a planning issue than an operations issue, as each scenario offers similar benefits.

Table 4.3: Summary of Depot Development Scenarios & Capital Costs

	Single Line		Network Scenario		
	Line 1	**Line 2**	**A**	**B**	**C**
	Leith Docks	Gogar	Gogar only	Leith Line Gogar main	Leith main Gogar line
Control and admin building	£3,110,000	£1,570,00	£1,970,000	£3,900,000	£4,290,000
Maintenance buildings	£2,760,000	£2,750,000	£3,440,000	£5,100,000	£5,090,000
Trackwork	£2,650,000	£4,450,000	£7,120,000	£7,420,000	£7,150,000
Traction power OLE Sub-station	£1,480,000	£1,310,000	£2,100,000	£2,850,000	£2,870,000
Maintenance equipment	£2,830,000	£2,750,000	£2,750,000	£4,450,000	£4,480,000
Roads Hardstanding Car parking	£320,000	£260,000	£300,000	£580,000	£580,000
Security Fences	£280,000	£260,000	£260,000	£540,000	£540,000
Total	**£13,430,000**	**£13,350,000**	**£17,940,000**	**£24,840,000**	**£25,000,000**

Includes optimism bias

The most practical and, thus, adopted strategy was to provide one main depot for heavy maintenance, day-to-day operations, and overnight stabling and a second, or line, depot to provide supplementary space for overnight stabling and to offer facilities for day-to-day operations, such as cleaning and washing the vehicles. The Gogar Depot site was therefore identified as the main depot because it is the larger site, and the Leith Docks Depot would have line depot capabilities only (Scenario B). Therefore, the anticipated savings in depot capital costs by adopting this strategy was £1.94m (compared to Line 1 + Line 2).

4.6 Environmental Impacts

The focus for assessing the environmental impacts has rested with the individual Line teams, through their requirement to produce Environmental Statements as part of the overall STAG submissions. Part of both the Line 1 and Line 2 Environmental Statements is a chapter in the 'cumulative effects' of operating Line 1 and Line 2 together. Therefore, the agreed approach with **tie** was to focus on the production of these within the Line teams, assuming the Base Case network options as presented in Section 6.2.

Appendix B sets out this chapter on cumulative effects from the Line 2 Environmental Statement.

4.7 Demand and Revenue Forecasting

The demand and revenue modelling work was done under the guidance of the Modelling & Appraisal Working Group (M&AWG), which meets on a monthly basis to ensure consistency of approach between the consultants responsible for Lines 1 and 2.

Demand modelling and car/public transport mode choice modelling was done using the Land Use and Transport Interaction (LUTI) model developed and run by consultants MVA. This produced highway and public transport (PT) demand matrices for use in the detailed assignment models.

Patronage forecasts were developed using several models:

- Land Use and Transport Interaction (LUTI) model, which incorporates:
  - DELTA land use model
  - Traffic Restrain analysis Model (TRAM)
- Highway Detailed Assignment Model (Highway DAM)
- Public Transport Detailed Assignment Model (PT DAM)

LUTI was developed for the Council specifically for the assessment of transport scheme. In forecasting transport demand account is taken of the impact of transport changes on land use, as well as the effect of land use changes on transport use. The result is highway and PT demand up to year 2026. LUTI uses large aggregate zones, unsuitable for considering the detail of a tram scheme. Therefore the LUTI demand matrices were input to detailed assignment models described below.

The Highway DAM was developed from the Central Scotland Transport Model (CSTM3), cordoned to Edinburgh and the environs. This used a much more disaggregate zone system. LUTI trip matrices were disaggregated to Highway DAM zones then assigned to this highway model. This model is used to calculate highway delays, which were then passed on to the PT modelling of buses. This model was also used to calculate the non-user benefits of the tram, such as congestion relief.

The PT DAM was developed from the Central Scotland Transport Model (CSTM3) cordoned to Edinburgh and the environs. However, even the CSTM zones were not disaggregate enough for consideration of the tram scheme, so larger zones in the proximity of the tram line were disaggregated.

This model was used to produce public transport patronage forecasts by mode for the AM peak hour, an inter peak hour and the PM peak hour, for 2011 and 2026. For each of these years a Reference Case was produced that is, in effect, the Do-Minimum scenario from which the tram options can be compared. This Reference Case incorporated the future year transport networks that are committed and also allowed for changes in development (new and redistributed), again based on committed plans. It is from this Reference Case that the 'Do-Something' tram options were developed.

Assumptions used in the Dam model are consistent with those used by the Line 1 and Line 2 teams. Some of the key assumptions included:

- Urban bus fares = 2001 Lothian Regional Transport bus fares, (50p up to 800m ride, 80p up to 7km ride, and 90p up to 15 km ride)
- Tram fares = urban bus fare, except:
  - Airport fare = half Airlink bus return fare
- Walk time weight = 1.6
- Wait time weight = 1.8
- Bus ride time weight = 1.1
- Rail ride time weight = 1.0
- Interchange penalty = 10 mins
- Tram mode constant = 0.8

Line 1 reviewed the level of bus service provision along Leith Walk following the introduction of the tram service and concluded that the most likely response would be that the numbers of buses operating along Leith Walk are reduced once a tram is introduced along that route. Network effects has modelled this same level of change in service provision.

The models use 2001 fares. Revenue was therefore inflated to 2003 values by applying a 1.5% growth rate per annum for two years. Period annualisation factors are shown in Table 4.4 The products are then summed to provide annual patronage. These patronage factors were determined by MVA using Edinburgh travel diary surveys, which revealed the proportion of trips outside the modelled periods. The number of evening and weekend trips by tram will depend on the tram service operated in these periods, as well as the demand for travel in these periods. Line 1 and Line 2 provided service patterns to MVA and a compromise annualisation for use in all scenario testing was agreed by the M&AWG.

Table 4.4: Annualisation Factors

	AM peak	Off peak	PM peak
PT	557	2425	563
Highway	585	2288	656

Further factors were required to be applied to the revenue to reflect the fact that not everyone pays full adult fare. Saver Tickets (peak and off peak) and weekly, monthly and annual passes provide alternatives for frequent travellers. There are also concessionary travellers, who pay a reduced fare. Most of this concession is recovered by the operators from the authorities, but not for trips that are considered to have been generated by a discount fare. Though 'generated' these trips are already included in the modelled demand, so full fare could not be recovered for these modelled trips.

Unlike other cities, Edinburgh bus services do not offer an off peak discount (except for Saver Tickets). This may be because Edinburgh peak fares are quite low to start with. As a result, off peak discounts will not reduce revenue as much as can happen in other cities. However, Saver Tickets and period tickets will reduce revenue. Analysis of ticket data provided by Lothian Buses suggested that the average AM peak revenue is 92% of the full adult fare. After 09:30, the revenue is 87% of the full adult fare. These values were therefore applied when calculating revenue.

Some element of fare evasion was deemed inevitable. As well as avoiding paying fares, it was anticipated that some passengers would seek to pay a lower fare for a shorter distance or for a ticket type they are not eligible. T here may also be some revenue loss due to staff dishonesty. The adoption of conductors for Edinburgh tram should ensure less fare evasion than has been seen on some UK systems. A value of 5% loss was therefore assumed.

4.7 Appraisal

The appraisal techniques used within the network effects study focussed on three formats:

- standard business case financial data;
- generation of cost:benefit ratios; and
- production of a standard TEE (Transport Economic efficiency) analysis.

The latter two essentially incorporated the form and also took into account wider economic benefits such as time savings to users and non users. Whilst the completion of a TEE appraisal is one part of a STAG appraisal, a full STAG appraisal was not required for the purposes of this study.

The focus of the appraisal was a standard 30 year scheme operating life, starting in 2009 through to 2038. Present Values were calculated back to 1998 using a standard discounting rate of 3.5% per annum. March 2003 prices were used throughout.

The standard business case financial data could be split into a number of key components, including:

- capital costs
- lifecycle costs;
- operating costs; and
- revenue.

The spend on capital costs was assumed to be over a 36 month period prior to scheme opening in 2009, with a spend profile of 20% in 2006, 40% in 2007 and 40% in 2008. The spend profile for lifecycle costs was allocated to specific years.

Operating costs, which included items such as staff wages, were assumed to rise at a faster rate than the retail price index (RPI). Wage rate inflation is currently rising at a rate of around 1% greater than the RPI rate, and overall wages constitute approximately half of the total operating costs. Therefore it was agreed with **tie** that a net real increase in operating costs of 0.5% per annum would be applied.

For revenue, within a full thirty-year scheme life profile, a period of ramp up to full demand levels is normally assumed, in which full revenue is only achieved in the fourth year of operation. Table 4.5 shows the ramp up assumed.

Table 4.5: Assumed Ramp Up

	Year 1	Year 2	Year 3
Percentage of base revenue	75%	85%	95%

Base revenue between 2011 to 2026 the two modelled years, was interpolated as a straight line, which was also extrapolated back to 2009. Post 2026, revenue was assumed to be constant (as per TUBA recommendations).

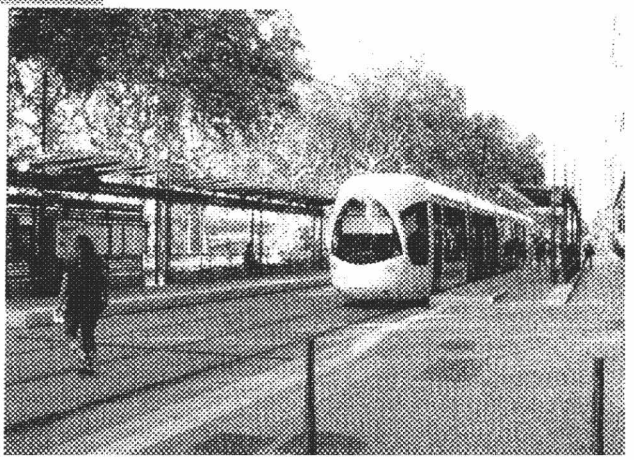
Additional appraisal of patronage levels in the two modelled years was also undertaken to determine if any capacity issues might arise. Analysis of the boardings and alightings in the modelled time periods also indicated where the busiest parts of the network were most likely to be.

The production of a TEE appraisal incorporates the following items:

- Net benefits to transport users:
  - Travel time savings;
  - User charges (including fares and parking charges);
  - Vehicle operating costs.
- Net benefits to transport operators:
  - Investment costs;
  - Operating and maintenance costs;
  - Revenues;
  - Grant/subsidy payments.

In order to then generate BCRs, the data outlined above is added to the costs and benefits to the public sector. These included items such as public sector investment costs (such as capital costs), grant/subsidy payments and taxation impacts.

5 OPTION IDENTIFICATION



5 Option Identification

5.1 Overall Strategy

The approach adopted to define the Line 1/Line 2 network options involved:
a/ confirmation of the 'Base Case' option; and
b/ identification of the best 'investment enhancement option' through appraisal.

Whilst the former could be described as fairly self-explanatory (Line 1 and Line 2 running side-by-side as specified by the individual Line teams), the latter option required the undertaking of a two stage appraisal process. In considering what a best 'investment enhancement option' might represent, it was clear that there were a large number of possible service pattern options – differing combinations of service configurations and frequencies. In most cases, these options would require additional investment, but would facilitate additional network-related benefits, as well as providing additional benefits to the individual lines (improved capacity where require, etc). Therefore, an initial option appraisal was undertaken which sieved through the potential options and shortlisted five for further analysis. From the more detailed appraisal focussing on these shortlisted options, a best 'investment enhancement option' was then identified.

5.2 The Base Case Option

This option simply puts the two lines side-by-side, therefore:

- Line 1 operates 8 trams per hour in each direction around the Line 1 loop; and
- Line 2 operates 6 trams per hour in each direction between the Airport and the city centre, with a Newbridge shuttle operating between Newbridge and Ingliston (also 6 tph).

On the joint running section between Roseburn Junction and the east end of the city centre, this results in 14 trams in each direction.

Whilst it was envisaged that, in the main, the features of the individual lines would be retained in the base Case, it should be noted that there would be a need for some additional infrastructure relating to:

a/ the line 1/line 2 junction at Roseburn; and
b/ the provision of suitable layover/turnback facilities for Line 2 trams at the east end of the city centre.

These were discussed in Section 4.3.

The key purpose of this additional infrastructure would be to provide operational flexibility and to maintain a robust operational plan when the two lines are combined.

From the demand/benefits perspective, the Base Case allows us to determine what the impacts might be without enhancing the service proposition.

The appraisal of the Base Case option is set out in Section 6.2.

5.3 Identification of the Best 'Investment Enhancement' Option

5.3.1 Initial Option Appraisal

5.3.1.1 Option Definition

It was important to ensure that, through the initial option appraisal process, it can be demonstrated that all reasonable network options were considered in order to identify the best investment enhancement option, with the justification underpinning those options recommended for further consideration clearly set out. The possible service patterns could be defined based upon the different combinations of:

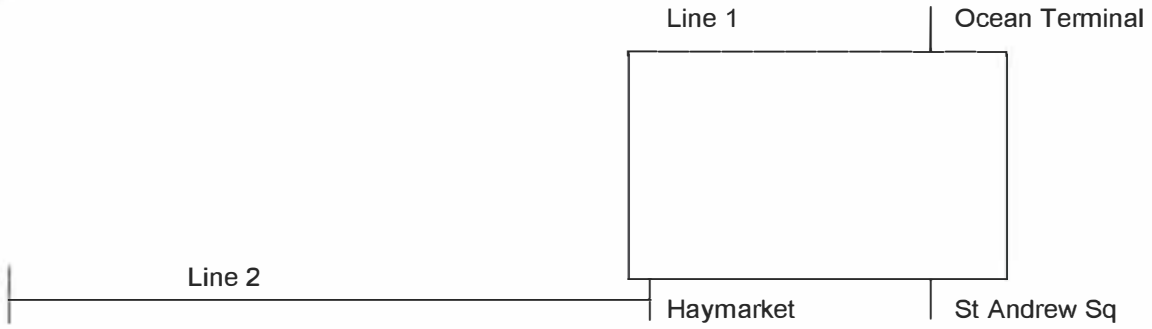
- service configurations; and
- service frequencies.

The possible service configurations are considered first, then the possible service frequencies and then the two are combined into all the possible options.

Possible Service Configurations

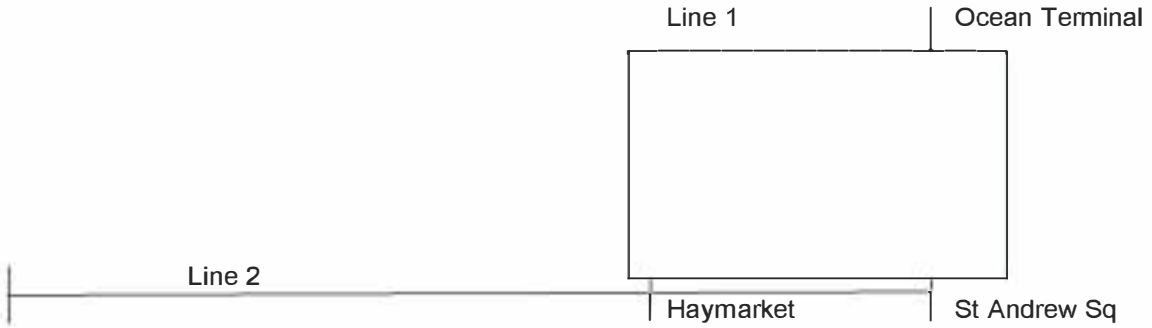
Five possible service configurations for merging lines 1 and 2 were identified, through adopting an incremental approach to their development. The starting point for defining these was the Base Case. These configurations are set out below.

Option A; Line 2 terminates at Haymarket



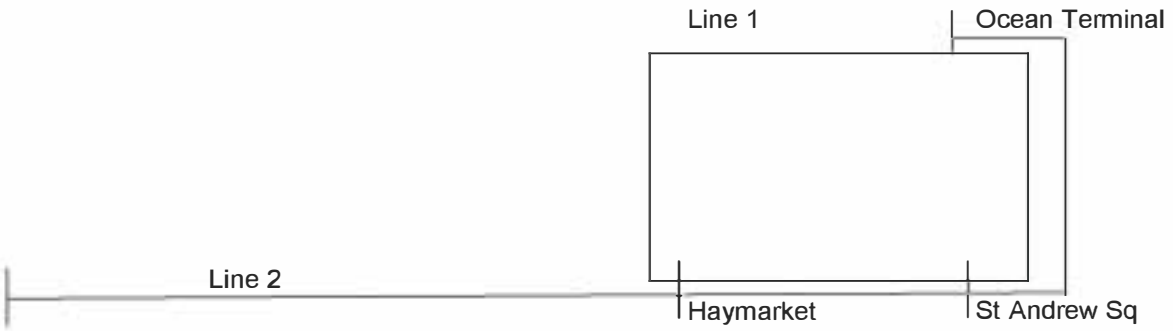
Line 2 terminates at Haymarket and this tram stop becomes a major interchange for tram passengers wishing to access the city centre/Princes St. This option would reduce any possible operational impact that might occur between the two lines. The Haymarket tram stop would need to have additional platform(s) and turn-back facilities and there would be a small section of joint running between Roseburn Junction and Haymarket.

Base Case: Both Lines operate as set out in Bills



Direct access for Line 2 into the City Centre. Focus on the east end of the city centre for termination and turn-back of Line 2 trams (this service configuration was considered within the appraisal as different service frequencies could be attached to it, thus potentially creating a new option for consideration).

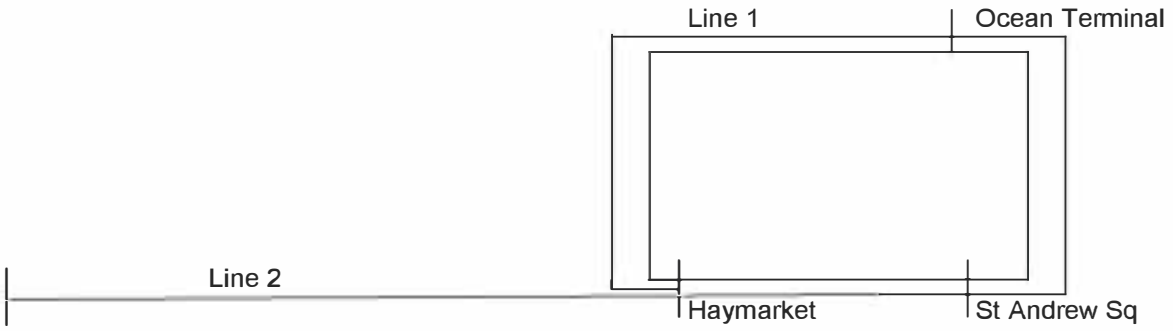
Option B: Line 2 operates around to Leith (Ocean Terminal)



Line 2 extended around to Leith/Ocean Terminal. This provides additional trams between Leith Walk and the city centre and also directly links key areas such as Leith/ocean Terminal with western Edinburgh, including the airport. Ocean Terminal chosen as Line 2 terminus in Leith areas (as opposed to say, Duke St (Northern end of Leith Walk)) to best cater for demand patterns and better opportunities to provide the necessary turn-back facilities.

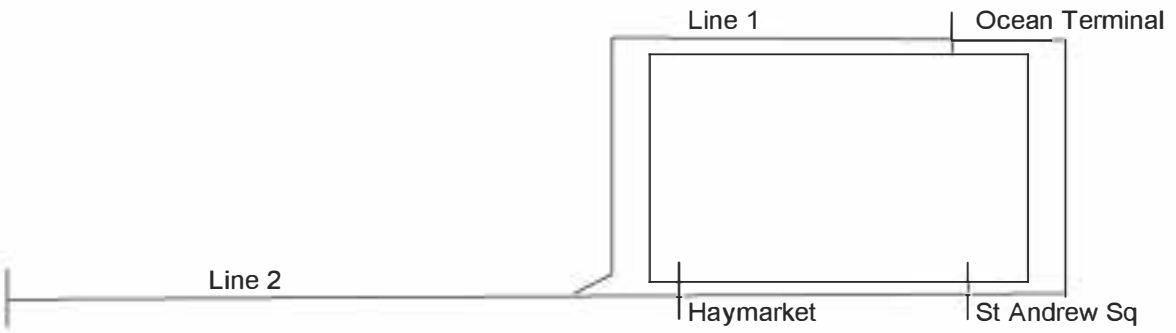
Consideration at this stage was given to the alternative of extending Line 2 trams around the west side of the Line 1 loop (rather than the east side). However, apart from the obvious lack of direct penetration of city centre for Line 2 trams, evidence from demand matrices produced for the Base Case option suggested that there were more potential network benefits in linking line 2 to the east side of Line 1 (over 4% of tram trips) than to the west side of Line 1 (less than 3% of tram trips). Both options C and D which do serve the west side of the Line 1 loop, were then considered as incremental extensions to option B.

Option C: Line 2 operates all around the Line 1 loop to terminate at Haymarket



Line 2 operates all the way around the Line 1 loop and terminates at Haymarket. Haymarket therefore requires turn-back facilities and appropriate interchange facilities.

Option D: 'Panhandle operation' – Line 2 trams operate each way around the Line 1 loop



Line 2 trams operate both clockwise and anti-clockwise alternately around the Line 1 loop. This option does reduce the number of Line 2 trams going direct between the City Centre and western Edinburgh/airport. Would require additional infrastructure at Roseburn Junction (a delta junction) with Line 1 to allow Line 2 trams to travel between Ravelston and Line 2.

Possible Service Frequencies

The base service frequencies currently being planned for Line 1 and for Line 2 are 8 tph and 6 tph respectively. It was deemed appropriate to assume that these service frequencies were defined after considerable analysis by the respective Line teams. Of course, any network (and service frequency) effects themselves are likely to increase demand and therefore the service frequencies defined by the Line 1 and Line 2 teams were viewed as being the minimum service frequency for any network service.

Therefore, the individual target frequencies for each of the lines (as per the Base Case) were viewed as the minimum service frequency permissible, with a maximum allowance for an additional 2 trams per hour to cater for the possible 'network effects' that may result. Table 5.1 thus presents the possible service frequency combinations for the network operation.

Table 5.1: Possible Service Frequency Combinations – Lines 1 and 2 Combined

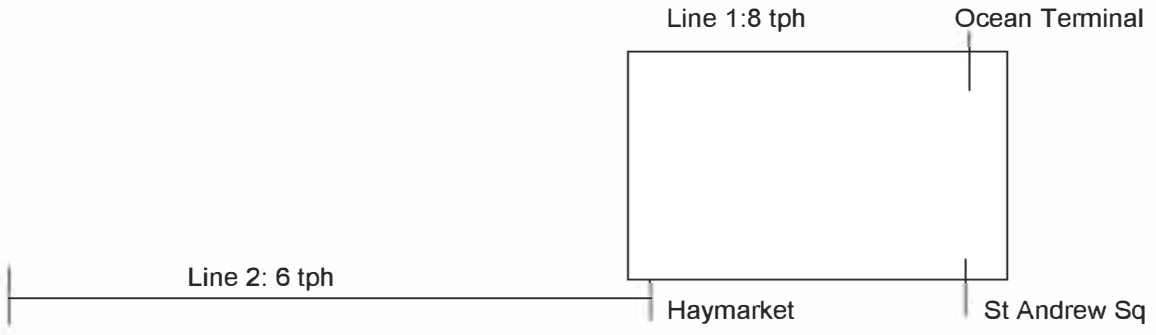
Combination	Line 1 (trams per hour)	Line 2 (trams per hour)	Joint Running Section	Comments
1	8	6	14	Target frequency on Line 1, target frequency on Line 2
2	8	7	15	Target frequency on Line 1, slightly higher than currently planned frequency on Line 2
3	8	8	16	Target frequency on Line 1, higher than planned frequency on Line 2, although frequencies do match
4	9	6	15	Frequency a bit high on Line 1, target frequency on Line 2
5	9	7	16	Frequency a bit high on Line 1, slightly higher than currently planned frequency on Line 2
6	9	8	17	Frequency a bit high on Line 1, higher than planned frequency on Line 2/joint running section frequency getting high
7	10	6	16	Frequency too high on Line 1, but target frequency on Line 2
8	10	7	17	Frequency too high on Line 1, slightly higher than planned frequency on Line 2/joint running section frequency getting high
9	10	8	18	Frequency too high on Line 1, higher than planned frequency for Line 2/joint running section frequency high

Given the evidence from the Line 1 and 2 demand data, there appeared to be little justification for increasing the Line 1 tram frequency above 8 tph, with sufficient spare capacity within the 8 tph to accommodate any likely network effect. Line 2 demand data was indicating that there could be further benefits from increasing service frequency (and thus capacity) as demand was beginning to exceed capacity in the peak hours by 2026. This therefore reduced the possible frequency combinations to 1, 2 and 3 in the Table above. Combination 1 is a combination of the target frequencies for the separate Lines, but it was clear that Line 2 might benefit from additional capacity (especially when any network effects on demand are taken into account). Combination 2 added a further Line 2 tram, whilst Combination 3 added two further line 2 trams and also had the added attraction of offering a standard service frequency across the network. Therefore, Combination's 1, 2 and 3 were recommended for further combining with the identified service configurations.

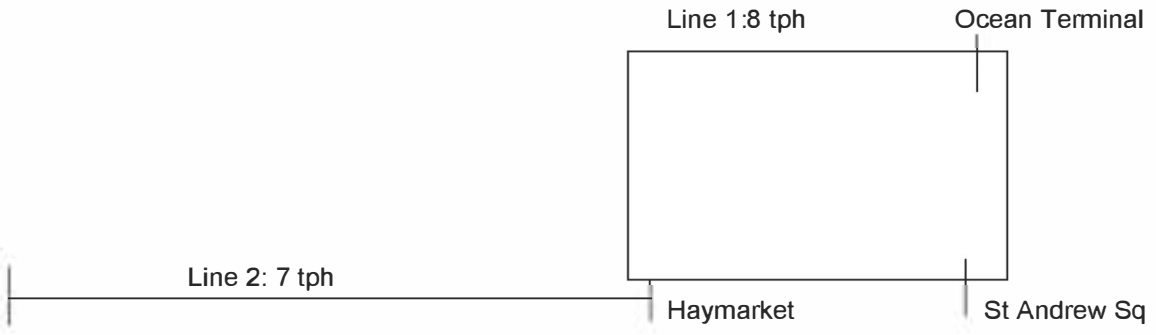
Initial Service Pattern Options for Appraisal

The service configurations and service frequencies outlined above were combined to develop a list of initial service pattern options. These are set out below.

Option A1:

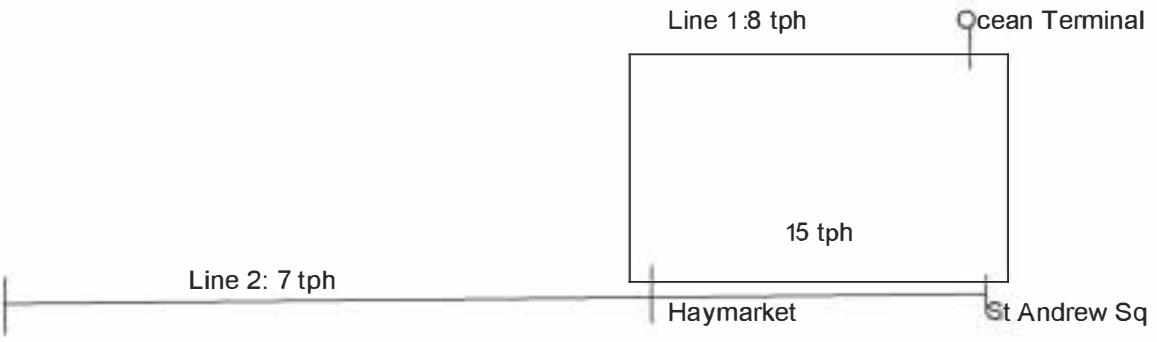


Option A2:

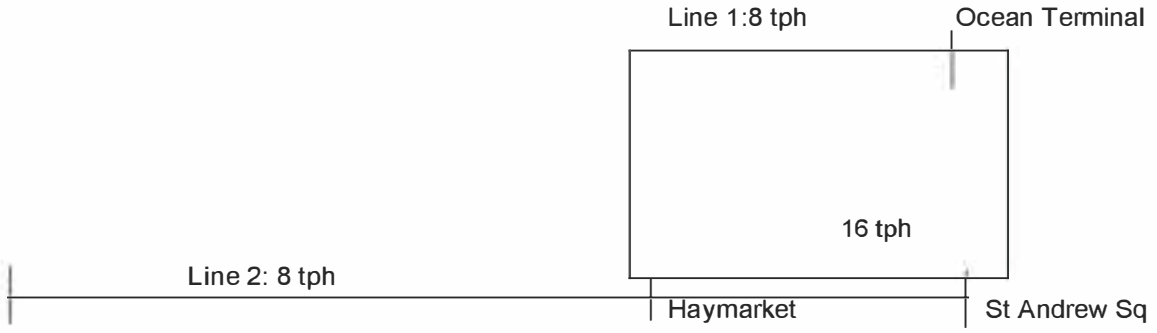


It was considered unlikely that, with Line 2 terminating at Haymarket that Line 2 would be able to sustain 8 tph and this was therefore not presented as a possible option.

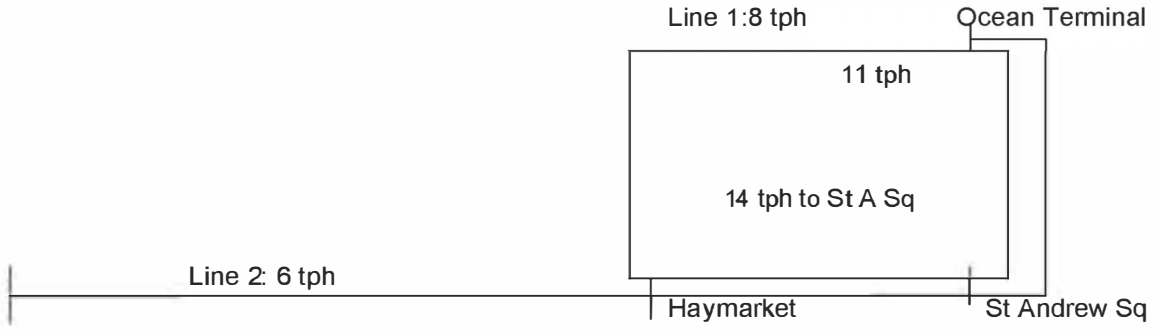
Base Case 2:



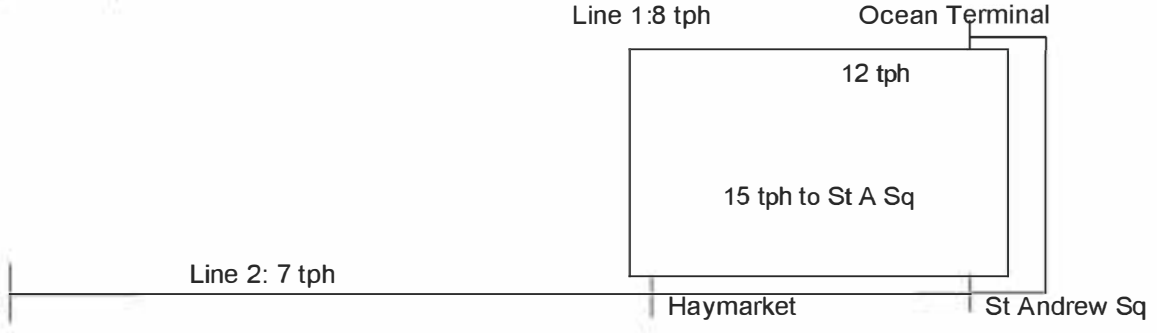
Base Case 3:



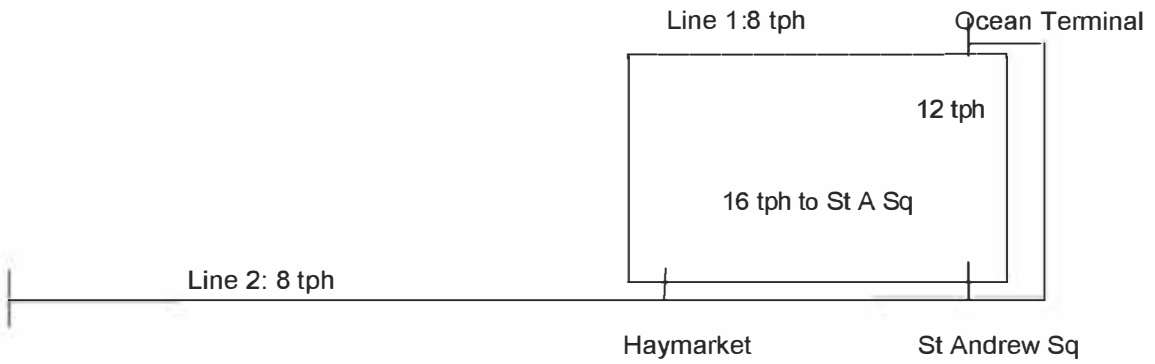
Option B1:



Option B2:

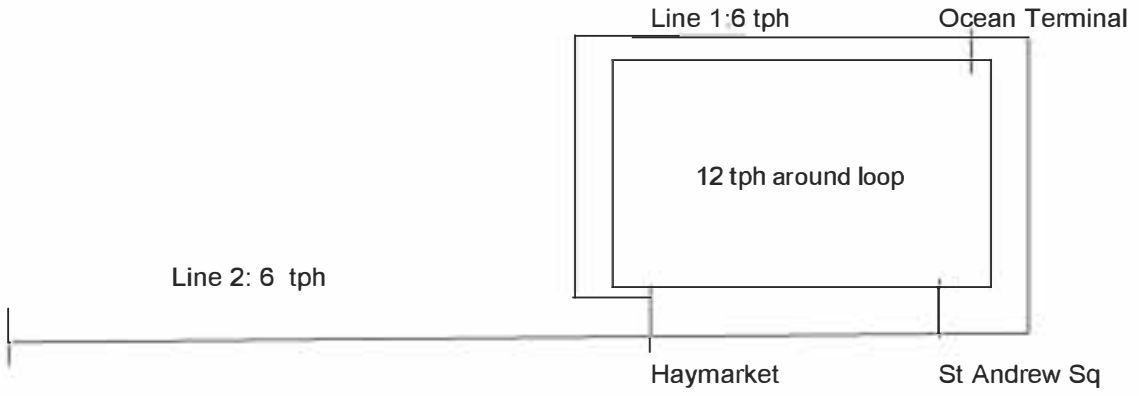


Option B3:

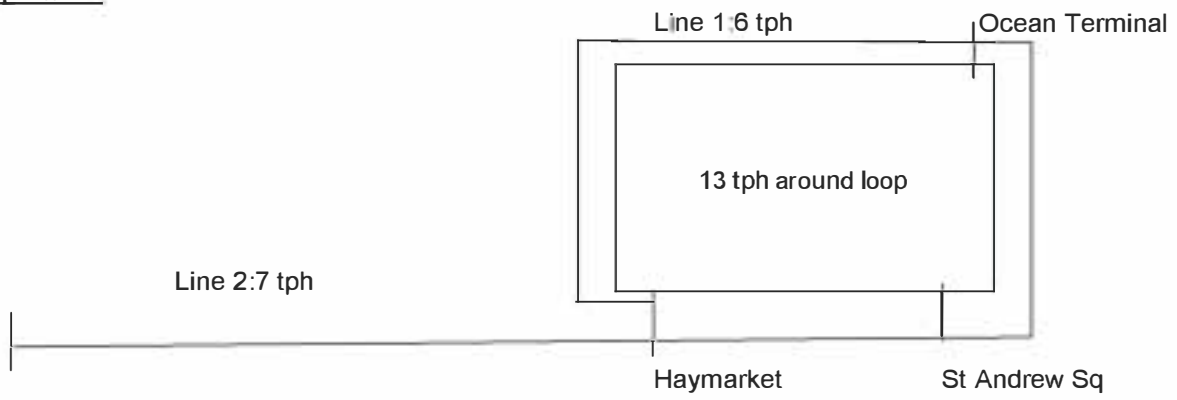


It was considered more realistic to assume in these 'B' options that half the Line 2 trams would be extended round to Ocean Terminal, as this reflected a better and more realistic match of capacity to demand along this section of route.

Option C1:

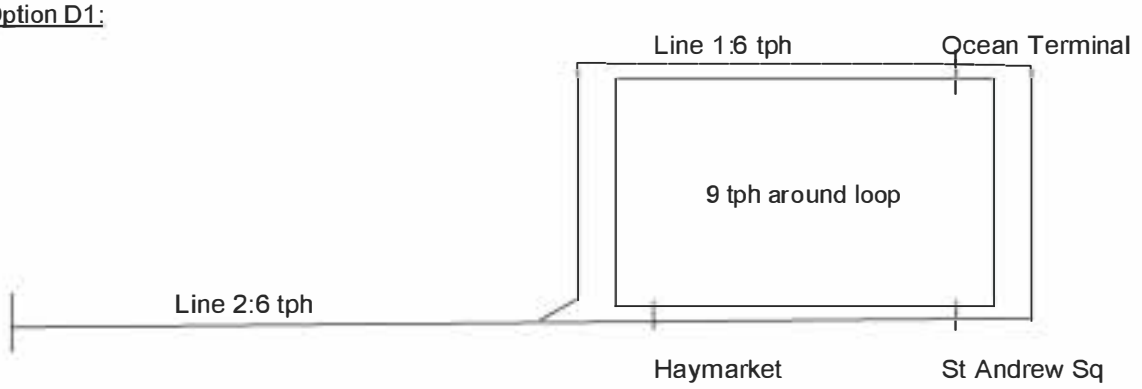


Option C2:

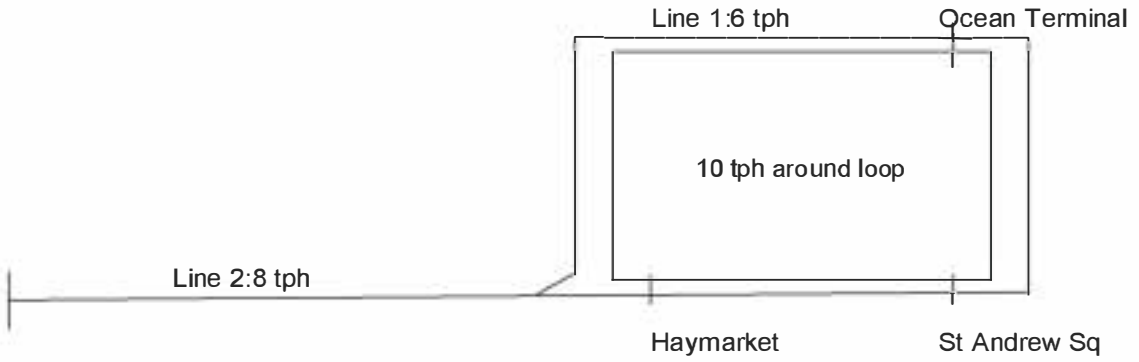


In options C1 and C2 the Line 1 frequencies were reduced to ensure the overall service frequency around the loop remained within relevant boundaries, but at the same time ensuring that Line 1 frequencies were not lower than 6 tph (ie a tram every 10 minutes), so that no movement on the network experienced average wait times greater than 5 minutes (ie half the headway). Similarly the Line 2 headway was not increased to 8 tph as it was considered that this would push up the overall loop frequencies to a level that was unjustified.

Option D1:



Option D2:



In Options D1 and D2 the same principle (as that used in the 'C' options) of reducing the Line 1 frequencies was applied. Also, the Line 2 frequency had to be an even number to ensure a 50:50 split of services either way around the loop. Line 2 trams split around the loop, so 8 tph on Line 2 was assessed.

5.3.1.2 Initial Option Assessment

In assessing the possible service patterns, a number of criteria were used to assess the relative merits of each possible option. These are listed below:

- *Fit to Edinburgh LTS:*
  The Council have set out their Tram Aspirational System Objectives. Whilst most of these focus on the technical specification for the proposed tram system, there are some more generalised objectives associated with the LTS against which each of the options were assessed. The two key assessments were associated with a/ the ability of the option to encourage use of public transport as a whole in Edinburgh and b/ the extent to which the option minimises the impact on other road users.
- *Passenger convenience:*
  Items included within this criterion included whether the option forces additional levels of interchange through reducing direct travel opportunities, whether the option introduced new direct travel opportunities not realised by Line 1and Line 2 separately ('network opportunities') and whether the service pattern is easy to understand by the travelling public;
- *Operational practicality and constraints:*
  Included within this criterion were items such as termination at sensible locations (taking into account demand patterns and operational/location constraints), ensuring compatible service frequencies between lines 1 and 2 and the level of joint running required between line 1 and Line 2 trams (more joint running means greater potential for one line to disrupt the other). Any issues relating to driver hours were also flagged under this heading;

- *Demand patterns:*
  How well each of the options catered for the various demand patterns – either to/from the city centre (likely to be the major flow) and also new potential network flows? The options range in configuration and service frequency and both these impact on the option's ability to serve the key (and secondary) demand flows.
- *Additional infrastructure requirements:*
  Any requirements for additional infrastructure (measured as that required over and above what's required for Lines 1 and 2 separately were identified here. As well as the associated increase in capital expenditure, there could be issues of land take, environmental and visual intrusion that may have an impact on the Bill submissions;
- *Tram-km;*
  Approximate tram-km was calculated for an average peak hour operation for each of the options. These were then used as a proxy for the operating costs for each option elative to each other. Similarly these figures could be used to assess the relative scale of operation of each of the options relative to each other, thus including items such as levels of staffing, number of trams required etc;
- Future interaction with Line 3:
  Each option was assessed for it's ability to 'plug in' Line 3 (given the options for Line 3 linking in with the city centre this was a broad assessment only);

Using these criteria, it was possible to undertake an initial assessment of the identified options with a view to shortlisting those most appropriate to take forward for more detailed analysis. A weighted scoring system was developed with **tie** to aid the analysis. Firstly, the listed criteria were weighted between 1 (less important to this assessment) and 3 (more important), and then a scoring system within each criteria was defined, with a range from '1' to '5' (where 1 means that option records relatively poorly for that criteria against the other options). Although by nature subjective, by summing these values it was possible to begin to differentiate and rank the relative potential of each of the options. The Appraisal Table is attached as Appendix C.

5.3.1.3 Initial Option Recommendations

The relative total scores of the options, based on the scores presented in the Appraisal Table, are set out in Table 5.2 below, with and without the weightings.

Table 5.2: Initial Appraisal Scores

Option	Unweighted Total Score	Weighted Total Score	Rank
A1	19	**38**	**6=**
A2	19	**38**	**6=**
Base Case 2	23	**53**	**3=**
Base Case 3	23	**53**	**3=**
B1	23	**55**	**2**
B2	24	**57**	**1**
B3	22	**51**	**5**
C1	14	**30**	**9=**
C2	14	**30**	**9=**
D1	14	**31**	**8**
D2	12	**25**	**11**

Based on the appraisal outlined within the Appraisal Table and summarised in Table 5.2 above, it was proposed to drop options A1, A2, C1, C2, D1 and D2. Therefore our recommendation was to shortlist options Base Case 2, Base Case 3, B1, B2 and B3 and take these forward for more detailed analysis. It was clear from this initial appraisal that these five option shad the capability to perform better than the other options and better meet the objectives and aspirations for introducing a tram network in Edinburgh.

Therefore, compared to the base Case option, the shortlised options represented either pure service frequency enhancements (options Base Case 2 and Base Case 3), extension of trams beyond that proposed in the base Case to attempt to generate additional network benefits (option B1), or a combination of the two (options B2 and B3). In other words they would require additional capital/operating expenditure.

5.3.2 Detailed Evaluation on the Shortlisted Options

5.3.2.1 Process

A detailed appraisal of the five shortlisted options was undertaken, where the following outline costs and revenues were developed:

- Operating costs;
- Capital costs;
- Lifecycle costs; and
- Farebox revenue.

It is important to note that these costs and revenues were developed only in order to appraise the relative merits of the five options against each other. The analysis had to take into account the available data from both the Line 1 and Line 2 tams at the time the appraisal was undertaken (September 2003). Therefore, the costs and revenues presented in this Section should be viewed as high level and for the sole purpose of comparing the shortlisted options. All costs were subsequently re-worked in the appraisal of the final options (Chapter 6).

5.3.2.2 Shortlisted Options: Operations

This section provides an overview of the changes in estimated operating costs that could be realised through the implementation of the shortlisted network options. The development of these costs was based on the assumptions and unit costs already developed for Line 1 and Line 2 at that time and, as such, enabled a reliable cost comparison amongst the options.

Fixed costs represent costs that are not directly related to, or derived from, tram operating parameters like headway or route length. They typically represent management and administrative costs where staffing is not as sensitive to tram operating conditions. For example, the same number of persons could staff a human resources department where the total tram fleet has 12 or 14 vehicles. Conversely, variable costs are directly related to tram operating conditions. An improvement in headway or a longer route length will require more drivers and conductors and will have an impact on the amount of certain maintenance that is needed. As a result, these costs vary with operating conditions. For drivers, for example, the operating costs assumed 217 days of productive work in a year, resulting in 1,411 equivalent driving hours per driver. As the total number of operating hours increase, the number of drivers does likewise.

In the five shortlised options, Line 1 operates under the same conditions – 8 trams per hour along the same 15.7 –km loop alignment. Line 2 operations, however, vary both by route length and by headway. For the Base Case options, Line 2 operates only as far as the east end of the city centre) as in the Line 2 project) under two headway variations (7 tph and 8 tph). In the B-series options, the headway vary (6 tph, 7 tph and 8 tph), but approximately one-half of the Line 2 trams terminate at Ocean Terminal, instead of the east end of the city centre, thus increasing their route length by 4.3 km.

As outlined above, a certain proportion of the annual operating costs are directly related to tram operating conditions. Thus, as the shortlised network options have varying route lengths and headways, the annual operating costs vary across the options.

Considering both the operating cost assumptions used by the Line 1 and Line 2 teams and the operating conditions for the five options, outline annual operating cost estimates were derived for the shortlisted network options:

- Base Case 2: £10.4m
- Base Case 3: £10.7m
- B1: £10.7m
- B2: £11.2m
- B3: £11.6m

High level annual operating costs, 2003 prices

As one would expect, operating scenarios with longer route lengths and/or better headway generated higher annual operating costs. When looking at the Base Case options – all with the same route lengths – annual operating costs vary from £10.4m for 7 tph for Line 2 to £10.7m for 8 tph for Line 2. For the B-series options, the cost range if £10.7m to £11.6m. The differences here are solely related to headway.

When the headways are maintained but the route lengths vary, the change in annual operating costs is also noticeable. For 7 tph on Line 2, Option B2 has an annual operating cost that is £0.8m higher than Base Case 2. The difference stems from the additional route length of reaching Ocean Terminal from the east end of the city centre.

Although tram operating conditions have a direct effect on operating costs, certain fixed costs remain unchanged across the options provided the overall fleet size remains relatively constant. For this reason, management and administration staff (eg, accountants, personnel, marketing), operations staff (eg, controllers, supervision, instructors) and certain maintenance staff (eg maintenance director, senior engineers, revenue system) are the same across the options. They do vary, however, when compared with the fixed staff for Line 1 and Line 2 separately – there is room for economies of scale when the two lines are treated as joint network operation.

As much as variations in operating conditions have effects on operating costs, these same variations also affect the size of the rolling stock fleet of the system. Simply put, the more service that a system provides, the more tram vehicles the system will need for that service. Changes in fleet size will also affect capital costs and could influence depot requirements. The following additional trams were calculated to be required in order to operate the enhanced network service patterns in the shortlisted options (compared to Line 1 plus Line 2 separately):

- Base Case 2: +1 tram;
- Base Case 3: +3 trams;
- B1: +1 tram;
- B2: +4 trams;
- B3: +5 trams.

At a unit cost for a tram vehicle of £1.55m (excluding optimum bias), as it is in the Line 1 and Line 2 projects, then it was possible to determine the impact of the relative scale of operations across the shortlisted options in terms of additional capital costs associated with the requirement for additional trams (+£1.6m for Base Case 2, through to +£7.8m for option B3 (excluding optimism bias)).

5.3.2.3 Shortlisted Options: Infrastructure

As the network options were derived from the two separate lines (Line 1 and Line 2), they do not require additional track infrastructure for revenue service. Trams in the shortlisted options will use the tracks proposed by Line 1 and/or Line 2 and will stop at platforms proposed for those two lines as well. For non-revenue service, however, additional infrastructure at the east end of the city centre and at ocean terminal would be needed to permit Line 1 and Line 2 trams to operate without impeding one another. Also, a three-way delta junction at Roseburn would facilitate line-loading before and after service hours, while maintaining operational flexibility for future revenue service patterns and configurations.

Turnback/Layover Facilities for Line 2 Trams

Perhaps the most crucial addition to the infrastructure of the network would be a new turnout facility for short-term stabling in the east end of the city centre. The turnaround would be needed to provide terminating Line 2 trams with recovery time to meet scheduling demands. A stabling are for one to two trams would permit Line 2 trams to wait temporarily while Line 1 operations continue without interference. This turnaround would be required for all five network options. Quite rightly, neither of the Line teams designed for an interface between the two Lines at this location as this was deemed to be a network effects issue.

An additional turnback/layover facility was required to accommodate Line 2 trams turning around at Ocean terminal under the three B-series options. It would allow Line 2 trams to terminate and layover to recover their schedule without impeding through movements on Line 1.

Roseburn Junction

Within network effects an estimation for the construction of a three-way delta junction at Roseburn was developed, based on the alignments and designs of Line 1 and Line 2 and provisionally costed using unit rates from Line 1 and Line 2.

Depot and Stabling Strategy

Lines 1 and 2 identified depot locations to work into their individual schemes, thereby including facilities to separately undertake all the necessary heavy and light maintenance and stabling required for the individual Lines. In this outline examination of possible integrated depot strategies for the shortlisted network options, an assessment of depot functions and capabilities, based on the depot strategies and sites tabled within the separate tramline projects was undertaken (it was assumed that no new sites would be considered).

The most practical and, thus, adopted strategy was to provide one main depot for heavy maintenance, day-to-day operations, and overnight stabling and a second, or line, depot to provide supplementary space for overnight stabling and to offer facilities for day-to-day operations, such as cleaning and washing the vehicles. The Gogar Depot site was therefore identified as the main depot because it is the larger site, and the Leith Docks Depot would have line depot capabilities.

Overall Changes to Capital Costs

Given the above, a high level estimate of the changes to overall capital costs (compared to Line 1 and Line 2 separately) for each of the shortlisted options was developed:

- Base Case 2: +£2.4m;
- Base Case 3: +£6.4m;
- B1: +£2.9m;
- B2; +£9.0m;
- B3: +£11.0m.

High level changes to capital costs, 2003 prices, includes optimism bias

These costs included the additional trams required to operate the enhanced network service. Overall, the changes represented less than a 2% difference in capital costs compared to Line 1 and Line 2 added together.

Lifecycle Costs

As the infrastructure changes, so do the life cycle costs. The five options would be divided into two principal scenarios with respect to infrastructure. The Base Case options include additional infrastructure at Roseburn Junction and an added turnback/layover in the east end of the city centre, whereas the B-series options also added in a turnback/layover facility at Ocean Terminal. The related life cycle costs are, thus, the same within the scenarios.

Differences within the two scenarios arose from the number of tram vehicles in each of them. A large amount of life cycle costs are associated with the major vehicle refurbishment. As a result, the options with larger fleet sizes had higher life-cycle costs.

Depot machinery, building, and sub-station life cycle cost differences are the same across all five options because the changes in these pieces of infrastructure are constant among the options. These costs are summarised in Table 5.3.

Table 5.3 Changes to Life Cycle Costs

	Base 2	Base 3	B1	B2	B3
TOTAL	(-£0.23m)	£1.08m	£0.12m	£2.09m	£2.74m

Changes relative to line 1 (whole loop) + Line 2 (Roseburn Jct to Newbridge/Airport) lifecycle costs
High level costs, 2003 prices

5.3.2.4 Shortlisted Options: Demand & Revenue

Demand and revenue results for the five shortlisted network options were produced using the LUTI and DAM models, as described in Section 3.7. These runs of the model reflected the base set of modelling assumptions used in Line 1 and Line 2 at the time.

Table 5.4 sets out the patronage and revenue results for each of the options for 2011 and 2026.

Table 5.4: Network Effects Shortlised Options: Patronage and Revenue

Option	2011		2026	
	Patronage	Revenue	Patronage	Revenue
Base Case 2	13.7m	£12.4m	19.9m	£18.1m
Base Case 3	13.9m	£12.6m	20.7m	£18.9m
B1	13.9m	£12.6m	19.9m	£18.2m
B2	14.6m	£13.2m	21.5m	£19.6m
B3	14.8m	£13.4m	21.7m	£19.8m

Revenue takes account of loss due to ticket type and fare evasion, but is before ramp up is applied
High level revenues

Interrogation of the B-series options indicates that the improvements in service frequency on Line 2 are worth approximately £1.5m in 2026, whilst comparison of these options to the Base Case options indicates that the extension of some Line 2 trams round to Ocean Terminal is worth between £0.9m and £1.5m.

Both options B2 and B3 generate considerably more revenue compared to the other options (+6% on the next best option in 2011, +4% in 2026).

5.3.2.5 Appraisal: Identification of the Best Investment Enhancement Option

The previous sections discussed the various operational, infrastructure and demand aspects of the shortlisted network options. Outline costs and revenues, base on the best available data at the time of appraisal, were determined for each of them so that comparisons between them could be made. The aim of this appraisal process was to identify one option, from the five shortlisted options, which could be taken forward for detailed evaluation as the 'best' investment enhancement option. A comparison of the associated costs and revenue for each of the shortlisted options was undertaken using selection criteria that measured costs relative to farebox revenue.

The analysis indicated overall that there was little to choose between the options – not surprising given the relatively minor changes distinguishing them apart. Table 5.5 summarises the performance of the shortlisted network options relative to each other using key cost and revenue criteria.

Table 5.5: Summary Comparison of Shortlisted Options

Criteria	Base Case 2	Base Case 3	Option B1	Option B2	Option B3
Annual tram patronage, 2026	19.9m	20.7m	19.9m	21.5m	21.7m
Annual revenue, 2026	£18.1m	£18.9m	£18.2m	£19.6m	£19.8m
Annual opex, 2026	£11.7m	£12.0m	£12.0m	£12.5m	£13.0m
Change in lifecycle costs	(-£0.2m)	+£1.1m	+£0.1m	+£2.1m	+£2.7m
Change in capex	+£1.8m	+£4.9m	+£2.2m	+£6.9m	+£8.4m

Patronage in millions / high level costs and revenues in £millions / 2003 prices / undiscounted
2026 opex allows for real wage rate inflation (0.5% per annum real growth over and above RPI)
Change in capex and lifecycle costs compared to Line 1 (whole route) plus Line 2 (Roseburn to airport/Newbridge)

As one would expect, the greater revenues and patronage were experienced by those options that offered more in terms of service frequencies and tram vehicle kilometres (extension of some Line 2 trams round to Ocean Terminal). Of course, this was balanced by the fact that the costs associated with these options were greater. Therefore, in order to ensure a more robust comparison of the relative merits of the options, greater focus was placed on key criteria that measured the costs relative to farebox revenue, including:

- Operating surplus (revenue to operating costs); and
- Revenue return per £ of additional capital expenditure.

Table 5.6: Comparison Using Selection Criteria

Option	Operating Surplus, £	Rank	BCR	Rank	Revenue Return, £	Rank
Base Case 2	133,670	4	0.386	4	0.54	5
Base Case 3	141,294	2	0.394	3	0.56	3
B1	126,921	5	0.385	5	0.55	4
B2	145,493	1	0.404	1	0.58	1=
B3	138,560	3	0.403	2	0.58	1=

Operating surplus is sum over 30 year scheme life
BCR is Present Value of farebox revenue to Present Value of all costs (capital, lifecycle and operating)
Revenue return per £ of initial capital expenditure (Present Value of farebox revenue/Present Value of capital + lifecycle cost)

Option B2 produced the greatest operating surplus over the evaluation period, some 3% better than the next best option. In 2026, option B2's operating surplus was estimated to be approximately £7.1m.

In terms of the potential return on capital expenditure, both options B2 and B3 recorded the best results. The Present Value (PV) of the capital expenditure and lifecycle costs were calculated and compared to the PV of the farebox revenue (at 2003 prices). Options B2 and B3 recorded a revenue of £0.58 per £1 of capital expenditure, which compared to the next best option, Base Case 3, with a value of £0.56.

A revenue:cost ratio was calculated comparing the PVs for farebox revenue to all costs (operating costs, capital costs and lifecycle costs). Option B2 produced the best value of 0.404.

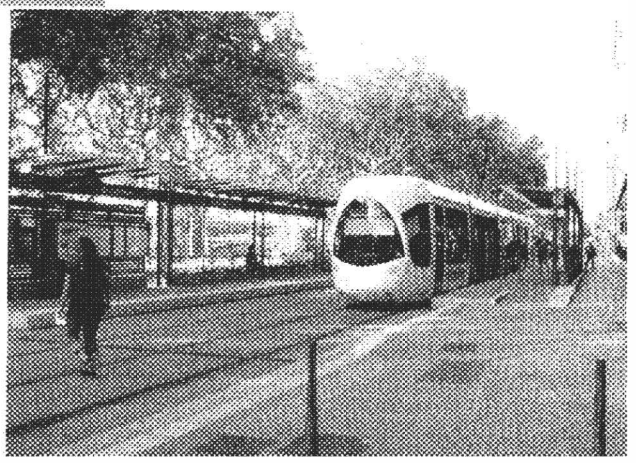
On the basis of the above evidence, Option B2 presented the set of results to indicate that it would be the best of the shortlisted network options. Of course, all the shortlisted options would require additional investment over and above that proposed for Lines 1 and 2 in isolation, and this 'best option' therefore represents what could be achieved through further network related investment.

The analysis to identify the preferred investment enhancement option deliberately focussed on the financial differences in costs and revenues between the shortlisted options. It did not take into account any wider benefits associated with them, nor any wider political or strategic implications (although the initial sieving of all the potential options did take into account 'strategic fit' to the Council's LTS). Options B3 and B2 recorded the highest patronage levels, thus implying they serve a greater part of the population.

By 2026 both these options record over 1 million more passengers than the next best option, and comparison back to the Base Case option indicated that these two options generated a 12% increase in annual tram patronage.

On this basis Option B2 was taken forward for detailed analysis as the potential best network option, and the detailed appraisal of this option is set out in Section 6.3.

6 DETAILED NETWORK OPTION APPRAISAL



6 Detailed Network Option Appraisal

6.1 Introduction

Two network options were identified that were developed to meet different objectives:

- A 'base Case Option' that reflects the separate Line Bills being submitted to the Scottish Parliament and can demonstrate some potential areas for cost savings and additional revenue generation; and
- An 'Investment Enhancement' Option that reflects what might be achieved through further investment which generated additional benefits.

The appraisal of these options was undertaken using the same assumptions and modelling methodology as that used to define the Line 1 and Line 2 business cases and STAG appraisal. Chapter 4 sets out the methodologies and assumptions used.

Each option is discussed in turn below.

6.2 Base Case Option

6.2.1 Operations

By operating Lines 1 and 2 as a network under the Base Case option, the annual operating costs would be reduced by consolidating the fixed staff costs (principally administrative, operational, and maintenance management) and by removing duplicated maintenance staff, maintenance materials, and rates associated with the common section between the city centre and Roseburn Junction. The annual operating costs are estimated at £10.4m of which Line 1 and Line 2 represent £3.9m and £4.2m, respectively, not including the network-wide fixed staff costs. Table 6.1 summarises these figures.

Table 6.1: Base Case – Annual Operating Costs

Base Case	**Annual Operating Costs (£m)**		
	Line 1 Northern Loop	**Line 2 Airport/Newbridge to New Town**	**Total**
Staff Costs	***2.13***	***2.41***	***6.65***
Fixed staff costs	0.00	0.00	2.11
Tram-variable staff costs	2.13	2.41	4.54
Other Costs	***1.41***	***1.45***	***2.86***
Power	0.28	0.27	0.55
Maintenance materials	0.66	0.68	1.34
Insurance	0.27	0.29	0.56
Policing	0.20	0.21	0.41
Sub-total (staff + other)	***3.54***	***3.86***	***9.51***
Overheads	0.18	0.19	0.48
Rates	0.19	0.18	0.37
Total (sub-total + overheads + rates)	**3.91**	**4.24**	**10.36**

6.2.2. Infrastructure

In the Base Case option, additional infrastructure is required for the delta junction at Roseburn (including additional structure over Russell Road) and for a turnback/layover facility in the east end of the city centre (assumed to be Picardy Place). One sub-station at Roseburn Junction could be removed, as could on e vehicle because of a consolidated tram fleet (total tram fleet therefore is 26). Savings in depot related costs are also incorporated.

The details and assumptions relating to these were presented in Chapter 4.

Table 6.2 sets out the overall reduction in capital costs including 31% optimism bias, which was estimated at £1.4m (see Table 6.2).

Table 6.2: Base Case – Difference in Capital Costs

Base Case		**Cost**
Civils	Structures	£779,398
Electrical	Sub-stations	(-£600,000)
	OHLE	£21,806
	Other power supply	£9,600
	Signalling	£53,524
	Communications	£11,696
Stops	Standard	£200,000
	Ticket machines	£50,000
	Stop equipment	£90,000
Depot	Facilities	(-£1,429,511)
Track	Ballasted	£160,819
	Grooved on-street	£160,819
	Turnout facilities	£850,500
Vehicles		(-£1,550,000)
Sub-total		**(-£1,191,347)**
Sub-total (excl. utilities, Network Rail, automatic ticket gates, land, vehicles) items below calculated on this sub-total		
Project costs	10%	£35,865
Preliminaries	20%	£71,730
Design	7%	£25,105
Coordination/Consents	3.35%	£12,014
Total		**(-£1,046,631)**
Optimism Bias	31%	(-£324,455)
Grand Total		**(-£1,371,086)**

Changes relative to Line 1 (whole loop) + Line 2 (Roseburn Jct to Newbridge/Airport) capital costs

The life cycle costs are subsequently reduced because of the change in infrastructure and tram vehicles. Over the 30 year life cycle period, the Base Case has an estimated reduction of approximately £880,000 compared with Line 1 and Line 2 separately. Table 6.3 summarises the changes in life cycle costs for the Base Case.

Table 6.3: Base Case – Difference in Life Cycle Costs

Element	Cost (£m)
Motorised Points Renewals	0.76
Customer Help Points	0.05
Passenger Information Displays	0.06
Stop Replacement of Shelters	0.01
Stops Replacement - general	0.06
Points heaters	0.12
Sub-Station Maintenance	(-0.32)
Vehicle Refurbishment - major	(-0.60)
Depot Machinery & Equipment	(-0.70)
Control & Admin Building	(-0.24)
Sub-Total	**(-0.80)**
Preliminaries @ 10 per cent	(-0.08)
TOTAL	**(-0.88)**

Changes relative to Line 1 (whole loop) + Line 2 (Roseburn Jct to Newbridge/Airport) lifecycle costs

6.2.3 Demand & Revenue

Table 6.4 sets out the demand and revenue associated with the Base Case.

Table 6.4: Base Case Patronage and Revenue (2003 prices)

	2011 (excluding ramp up)	2026
Patronage	18.64m	25.69m
Revenue (full adult fare)	£13.78m	£19.66m
Loss due to ticket type	£1.61m	£2.22m
Loss due to fare evasion	£0.61m	£0.87m
Revenue, less revenue loss	£11.57m	£16.56m

The key boarding points for Line 1 in the AM peak are all located on the west side at Craigleith and West Granton, boarding anti-clockwise trams. There is also a significant clockwise flow between Haymarket and Caroline park. On Line 2 they key boarding points are Ingliston P&R, Broomhouse Rd and Stenhouse Dr. There is also a significant outbound flow in the AM peak to Edinburgh Park and the Airport. They key destinations for both Lines are located in the city centre between Shandwick Place and St Andrew Sq.

A 30 year revenue profile for the Base Case from first year of operation (2009) has been produced and is shown in table 6.5. Note that this includes the effects of ramp up in the initial three years.

Table 6.5: Annual Revenue Profile (2003 prices)

2009	2010	2011	2012	2013-2025	2026 & beyond
£8.18m	£9.55m	£10.99m	£11.90m	Straight line growth from 2012 to 2026	£16.56m

6.2.4 Appraisal

Table 6.6 summarises the key financial business case results for the Base Case.

Table 6.6: Base Case Financial Summary

£m	2011	2026	Total over Scheme Life
Total Capital Costs, £m			£565.34m
Total lifecycle Costs, £m			£88.65m
Total Operating Costs, £m	£10.78m	£11.62m	£344.62m
Total Revenue, £m	£10.99m	£16.56m	£440.92m
Total operating surplus, £m	£0.21m	£4.94m	£96.30

Totals are undiscounted

Taking into account real increases in operating costs during the scheme life of the tram, plus the revenue profile that incorporates ramp-up, an operating surplus is recorded in each year of operation apart from the opening two years (2009 & 2010). Total revenue over the scheme life is sufficient to cover operating costs and lifecycle costs.

Table 6.7: Base Case TEE and BCR Results £000s

SAFETY		
Accidents		
Total Discounted Savings	PV1	4,230
ECONOMY (TEE)		
Transport User Benefits		
Travel Time	PV2	557,430
User Charges	PV3	104,261
Vehicle operating Costs	PV4	18,087
Quality/Reliability Benefits	Not quantified	
Private Sector Operator Impacts		
Investment Costs	PV5	-364,136
Operating & Maintenance Costs	PV6	-135,463
Revenues	PV7	22,075
Grant/Subsidy Payments	PV8	364,136
COST TO PUBLIC SECTOR		
Public Sector Investment Costs	PV9	0
Public Sector Operating & Maintenance	PV10	0
Grant/Subsidy Payment	PV11-PV8	-364,136
Revenues	PV12	22,906
Taxation Impacts	PV13	-11.043
Present Value of Transport Benefits	PVB = sum PV1-PV8	570,620
Present Value of Cost to Government	PVC = sum PV9-PV13	-352,273
Net Present Value	PVB + PVC	218,347
BCR to Government	PVB (-PVC)	**1.62**

The TEE and BCR calculations are summarised in table 6.7. these were calculated using the same set of assumptions and methodologies as far as possible as per those used by the Line 1 and Line 2 teams (refer to Section 4.8) and are therefore compatible with the 'economy' element of the STAG appraisal.

The Base Case records a BCR of 1.62 and a Net Present Value of nearly £220m.

6.3 Investment Enhancement Option

The 'best' option involves an expanded service pattern for Line 1. In it, Line 2 would provide a service from the city centre to Ocean Terminal, which increases the number of operating hours and the number of tram vehicles required. Consequently, the annual operating costs are higher in this option than in the Base Case. They are estimated to be approximately £11.4m, including £3.9m for Line 1 and £5.2m for Line 2, not including the network-wide fixed staff costs (see Table 6.8).

Table 6.8: Investment Enhancement Option – Annual Operating Costs

	Annual Operating Costs (£m)		
	Line 1 Northern loop	**Line 2** Airport to Ocean Terminal (including Newbridge)	**Total**
Staff costs	***2.13***	***3.07***	***7.31***
Fixed staff costs			2.11
Tram-variable staff costs	2.13	3.07	5.20
Other costs	***1.41***	***1.75***	***3.16***
Power	0.28	0.35	0.63
Maintenance materials	0.66	0.76	1.42
Insurance	0.27	0.37	0.64
Policing	0.20	0.27	0.47
Sub-total (staff + other)	***3.54***	***4.81***	***10.47***
Overheads	0.18	0.24	0.52
Rates	0.19	0.18	0.37
Total (sub-total + overheads + rates)	**3.91**	**5.24**	**11.36**

6.3.2 Infrastructure

With the extension to ocean terminal comes the need for additional infrastructure to handle turnback/layover for Line 2. Because some Line 2 trams will turn around at ocean Terminal and some will turn around in the New Town, additional infrastructure is needed in both locations. Furthermore, as with the Base Case, infrastructure is added at Roseburn Junction, while a power sub-station is removed.

The details and assumptions relating to these were presented in Chapter 4.

The extension of Line 2 to ocean Terminal increases the number of tram vehicles required by four, which will add over £6m to the capital costs (total tram fleet is therefore 31). The total change in capital costs including 31% optimism bias is estimated at £9.8m as presented in Table 6.9.

Table 6.9: Investment Enhancement Option – Difference in Capital Costs

		Cost
Civils	Structures	£779.398
Electrical	Sub-stations	(-£600,000)
	OHLE	£21,086
	Other power supply	£9,600
	Signalling	£53,524
	Communications	£11,696
Stops	Standard	£300,000
	Ticket machines	£100,000
	Stop Equipment	£180,000
Depot	Facilities	(-£1,429,511)
Track	Ballasted	£160,819
	Grooved on-street	£223,806
	Turnout facilities	£1,086,750
Vehicles		£6,200,000
Sub-total		**£7,097,890**
Sub-total (excl utilities, Network Rail, automatic ticket gates, land, vehicles) items below calculated on this sub-total.		
Project costs	10%	£89,789
Preliminaries	20%	£179,578
Design	7%	£62,852
Coordination & Consents	3.35%	£30,079
Total		**£7,460,188**
Optimism Bias	31%	£2,312,658
Grand total		**£9,772,847**

Changes relative to Line 1 (whole loop) + Line 2 (Roseburn Jct to Newbridge/Airport) capital costs

Life cycle costs are related to infrastructure. As the option increases the amount of infrastructure in the network, the associated life cycle costs will also increase. For this option, the largest change in life cycle costs comes with the increased fleet size, which adds £2.4m to the overall life cycle costs (Table 6.10).

Table 6.10: Investment Enhancement Option – Difference in Life Cycle Costs

	Cost (£m)
Motorised Points Renewals	0.95
Customer Help Points	0.10
Passenger Information Displays	0.12
Stop Replacement of Shelters	0.01
Stops Replacement – General	0.11
Points Heaters	0.15
Sub-station Maintenance	(-0.32)
Vehicle Refurbishment – major	2.38
Depot machinery & Equipment	(-0.70)
Control & Admin Building	(-0.24)
SUB_TOTAL	**2.57**
Preliminaries @ 10 per cent	0.26
TOTAL	**2.82**

Changes relative to Line 1 (whole loop) + Line 2 (Roseburn Jct To Newbridge/Airport lifecycle costs

6.3.3 Demand & Revenue

Table 6.11 sets out the demand and revenue associated with the Investment Enhancement Option.

Table 6.11: Investment Enhancement Option Patronage and Revenue (2003 prices)

	2011 (excluding ramp up)	2026
Patronage	21.79m	28.11m
Revenue (full adult fare)	£16.42m	£21.71m
Loss due to ticket type	£1.90m	£2.47m
Loss due to fare evasion	£0.73m	£0.96m
Revenue, less revenue loss	£13.80m	£18.27m

The key boarding points for Line 1 in the AM peak are all located on the west side at Craigleith and West Granton, boarding anti-clockwise trams. There is also a significant clockwise flow between Haymarket and Caroline park. One Line 2 the key boarding points are Ingliston P&R, Broomhouse Rd and Stenhouse Dr. There is also a significant outbound flow in the AM peak to Edinburgh Park and the Airport. The key destinations for both Lines are located in the city centre between Shandwick Place and St Andrew Sq.

A 30 year revenue profile for the Investment Enhancement Option from first year of operation (2009) has been produced and is shown in Table 6.12. Note that this includes the effects of ramp up in the initial three years.

Table 6.12: Annual Revenue profile (2003 prices)

2009	2010	2011	2012	2013-2025	2026 & beyond
£9.90m	£11.48m	£13.11m	£14.10m	Straight line growth from 2012 to 2026	£18.27m

6.3.4 Appraisal

Table 6.13 summarises the key financial business case results for the Investment Enhancement Option.

Table 6.13: Investment Enhancement Option Financial Summary

£m	2011	2026	Total over Scheme Life
Total Capital Costs, £m			£576.48m
Total Lifecycle Costs, £m			£92.36m
Total Operating Costs, £m	£11.82m	£12.74m	£377.90m
Total Revenue, £m	£13.11m	£18.27m	£496.54m
Total Operating Surplus, £m	£1.29m	£5.53m	£118.64m

Totals are undiscounted

Taking into account real increases in operating costs during the scheme life of the tram, plus the revenue profile that incorporates ramp-up, an operating surplus is recorded in each year of operation apart from the opening two years (2009 and 2010). Total revenue over the scheme life appears sufficient to cover operating costs and lifecycle costs.

The TEE and BCR calculations are summarised in table 6.14. These were calculated using the same set of assumptions and methodologies as fare as possible as per those used by the Line 1 and Line 2 teams (refer to Section 4.8), and are therefore compatible with the 'economy' element of the STAG appraisal.

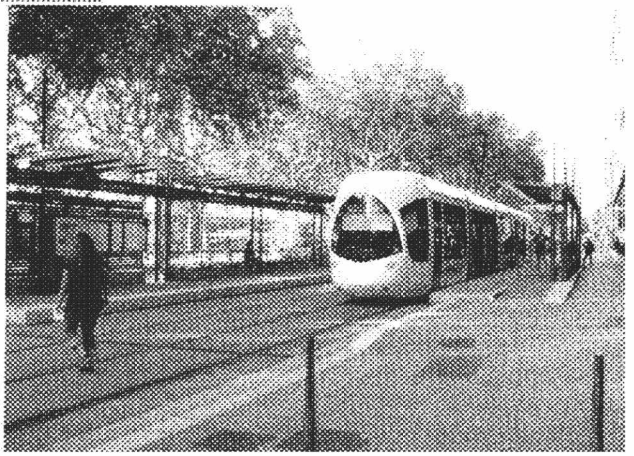
The Investment Enhancement option records a BCR of 1.51 and a net present Value of just over £180m. Compared to the Base Case, the reason for the reduction in the BCR value is due to the increase in operating and lifecycle costs (+32%) outweighing the additional benefits (+7%). This reflects the fact that the investment enhancement option requires five more trams to operate the service compared to the Base Case and operates significantly greater annual tram km.

Table 6.14: Investment Enhancement Option TEE and BCR Results

SAFETY		
Accidents		
Total Discounted Savings	PV1	8,680
ECONOMY (TEE)		
Transport User Benefits		
Travel Time	PV2	573,502
User Charges	PV3	129,000
Vehicle Operating Costs	PV4	20,697
Quality/Reliability Benefits	Not quantified	-
Private Sector Operator Impacts		
Investment Costs	PV5	-371,270
Operating & Maintenance Costs	PV6	-179,440
Revenues	PV7	-17,023
Grant/Subsidy Payments	PV8	371,270
COST TO PUBLIC SECTOR		
Public Sector Investment Costs	PV9	0
Public Sector Operating & Maintenance	PV10	0
Grant/Subsidy Payment	PV11-PV8	-371,270
Revenues	PV12	25,485
Taxation Impacts	PV13	-7.750
Present Value of Transport Benefits	PVB = sum P1-PV8	535,416
Present Value of Cost to Government	PVC = sum PV9-PV13	-353,535
Net present Value	PVB + PVC	181,881
BCR to Government	PVB/(-PVC)	**1.51**

costs and benefits in £000s

7 ADDITIONAL NETWORK ISSUES



7 Additional Network Issues

7.1 Opportunities

The additional opportunities that the development of a tram network can generate, compared to the introduction of a single line, can be categorised under the following headings:

- new journey opportunities;
- economies of scale;
- flexibility;
- perception; and
- marketing/branding.

The first two are reflected in the financial results that have been presented in Chapter 6. Any new journey opportunities made due to network effects have been translated into revenue and associated wider economic benefits, whilst any economies of scale have been reflect in the capital, lifecycle and operating costs.

The benefits resulting from flexibility are of equal importance, although their effect on the viability of the system is harder to quantify. For example, as well as their quantifiable effect on revenue, different configurations of cross-city service provision may allow greater flexibility in terms of tram operation (timetable optimisation, closure of princes St, minimising tram use of congested shared track sections, allowance for staff changeovers etc).

Also important is the issue of the public's perception of the system. It is easier to market an extensive system covering large parts of the city than a system that is limited to a single locality. The travelling public's perception of the London Underground network is an example of this, where the perception if that you can enter the network and virtually get to wherever you want to go. As well as being likely to result in higher patronage, greater public acceptance could lead to a number of additional benefits, not least the possibility that it will minimise objections during the planning stage and will aid the rapid ramp-up to full ridership in the early years of operation. Public acceptance of the system could also have wider benefits for Edinburgh, such as greater awareness of overall public transport operation within the city.

The important of selling Edinburgh tram as a 'brand' cannot be understated. Clearly, **tie** is aware of this and the 'Time' initiative by Weber Shandwick is an essential first step in establishing the brand. As indicated above, greater public awareness and acceptance of the system is likely to increase patronage, minimise objections during the planning stage and aid the rapid ramp-up to full ridership in the early years of operation. However, consideration of how the full system is branded provides opportunities for assessing how the network is marketed to the public that would not be possible in the case of individual lines.

For example, a decision will need to be taken as to whether the system is branded as a single network of lines (similarly to Manchester Metrolink), or as individual "coloured" lines within an integrated system (similarly to Sheffield Supertram and London Underground). This approach could also be widened to the complete Edinburgh public transport network, perhaps drawing on the experience of 'Overground' in Glasgow. This would allow the overall public transport network to be branded as a seamless, fully integrated network on the basis of a series of coloured lines, regardless of mode.

The integration of Line 3 with Lines 1 and 2 should be considered, although the detailed alignment and service patterns for Line 3 are being developed at the time of writing. In the Base Case option, there is the opportunity to simply extend Line 2 trams onto Line 3. As well as the benefits relating to new direct journey opportunities (eg: Broomhouse to the New Royal Infirmary), the benefits of this could also include removing the need to turnback/layover Line 2 trams at the east end of the city centre and allowing Line corridor passengers the ability to directly access the west end of the city centre.

In the Investment Enhancement Option, Line 3 trams could be extended down to Haymarket and round the west side of the Line 1 loop to terminate at Ocean terminal. Again, the benefits would include new direct journey opportunities, the removal of the need for Line 3 turnback/layover facilities in the city centre, direct access to the west end of the city centre for Line 3 passengers and the opportunity to better tailor the service frequency around the Line 1 loop to demand (possible reduction of Line 1 trams and/or transfer of some of these trams to Line 3, as Line 2 and 3 trams would be providing the service around the Line 1 loop).

The Network Effects Study will be addressing the integration of Line 3 into a Line1/Line 2 network operating during 2004. The Line 3 study programme if 12 months behind Lines 1 and 2 and has still to identify a preferred option.

7.2 Wider Economic Benefits

The appraisal methodology takes into account the wider economic benefits associated with the options. There are a wide range of additional benefits that a new transport infrastructure investment scheme can generate which aren't captured directly through the farebox. These relate to both users (in this case tram) and non users (in this case remaining car and bus users) and include:

- Travel time benefits;
- Accident benefits; and
- Savings in vehicle operating costs.

The appraisals set out in Chapter 6 have demonstrated the performance of the network options considered through the calculation of net Present Values and Benefit: Cost Ratios. The extraction of the wider economic benefits relating to each of these options can be obtained from these calculations. These are set out in Table 7.1.

Table 7.1: Wider Economic Benefits by Option

	Base Case	**Investment Enhancement Option**
Travel time benefits	£557.4m	£573.5m
Accident benefits	£4.2m	£8.7m
Vehicle operating costs	£18.1m	£20.7m
TOTAL	£579.7m	£602.9m

Present value of benefits

The appraisal indicated that the Base Case generates nearly £580m of wider economic benefits over the scheme life of the tram. The Investment Enhancement Option increases these benefits by a further 4% to just over £600m. this compares to wider benefits of around £313m for Line 1 and £225m for Line 2, clearly demonstrating that the network generates additional wider benefits (Base Case is +8% compared to Line 1 plus Line 2).

7.3 Public Consultation

A public consultation exercise was undertaken by **tie** during May/June 2003. This focussed on presenting the separate routes (Line 1 and Line 2), but provided the opportunity for the public to respond on network impacts. To support this, a Briefing note was prepared by the network effects team that set out the possible impacts of a tram network. The purpose of this Note was to inform the tram representatives during the consultation exercise and to set out the wider implications and considerations associated with the merging of Line 1 and Line 2.

The outcome of this exercise was incorporate into both the Line 1 and Line 2 detailed design as necessary and therefore, by definition, was inherited by network effects.

Therefore, it was felt that the public consultation undertaken at this time sufficiently covered network impacts.

7.4 Construction Programme and Implementation

The individual Lines are working to a construction period of 41 months including optimum bias. It is envisaged that the construction of both Line 1 and Line 2 could be achieved within that same timescale, although this would be subject to available resources (as it would be for Line 1 and Line 2 in isolation).

Large construction projects require large construction crews. As with other large construction projects, the Line 1 and Line 2 construction programmes will rely on the availability of appropriate construction teams to build the infrastructure. If constructed together (as part of a network, for instance), the two lines would require an even larger construction team.

A combined construction programme for network operations should not, by itself, pose any concerns for attracting the necessary labour for the construction. The European labour pool is sufficient to cover the needed resources. Civil projects by their nature, however, are unpredictable. Certain years can have a surplus of labour because of few large construction projects, while others can see the availability of labour be low because of competing projects.

For this reason, the availability of construction resources I unpredictable, where for Lines 1 and 2 constructed as a network or individually. The ebb and flow of major civil works projects throughout the UK, Europe, and even the world affect labour availability. But, if the pressures on suitable labour pool are not unusual, the construction of an integrated tram network should not be encumbered.

7.5 Technical Feasibility and Risks

7.5.1 Revenue Risk and Fares

Revenue risk was assessed within the Line 1 and Line 2 appraisals through a number of key sensitivity analyses. These sensitivities were designed to test the overall financial robustness of the individual Lines and to give an indication of the impact of key project risks on the financial structure proposed. These sensitivities included the impact of congestion charging, changes in level of bus competition, airport heavy rail link and tram fare adjustments.

The tram fares that have been used in the modelling of these network effect options were based on the assumptions used by the Line 1 team – that tram fares are the same as the bus fares and no premium was applied. This compared to tram systems elsewhere in the UK (such as Manchester Metrolink) where premiums are applied compared to the equivalent bus fare (although the use of travelcards and multi-modal tickets distorts the overall effect).

A result of network effects adopting the Line 1 tram fare assumptions was that the cheaper tram fares (compared to Line 2's assumption of applying a 33% tram fare premium on top of the bus fares) resulted in high average peak our tram loadings by 2026 on Line 2. in reality, these loadings in the peak hours would, in the absence of capacity enhancements, lead to a certain amount of trip suppression. The possible levels of trip suppression in these time periods as not calculated and therefore the revenues (and patronage) that have been reported for the network effect options do not allow for this.

The issue of under-capacity can be addressed in a number of ways, including:

- capacity enhancements:
  - increase the length of the trams (more trams required, plus tramstop platform extensions required);
  - increase service frequency (more trams required, plus more drivers required, plus this would generate additional demand)
- managing demand
  - do-nothing = suppression of demand (revenue reduced);
  - marketing to encourage peak spreading;
  - development of a suitable fares strategy.

Appendix D sets out the results of further sensitivity analysis undertaken on demand and revenue, reflecting the suppression of demand to match the available capacity.

It is recognised that further development of a fares strategy is required and that this will take place with the involvement of the operator (once appointed) through the DPOF process. As well as the issues regarding adoption of either the Line 1 or Line 2 tram fares assumptions, there are more specific issues relating to the development of a fares strategy that would be more suitable for network application, as discussed below.

As the tram structure has, by definition, inherited the bus fare structure, then there is a capping of tram fares beyond a certain distance travelled. This is currently eight fare stages or greater where the maximum single fare is £0.90 in the model (fares have since risen to £1.00). Therefore, as the combination of Line 1 and Line 2 into a network encourages trips by tram of a longer distance, then is become obvious that the capping of fares leads to relatively cheaper tram fares for these longer distance 'network' trips. It should be noted, of course, that currently bus users in /Edinburgh that are 'crossing the city centre' enjoy relatively cheaper bus fares that are capped (assuming they are travelling more than 8 fare stages).

In order to attempt to maximise revenue, the following initiatives could be explored:

- apply a 'cross-city fare premium; and/or
- add additional fare stages to reflect the longer distance journey opportunities.

The potential impacts of these would need to be carefully assessed as there would be impacts on modal transfer, patronage and revenue. Also, there would need to be a debate as to whether these could be applied solely to tram fares or whether they could also be applied to bus fares. Increasing the fares of longer distance tram journeys may allow scope for reducing some shorter distance fares.

Providing that the pricing of such trips is not set too high (which could price people off to other modes), there could be a number of benefits related to decreasing short distance fares, including a better acceptance of the system by the travelling public as fares are seen as being more suitable and also discouraging ticketless travel (which can be encouraged if short distance cares are seen to be too high).

7.5.2 Infrastructure

For the Network Effects Study, several assumptions that do not exist within the individual line projects were made, as set out in Section 4.3. These assumptions introduced a certain degree of risk and, to a lesser degree, may require further work to ensure they are technically feasible.

Picardy Place turnback/layover

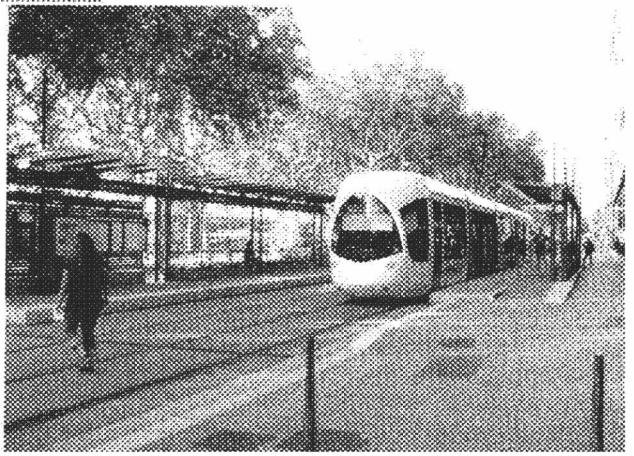
A number of layover/turnback configurations in the new Town area, including options in St Andrew Square, on Queen Street, on Princes Street, and at Picardy Place were examined. For the purposes of this evaluation, it was assumed, in agreement with **tie**, that Picardy Place would be the turnback/layover location for Line 2 trams.

Against this background, the Line 1 team is examining the feasibility and alternatives to this site, including a further site at Elm Row on Leith Walk. Both Picardy Place and Elm Row are within the Limits of Deviation included in the Line 1 Bill.

Single-track alignment

Capital cost estimates for the Network Effects Study included small portions of single-track alignment. As no cost assumptions were needed by Line 1 or Line 2 for such infrastructure, we assumed that single-track alignment costs two-thirds of what double-track alignment costs. This assumption was checked by the Line 2 team and found to be sufficient.

8 CONCLUSIONS



8 CONCLUSIONS

8.1 Identification and Development of Network Options

The Network Effects Study was conceived through the recognition that it would be necessary to assess in detail the impacts of operating Edinburgh Tram Line 1 and Line 2 together. The study was viewed as a complementary workstream to support the case for the individual Lines through Scottish Executive review and the parliamentary process.

The detailed costing and demand modelling exercises developed by the line 1 and 2 teams were mirrored for network effects. The benefit:cost ratios developed for each of the Lines was:

- Line 1: 1.51; and
- Line 2: 1.38.

A full STAG2 appraisal of each of these two lines' Base Case has been submitted to the Scottish Executive in November 2004 for their consideration and approval.

The approach adopted to define the Line 1/Line 2 network options involved:

a/ identification of the 'Base Case' option; and

b/ identification of the best 'investment enhancement option' through appraisal.

Whilst the former could be described as fairly self-explanatory (Line 1 and Line 2 running side-by-side as specified by the individual line teams), the latter option required the undertaking of a two stage appraisal process. In considering what a best 'investment enhancement option' might represent, it was clear that there were a large number of possible service pattern options – differing combinations of service configurations and frequencies. In most cases, these options would require additional investment, but would facilitate additional network-related benefits, as well as providing additional benefits to the individual lines (improved capacity where required, etc). Therefore, an initial option appraisal was undertaken which sieved through the potential options and shortlisted five for further analysis. From the more detailed work focussing on these shortlisted options, a best 'investment enhancement option' was then identified.

8.2 The Benefits Associated with Operating Edinburgh Tram, as a Network

The additional opportunities that the development of a tram network can generate, compared to the introduction of a single line, can be categorised under the following headings:

- New journey opportunities;
- Economies of scale;
- Flexibility;
- Perception; and
- Marketing/branding.

The first two are reflected in the financial and economic results. Any new journey opportunities made due to network effects have been translated into revenue and associated wider economic benefits, whilst any economies of scale have been reflected in the capital, lifecycle and operating costs.

Operating Line 1 alongside Line 2 is the base Case and reflects what the network could achieve in its simplest form. The benefits associated with the ability to travel by tram between, for example, Edinburgh Park and Leith, coupled with the potential for savings in costs through economies of scale, have resulted in this option recording a BCR of 1.62. This is greater than both Line 1 and Line 2 and reflects the benefits and economies of scale associated with operating them as a network.

This figure would also take into account the scale of potential double-counting of benefits compared to 'Line 1 plus Line 2'. For example, a journey using tram from Edinburgh Park to Leith would be recorded in both the Line 1 (Haymarket to Leith) and Line 2 (Edinburgh Park to Haymarket) results separately. In the Network Effects results this would naturally be represented as one tram trip.

The ability to enhance the network through additional investment was explored in some detail through an optioneering process. The ability to provide improved direct linkages by tram between key focal points in Edinburgh should be viewed as opportunities to attract more trips onto public transport, especially those trips that have not traditionally been best served by public transport (ie; non city centre trips). The preferred investment enhancement option required additional capital expenditure over and above the Base Case (more trams and turnback/layover facilities), but generated greater passenger numbers and hence revenue. The option, though, recorded a BCR of 1.51 which is a reduction compared to the Base Case. The reasons for this focussed on the fact that, compared to the Base Case, the increase in operating and lifecycle costs (plus to a lesser extent, capital costs) outweighed the increase in overall benefits. Nevertheless, the option generated additional revenue and increased the operating surplus by approximately £0.5 million per annum compared to the Base Case.

8.3 Supporting the Case for Lines 1 and 2

This Network Effects Report has addressed the aims as set out in Section 1.1 and has demonstrated that:

- A robust appraisal process has been carried out with support from the individual Line technical advisors;
- New journey opportunities and economies of scale are reflected in the Preliminary Financial Case and overall financial and economic appraisal;
- The network will provide increased operational flexibility and has the potential to allow sensible and coherent integration with Line 3;
- The network configurations present stronger economic cases than the individual Lines, including significant additional wider benefits relating to travel time benefits;
- Fundamentally, Line 1 and Line 2 can be configured into an operating network with demonstrable savings in capital, operating and lifecycle costs and increased revenue without service re-configuration;
- This (Base) network can be further enhanced through service re-configuration with consequent need for additional capital investment to further increase the operating surplus and revenue of the scheme;
- Additional infrastructure requirements and deposit configurations have been examined and costed;
- The network can be constructed in a 41 month period including optimism bias;
- The Base Case network can be delivered for £565m, including optimism bias, which represents a saving of £58m on the sum of the capital costs for the individual lines;
- The revenue of the network can be optimised through service re-configuration to increase by nearly £2m per annum, an increase of 10% on the Base Case network option; and
- The Base Case and Investment Enhancement networks generate sufficient surplus to cover operating costs and ongoing lifecycle costs.
- It is easier to market and brand an extensive (network) system than a system limited to a single line/locality. As well as being likely to result in higher patronage, greater public acceptance could lead to additional benefits, including:
    - Minimise objections during the planning stage;
    - Aid the rapid ramp-up to full ridership in the early years of operation;
    - Lead to greater awareness of the overall public transport operation within the City;

- The STAG appraisals for the individual lines are not imp[acted by the findings of this Report;'
- The Parliamentary Bills will cater for the individual lines, 'Base Case' network and 'Investment Enhanced' network;
- No further consultation would be required;
- Development of the network and associated fares strategy will be ongoing through the DPOF (operator) process. The Report has raised a number of issues with regard to demand modelling assumptions and the matching of capacity to forecast demand levels. These issues will be considered by **tie** and are likely to be addressed with the appointed operator in due course; and
- No significant new risks have been identified as a result of this exercise.

The opportunities associated with developing the Edinburgh tram Network have been developed in some detail and demonstrated to be robust and complementary to the separate Line 1 and Line 2 Bill submissions. Two network options were identified that were developed to meet different objectives:

- A 'base Case Option' that reflects the separate Line Bills being submitted to the Scottish Parliament and can demonstrate some potential areas for cost savings and additional revenue generation;
- An 'Investment Enhancement Option' that reflects what might be achieved through further investment and service re-configuration which generates additional benefits.

Both options demonstrated a stronger economic case for a network solution rather than individual lines and recorded good benefit to cost ratios that compared favourably with the separate Line 1 and Line 2 results.

APPENDIX A: OPERATING COST ASSUMPTIONS

Operating Costs Assumptions

	Salary	Overhead	Cost
1. Staff Costs			
Fixed Staff			
Management, Finance & Administration			
Managing Director	£80,000	12.0%	£89,600
Finance & Administration Director	£60,000	12.0%	£67,200
Finance Assistant	£25,000	12.0%	£28,000
Accountant	£35,000	12.0%	£39,200
Training Manager	£25,000	12.0%	£28,000
Training Asst	£15,000	12.0%	£16,800
Personnel Manager	£30,000	12.0%	£33,600
Marketing Manager	£35,000	12.0%	£39,200
Marketing Assistant	£20,000	12.0%	£22,400
Admin Assistant	£20,000	12.0%	£22,400
Secretarial/Clerical	£20,000	12.0%	£22,400
Operations			
Operations Director	£55,000	12.0%	£61,600
Operations Manager	£40,000	12.0%	£44,800
Assistant Operations Manager	£30,000	12.0%	£33,600
Clerical	£16,000	12.0%	£17,920
Controllers	£20,000	12.0%	£22,400
Supervision	£20,000	12.0%	£22,400
Instruction	£25,000	12.0%	£28,000
Revenue Control Inspectors	£15,000	12.0%	£16,800
Maintenance			
Maintenance (Engineering) Director	£55,000	12.0%	£61,600
Senior Engineers	£40,000	12.0%	£44,800
Revenue System	£15,000	12.0%	£16,800
Tram-variable Staff			
Operations			
Drivers	£18,000	12.0%	£20,160
Senior Conductors	£18,000	12.0%	£20,160
Conductors	£13,000	12.0%	£14,560

	Salary	Overhead	Cost
Maintenance			
Vehicles Supervisors	£25,000	12.0%	£28,000
Vehicles Technicians	£20,000	12.0%	£22,400
Signals & Telecom Inspector	£25,000	12.0%	£28,000
Signals Telecom Technician	£20,000	12.0%	£22,400
Cleaning staff	£10,000	12.0%	£11,200
Track Staff	£15,000	12.0%	£16,800
E&M Inspectors	£25,000	12.0%	£28,000
E&M Technicians	£25,000	12.0%	£28,000
Civil inspectors	£20,000	12.0%	£22,400
Civil Tradesmen	£15,000	12.0%	£16,800
2. Power			
Electric traction power	8.40 kWh per km		
Depot power consumption	178,500 kWh per year per depot (average for 2 depots)		
Cost of power	£0.025 per kWh		
3. Maintenance materials			
Vehicles	£0.004 per total tonne km		
Power supply	£500 per single track km		
Signals	£5,000 per single track km		
Track	£0.002 per total tonne km		
Stops	£2,500 per stop per annum		
4. Insurance	£0.23 per service km		
5. Policing	£0.17 per service km		
6. Overheads	5% of total costs (excluding 'rates')		
7. Rates	£12,000 per route km		

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APPENDIX B: ENVIRONMENTAL STATEMENT ON CUMULATIVE EFFECTS OF TRAM NETWORK (FROM LINE 2 ENVIRONMENTAL STATEMENT)

Introduction

This section of the ES examines the cumulative impacts of Lines 1 and 2 running simultaneously. For the purpose of this assessment this would mean increasing the number of trams to 14 trams per hour (tph) between Roseburn and St Andrew Square (ie combining tram lines 2's 6 tph with Line 1's 8 tph).

The requirement to undertake an assessment of cumulative effects as part of an EIA is set out in Schedule 4 of the Environmental Impact Assessment (Scotland) Regulations 1999 (as amended), which required:

"A description of the likely significant effects of the development on the environment, which should cover the direct effects and any indirect, secondary cumulative short, medium and long-term permanent and temporary positive and negative effects of the development, resulting from … the development".

The previous chapters of this ES assess the environmental impacts of the proposed Tram Line 2 scheme as a stand-alone system. However, consideration must be given to the impacts of Tram, Lines 1 and 2 running simultaneously. A full Environmental Statement for Tram Line 1 has been prepared and has been issued under separate cover.

Note that there are a number of different network scenarios made possible by the proposed Tram Line 1 and Tram Line 2 track arrangements. However, for clarity only one of these possible options is considered in the current cumulative impact assessment. Details of this scheme are provided in the Scheme Description below.

Method

The approach taken to the cumulative assessment has been to examine potential differences between the tram line 2 operating base case, as discussed in other chapters of the ES, and the proposed combined operation on areas of common running within the tram Line 2 route. Note that cumulative impacts that impact on Line 1 are addressed in the line 1 ES.

No additional baseline studies have been undertaken for this assessment as the baseline information for tram line 2 operating as a standalone route or as part of a network is considered to be the same. The assessment has been undertaken mainly on a qualitative basis. At the time of writing there are some significant information gaps and various other study limitations. Significant data omissions include traffic modelling data and the noise and air quality effects that are calculated on the basis of this modelling.

The significance of cumulative impacts identified in this Chapter is based on the criteria set out in chapters 5 to 14 of the line 2 ES. In addition, Table 1 provides criteria to provide an indication of significant of the change in impacts over and above those identified in the Tram Line 2 ES.

Table 1: Impact Criteria for Cumulative Impact Assessment

Impact	Criteria
Negligible Change	Operation of the network would result in no change on the parameter considered.
Minor Change	Slight changes would occur (either positive or negative) that are not significant and do not require any additional mitigation
Moderate Change	Additional impacts would be significant and, where negative, require additional mitigation
Major Change	Additional impacts would be substantially higher than those assessed in the Line 2 ES.

Scheme Description

The scenario that is the subject of this cumulative assessment is summarised in Table 2 below.

Table 2: Line 1 & 2 Characteristics

Location/Issue	Network Characteristics and Assumptions
Area of Common Running	Common tram route runs in both directions from St Andrew Square to the Roseburn Delta Junction.
Tram Line 1	Would operate 8 tph between St Andrew square and Roseburn
Tram Line 2	Would operate 6 tph between St Andrew Sq and Roseburn
Depots	Depot facilities and their operational characteristics are assumed to be the same as those assessed in Tram Line 2 ES.
Other infrastructure changes compared to Line 1 and Tram Line 2 existing in isolation	Other infrastructure (including sub-stations and turn back facilities) are assumed to be the same as those covered in the Tram Line 2 ES.
Traffic Data	Limited data available at the time of writing

For the purposes of the current Chapter, the scope of the cumulative impact assessment of network operations is confined only to those impacts associated with running additional trams on the shared network section between St Andrew Square and the Roseburn Junction.

As Table 2 above shows this would mean an additional 8 tph along the shared section, giving a total number of trams on the shared section as 14 tph. This is the only operational difference between the standalone Tram line 2 scheme and the combined scheme that will be considered in this Chapter.

Assessment

Traffic and Transport

Impacts on traffic and transport for Tram Line 2 are discussed in the Line 2 ES Chapter 5. The following permanent and operational effects are considered of overall significance:

There are likely to be benefits within the city centre for pedestrians and cyclists although it is difficult to be precise about these given other traffic measures, for example traffic management, that are also proposed. A Local Benefits of Moderate Significance is predicted.

At a city-wide level the Edinburgh tram line 2 can be expected to bring significant benefits in the form of a small reduction in overall traffic flows on highways. However, there are a few locations where this is likely to be significant at a local level, providing a Regional Benefit of moderate to major Significance.

Running additional trams on the St Andrew Square to Roseburn section would not have a significant effect on pedestrian and cyclist as these impacts relate to the placement of tram infrastructure and not to the frequency or capacity of trams operated. The cumulative effect is therefore assessed Negligible for both parameters.

Running additional trams on the section of track shared by Line 1 and Line 2 would impact on overall traffic flows within Edinburgh. Based on the network effects tests examining the combined effects of lines 1 and 2 (14 tph); whilst detailed traffic modelling has not been carried out, the indications from the tests undertaken are that the impact of adding Line 1 to Line 2 is to generate a decrease in the peak and an increase in the off-peak highway mileage, with an overall decrease of 0.1% highway mileage for 2011 & 0.3% for 2026.

Table 3: Impact on Highway Mileage of increasing to Tram Line 2

Year	AM	Off peak	PM Peak	Annual
2011	-0.4%	+0.1%	-0.3%	-0.1%
2026	-0.7%	-0.04%	-0.8%	-0.3%

Information is not available to compare this to a base case of Line 2 operating in isolation over this stretch of the route without operation of the additional Line 1 trams so it is difficult to assess actual cumulative impact at this stage. However, the figures do show an overall decrease in highway mileage that may be caused by an actual reduction in vehicle journeys and/or a modal shift from other forms of transport to the tram.

Land Use

Impacts on land use for Tram Line 2 are discussed in the Line 2 ES Chapter 6. No additional land take is required and therefore no additional impacts on existing or future land use in this area is anticipated. The cumulative impact is therefore assessed as Negligible.

Geology, Soils & Contamination, Including Hydrogeology and Waste Management

Impacts on geology, soils and contamination for Tram Line 2 are discussed in the Line 2 ES Chapter 7. The operation of additional trams on the section of common running would not impact on geology or soils over and above the impact already associated with Tram Line 2 in isolation, as no additional land take or construction work would be required. No geological SSSIs or RIGS would be affected and therefore the impact would be Negligible. There would be no additional impacts on contaminated land with the route limits and the cumulative impact associated with contaminated land is assessed as Negligible.

There are no active or potential mining reserves or agricultural land within this section of Tram line 2, nor evidence of undermining. The cumulative impacts on these issues would therefore all be Negligible. Assuming that the adequate drainage arrangements and environmental management procedures are put in place there would be no additional impact on shallow or deep aquifers during operation of the network and therefore the impacts on hydrogeology would be Negligible. In addition, operation of the network would not generated any significant impacts on waste management sites or create significantly greater waste management issues. The cumulative impact on waste management is therefore assessed as unchanged and therefore negligible.

Landscape and Visual Impacts

Impacts on landscape and visual impacts for Tram Line 2 are discussed in the Line 2 ES Chapter 8. The increase in number of trams operating between Roseburn and St Andrew Square would not significantly increase the landscape impact on the local character areas already assessed in Chapter 8 (Area A: Historic City Core).

The long term impacts would remain moderate to Substantial and adverse. Equally, the additional number and movement of trams on the shared section between Roseburn and St Andrew Square would not result in measurable additional visual impacts to those already assessed under the operation of Line 2 for receptors along this section of the corridor. In summary there would be not significant landscape or visual cumulative impacts occurring as a result of the network operation.

Ecology and Nature Conservation

Impacts on ecology and nature conservation resulting from the tram Line 2 proposals (including the effect on the Disused Railways UWS and delta junction at Roseburn) are assessed in the Line 2 ES Chapter 9. No additional landtake or construction impacts would occur as a result of combining tram Lines 1 and 2 in this common area. Beyond the UWS ecological resources are of low ecological value and limited to scrub and grassland adjacent to the railway, and amenity grassland and formal planting at St Andrew Square, princes Street Gardens and Atholl Crescent/Coates Crescent. There are not known protected species in this area. The cumulative impact of running additional trams on this section is therefore unlikely to have an effect on ecological receptors. The cumulative impact is therefore assessed as negligible.

Surface water

Impacts on surface water for Tram Line 2 are discussed in the Line 2 ES Chapter 10. There are no surface watercourses that cross or are close to the section of tram Line 2 track in this study area. The cumulative impacts resulting from the operation of Tram Line 2 on water quality would therefore be Negligible.

There would be Minor potential for accumulated pollutants to be washed from the track areas to the permanent drainage system. Pollution control measures would be incorporated into the drainage system wherever necessary such as from the depot. Sustainable urban Drainage systems (SUDS) would be integral to the drainage system designed during the detailed design phase. As the network does not operate close to any watercourses there would be no cumulative impacts on watercourse characteristics or flooding and the impact would therefore be negligible.

Heritage

Impacts on archaeology and heritage traffic and transport for Tram Line 2 are discussed in the Line 2 ES Chapter 11. The passage of additional trams along the route section between St Andrew Square and Roseburn would not result in any measurable cumulative effects occurring. The significantly adverse effects of Tram line 2 on the cultural heritage in this area result from the addition of fixed fixtures (overhead line equipment, tram stops, etc) into the highly sensitive New Town Townscape, rather than from the proposed passage of trams along what are already busy transport corridors.

In summary, it is anticipated that the combined running of tram Line 1 and 2 would not give rise to any cumulative network effects occurring on cultural heritage.

Socio-Economic Effects

Impacts on socio-economic effects for Tram Line 2 are discussed in the line 2 ES Chapter 12. The main conclusions relating to the operation are as follows:

There would be Minor benefits from direct and indirect employment gains resulting from the operation of Tram Line 2.

The tram would be Minor benefits resulting from induced economic growth through improved linkages and greater economic efficiency.

Assuming the operation of trams Line 1 and 2 remains the same, the impact on direct employment creation would be negligible. However, it is likely that the operator would attempt to reduce costs and improve overall efficiency of the network and direct job creation may therefore be reduced. The effects on indirect employment are not known but it is likely that the improved linkages and further reduction of spatial separation in the economy would have benefits for the economy of Edinburgh and the Lothians. This would constitute a Minor Benefit.

Noise and Vibration

Impacts on noise and vibration for Tram Line 2 are discussed in the Line 2 ES Chapter 13. For the purpose of this cumulative impact assessment calculations of tram noise and vibration were carried out on the common section of Lines 1 and 2.

Table 4 below summarises the results, showing the predicted tram Line 2 overall noise levels (ambient noise plus 6 trams per hour) and the cumulative noise level (ambient plus 14 trams per hour). The increase in tram movements from 5 per hour to 14 per hour resulted in increases to the tram noise levels but due to the high ambient levels in these areas the increases in combined noise levels were small. There is only one location at Roseburn Maltings where the impact description is likely to change. This change from Negligible to Minor is not considered to be significant.

Table 4: Daytime Cumulative Impact of Tram Noise

Location	Distance from track (m)	Estimated Ambient noise Level $L_{Aeq, 18\ hr}$	Predicted Line 2 Noise Level $L_{Aeq, 18\ hr}$	Line 1 + Line 2 Noise Level $L_{Aeq, 18\ hr}$	Cumulative Difference from ambient dB	Change of Impact from Line 2 to cumulative
Princes Street	20	70	70	71	+1	None
Shandwick Place	10	72	73	74	+2	None
West Maitland Street	15	71	71	72	+1	None
Balbirnie Place (Unmitigated)	5	57	70	73	+16	None
Balbirne Place (Mitigated)	5	57	62	65	+8	None
Russell Road, Roseburn Maltings	22	62	64	66	+4	Negligible to Minor

Vibration levels were recalculated for the increased tram activity, showing a typical 0.03 $ms^{-1.75}$ increase to the daytime VDV values. This did not result in any changes to the impact descriptions at the locations where tram vibration levels were assessed.

Air Quality

Impacts on air quality for Tram Line 2 are discussed in the Line 2 ES Chapter 13. The assessment concludes that a Moderate beneficial impact on air quality would result from Tram Line 2. Limited traffic data was available to inform the assessment of cumulative impacts. However, it is anticipated that running additional trams on the network section between St Andrew Square and Roseburn is likely to result in a small further improvement in air quality across the city. Overall a Minor beneficial cumulative impact on air quality is predicted, with regard to both CO_2 emissions and concentrations of local air pollutants.

Summary of Cumulative Impacts

Cumulative impacts associated with operation of the network were assessed on the basis of running additional trams on the section between St Andrew Square and Roseburn (operating 14 tph as opposed to 6 tph). Cumulative impacts are summarised in Table 5 below, which compares the cumulative impact against the impact associated with the standalone scheme.

Cumulative impacts over and above those impacts associated with Line 2 as a standalone scheme are generally Negligible with Minor Beneficial Impacts identified for Traffic Flows, Air Quality and Economic Activities. Minor Negative Impacts were identified for Noise, particularly with regard to impacts at Balbirnie Place between Haymarket Yards and Roseburn.

Table 5: Summary of Cumulative Impacts

Environmental Issue	Summary of Significance Set out in Line 2 ES for Common Study Area when Tram I Operating	Cumulative Impact (over and above that Stated in the Line 2 ES)
Traffic and Transport		
Pedestrian and Cyclists	Moderate to Benefit	Negligible Impact
Reduction in Traffic Flows	Moderate to Major Benefit	Minor Beneficial Impact
Landuse		
Land-take	Moderate Negative Impact	Negligible Impact
Geology		
Designated Sites	Negligible Impact	Negligible Impact
Agricultural Soils	Negligible Impact	Negligible Impact
Contaminated Land	Minor Negative Impact	Negligible Impact
Mineral Reserves	Negligible Impact	Negligible Impact
Hydrogeology	Negligible Impact	Negligible Impact
Waste Management	Minor negative Impact	Negligible Impact
Landscape and Visual		
Landscape Impacts	Moderate to Major Negative Impact	Negligible Impact
Visual Impacts	Moderate to major Negative Impact	Negligible Impact
Ecology and nature Conservation		
Designated Sites	Negligible Impact	Negligible Impact
Species	Negligible Impact	Negligible Impact
Habitats	Minor Negative Impact	Negligible Impact
Surface Water		
Water quality	Minor Negative Impact	Negligible Impact
Flooding and drainage	Moderate Negative Impact	Negligible Impact
Heritage		
Cultural heritage	Major Negative Impact	Negligible Impact
Socio-economic Effects		
Economic	Minor Beneficial Impact	Minor Beneficial Impact
Community	Minor Negative Impact	Negligible Impact
Noise and Vibration		
Noise	Negligible to Minor Negative Impact	Negligible to Minor Negative Impact
Vibration	Negligible Impact	Negligible Impact
Air Quality		
CO_2	Minor Beneficial Impact	Minor Beneficial Impact
NO_x and PM_{10}	Moderate Beneficial Impact	Minor Beneficial Impact

APPENDIX C: INVESTMENT ENHANCEMENT OPTION: INITIAL APPRAISAL TABLE

Initial Option Appraisal

Option	Operational practicality	Additional Infrastructure Requirements	Demand Patterns	Passenger Convenience	Tram-km (Operating Costs)	Fit to Edinburgh LTS	Future interaction with Line 3
Weighting	**1**	**1**	**3**	**3**	**3**	**2**	**3**
A1	Very little joint running (0.7km)	Constrained Haymarket site would require turn-back facilities & appropriate interchange facilities	Not adequately catered for – no direct trams between city centre and west Edinburgh/airport Target frequency on both lines – although Line 2 might benefit with another tram	Need for interchange at Haymarket for all Line 2 trips with an origin/destination in city centre Otherwise service patterns are simple to understand	Peak hour tram km approx 438 km	Performs less well due to Line 2 terminating at the western edge of the city centre	Simple extension of Line 2 along Princes St to link in with Line 3 is possible
	5	1	1	1	4	2	5
A2	Very little joint running (0.7km)	Constrained Haymarket site would require turn-back facilities & appropriate interchange facilities	Not adequately catered for – no direct trams between city centre and west Edinburgh/airport Target frequency on Line 1, better frequency for Line 2 to allow for network effects	Need for interchange at Haymarket for al Line 2 trips with an origin/destination in city centre Otherwise service patterns are simple to understand	Peak hour tram km approx 468 km	Performs less well due to Line 2 terminating at the western edge of the city centre	simple extension of Line 2 along Princes St to link in with Line 2 is possible.
	5	1	1	1	4	2	5
Base Case 2	Joint running in city centre (2.7 km) – requires turn-back facilities for Line 2 trams at east end of city centre	Turn-back facilities at east end of city centre required – could be sensitive and constrained	Both lines serve the city centre Target frequency on Line 1, better frequency for Line 2 to allow for network effects	Service patterns straightforward and easy to understand No direct network connections – Lines sill operated separately, but easy interchange at city centre stops	Peak hour tram km approx 496 km	No additional network effects, but city centre penetration for both lines	Simple extension of Line 2 to link in with Line 2 is possible
	3	1	4	4	3	3	5
Base Case 3	Joint running in city centre (2.7 km) – requires turn=back facilities for Line 2 trams at east end of city centre	Turn-back facilities at east end of city centre required - could be sensitive and constrained	Both lines serve the city centre Target frequency on Line 1, perhaps Line 2 frequency a little high	Service patterns straightforward and easy to understand – Line 1 and Line 2 frequencies the same No direct network connections – Lines still operated separately, but easy interchange at city centre stops	Peak hour tram km approx 496 km	No additional network effects, but city centre penetration for both Lines	Simple extension of Line 2 to link in with Line 3 is possible
	3	1	3	5	3	3	5
Option	**Operational Practicality**	**Additional Infrastructure Requirements**	**Demand Patterns**	**Passenger Convenience**	**Tram-km (Operating Costs)**	**Fit to Edinburgh LTS**	**Future Interaction with Line 3**

B1	Extended joint running beyond city centre and up Leith Walk to Ocean Terminal (6 km)	Turn-back facilities at Ocean Terminal area and at the east end of the city centre required	Both lines serve the city centre Target frequencies on both Lines Provides additional capacity between ocean terminal/Leith and city centre (+3 tph)	Service patterns straightforward and easy to understand – although Line 2 trams mixed destination as half go through to Ocean Terminal Additional direct network connections (Leith/Ocean terminal and western Edinburgh/airport)	Peak hour tram km approx 482 km	New direct journey opportunities by tram. Operation of Line 1 and Line 2 trams over all possible 'on-road' running sections	Opportunity to run line 3 around west side of Line 1 loop to terminate at Granton or ocean terminal (with subsequent reduction of Line 1 tram accordingly) – this could provide for more suitable service frequencies around the loop.
	2	1	5	4	3	4	4
B2	Extended joint running beyond city centre and up Leith Walk to ocean Terminal (6 km)	Turn-back facilities at ocean terminal area and at the east end of the city centre required.	Both lines serve the city centre Target frequencies on line 1, better frequency on Line 2. Provides additional capacity between ocean terminal/Leith and city centre (+4 tph)	Service patterns straightforward and easy to understand – although Line 2 trams mixed destination as half go through to ocean terminal Additional direct network connections (Leith/ocean terminal and western Edinburgh/airport)	Peak hour tram km approx 524 km	Higher frequency version of Option B1	Opportunity to run line 3 around west side of Line 1 loop to terminate at Granton or ocean terminal (with subsequent reduction of line 1 trams accordingly) – this could provide for more suitable service frequencies around the loop
	2	1	5	4	3	5	4
B3	Extended joint running beyond city centre and up Leith Walk to ocean Terminal (6 km)	Turn-back facilities at ocean Terminal area and at the east end of the city centre required	Both lines serve the city centre Target frequencies on Line 1, perhaps slightly high frequency on Line 2 Provides additional capacity between ocean terminal/Leith and city centre (+4 tph)	Service patterns straightforward and easy to understand – Line 1 and 2 frequencies the same – although the Line 2 trams mixed destination as half go through to Ocean Terminal Additional direct network connections (Leith/Ocean terminal and western Edinburgh/airport)	Peak hour tram km approx 558 km	Higher frequency version of option B1	Opportunity to run Line 3 around west side of Line 1 loop to terminate at Granton or ocean Terminal (with subsequent reduction of Line 1 trams accordingly) – this could provide for more suitable service frequencies around the whole loop
	2	1	4	4	2	5	4
Option	**Operational Practicality**	**Additional Infrastructure Requirements**	**Demand Patterns**	**Passenger Convenience**	**Tram-km (Operating Costs)**	**Fit to Edinburgh LTS**	**Future Interaction with Line 3**

C1	Extended joint running around the whole Line 1 loop (15.7 km) (but Line 1 frequencies reduced accordingly) Possible problems relating to driver's hours of continuous driving 18 tph in each direction through Roseburn junction	Constrained Haymarket site would require turn-back facilities and appropriate interchange facilities	Only 6 tph (Line 1 trams) directly linking west side of Line 1 loop and city centre – evidence *source: Network Effects: Briefing Note for Public Consultation) suggests that patronage suffers as a result Target frequency on Line 2, although Line 2 might want another tram	Reduced number of direct tram services between west side of Line 1 loop and city centre – alternative is to change at Haymarket Direct network connections from all the Line 1 loop to Line 2 (although the west an, to a lesser extent, the north side of the loop have to travel the long way around to Line 2 via Princess St) Potentially confusing service pattern for passengers (eg: westbound departures from Haymarket with a destination stating Newbridge but actually travelling via Line 1 loop)	Peak hour tram km approx 562 km	Direct network connections throughout (but some require 'long way round' movements), at expense of less direct trams between western side of loop and city centre. All possible areas of 'on-road' running used by Line 1 and Line 2 trams	No easy add-on for Line 3 – extending Line 2 back along Princes St would add further trams through the city centre and potential for driver's hours of continuous driving problems An alternative would be to extend the Line 1 trains out to include line 3 – a 'panhandle operation' – but this would mean 50% of Line 3 trams would not go along Princes St directly off line 3
	2	1	2	2	2	3	2
C2	Extended joint running around the whole Line 1 loop (15.7km) (but Line 1 frequencies reduced accordingly) Possible problems relating to driver's hours of continuous driving 20 tph in each direction through Roseburn junction	Constrained Haymarket site would require turn-back facilities 7 appropriate interchange facilities	only 6 TPH (Line 1 trams) directly linking west side of Line 1 loop and city centre – evidence (source: Network Effects: Briefing note for Public consultation) suggests that patronage suffers as a result Better frequency on Line 2 to cater for additional network effects	Reduced number of direct tram services between west side of Line 1 loop and city centre – alternative is to change at Haymarket Direct network connections from all the Line 1 loop to Line 2 (although the west and, to a lesser extent, the north side of the loop have to travel the long way around to Line 2 via Princess St) Potentially confusing service pattern for passengers (eg: westbound departures from Haymarket with a destination stating Newbridge but actually travelling via Line 1 loop)	Peak hour tram km approx 626 km	Higher frequency version of option C1	No easy add-on for Line 3 – extending Line 2 back along Princes St would add further trams through the city centre and potential for driver's hours of continuous driving problems An alternative would be to extend the Line 1 trains out to include Line 3 – a 'panhandle operation' – but this would mean 50% of Line 3 trams would not go along Princes St directly off Line 3.
	2	1	3	2	1	3	2
Option	**Operational Practicality**	**Additional Infrastructure Requirements**	**Demand Patterns**	**Passenger Convenience**	**Tram-km (Operating Costs)**	**Fit to Edinburgh LTS**	**Future Interaction with Line 3**
D1	Extended joint running around the	New delta junction required at	Only 6 tph (Line 1 trams) directly linking west side of	All of Line 1 loop enjoys direct access to Line 2 (although only 3	Peak hour tram km	Improved direct connectivity	Options could be to either: a/ operate Line 3 the same as

	whole Line 1 loop (15.7 km) (but Line 1 frequencies reduced accordingly) Possible problems relating to driver's hours of continuous driving	Roseburn junction	Line 1 loop and city centre – evidence (source: Network Effects: Briefing Note for Public consultation) suggests that patronage suffers as a result Only 3 tph directly linking Line 2 with city centre – this is too low	tph) Reduced number of direct tram services between west side of Line 1 loop and city centre – alternative is to change at Haymarket Reduced number of direct trams between line 2 and city centre means more interchanging at Murrayfield Stadium station Potentially confusing service pattern for passengers (eg: alternative Line 2 services going either way around the Line 1 loop)	approx 460 km	between Line 2 and non city centre elements of Line 1, at the expense of worsening direct connections for some specific flows including Line 2 and the city centre and the west side of Line 1 and the city centre.	Line 2 as a 'panhandle – assuming a Line 3 frequency of 6 tph, this would increase the number of trams around the Line 1 loop to 12 tph (slightly high), plus half the Line 3 trams would not feed directly onto Princes St b/ extend Line 1 trams out to Line 3 (6 tph), again in a 'panhandle' operation – but this would mean 50% of Line 3 trams would not go along Princes St directly off Line 3.
	2	1	1	1	4	3	2
D2	Extended joint running around the whole Line 1 loop (15.7 km) (but Line 1 frequencies reduced accordingly) Possible problems relating to driver's hours of continuous driving	New delta junction required at Roseburn junction	Only 6 tph (Line 1 trams) directly l inking west side of Line 1 loop and city centre – evidence (source: Network Effects: Briefing note for Public Consultation) suggests that patronage suffers as a result Only 4 tph directly linking Line 2 with city centre – this is too low	All of Line 1 loop enjoys direct access to Line 2 (although only 4 tph) Reduced number of direct tram services between west side of Line 1 loop and city centre – alternative is to change at Haymarket Reduced number of direct trams between Line 2 and city centre means more interchanging at Murrayfield stadium station Potentially confusing service pattern for passengers (eg: alternative Line 2 services going either way around the Line 1 loop)	Peak hour tram km approx 550 km	Improved direct connectivity between Line 2 and non city centre elements of Line 1, at the expense of worsening direct connections for some specific flows including Line 2 and the city centre and the west side of Line 1 and the city centre	Options could be to either: a/ operate Line 3 the same as Line 2 as a 'panhandle' – assuming a Line 3 frequency of 6 tph, this would increase the number of trams around the Line 1 loop to 13 tph (slightly high), plus half the Line 3 trams would not feed directly onto Princes St b/ extend Line 1trams out to Line 3 (6 tph), again in a 'panhandle' operation – but this would mean 50% of Line 3 trams would not go along Princes St directly off Line 2
	2	1	1	1	2	3	2

APPENDIX D: DEMAND AND REVENUE SENSITIVITY ANALYSIS

DEMAND AND REVENUE SENSITIVITY ANALYSIS

Introduction

Additional sensitivity analysis has been undertaken to revisit the demand and revenue data presented in this Report in the light of a review of demand levels in relation to available capacity. The aim of this additional work was to:

- Define the issue;
- Identify and develop a methodology to address the issue within the timescales available; and
- Confirm the impact on option revenues.

The Issue

Within the Network Effects analysis set out in this Report, it was identified that high average peak hour loadings were being experience on certain links. In particular, on certain sections of Line 2 the average peak hour customer demand was shown to exceed the available tram capacity in both 2011 and 2026 (the two modelled years). By 2026 Line 1 was also indicating an under-capacity problem on certain links in the AM peak.

In their separate studies, both the Line 1 and Line 2 teams have indicated that there are likely to be under-capacity issues by 2026, although the scale of the problem compared to that experienced in network effects was much reduced, particularly on Line 2. There are a number of reasons why greater levels of overcrowding are experience on Line 2 under network effects conditions, and not under Line 2 only conditions:

- the network effects demand modelling was based on the Line 1 set of assumptions. Hence. amongst other differences, tram fares were set at the same levels as the bus fares (in 'Line 2 only' tram was 33% more expensive than bus – thus making bus relatively more attractive). Also, tram in-vehicle time factors (mode constant) in network effects were set to 0.8 (in the 'Line 2 only' work it was set to 0.9, which made bus more attractive in relation to tram).
- Network effects in itself attracts further demand due to the new direct journey opportunities now offered.

In reality, the different modelling assumptions had a much more considerable impact on the relative results ('Line 2 only' compared to network effects). 'Line 1 only' and network effects used the same set of modelling assumptions, and therefore it is reasonable to assume that 'Line 1 only' experiences the same problems of under-capacity t the locations highlighted in Table 1 below (although there will be slight differences due to the impact of network effects).

Table 1 summarises where modelled demand exceeds capacity. Elsewhere on the network, the available capacity in the peak hours is sufficient to meet the estimated demand.

Table 1: Demand Exceeding Capacity

Option	Year	Time Period	Line	Location	Maximum Average Peak Hour load Factor
Base Case	2011	AM	L2	Stenhouse Dr to Haymarket	116%
	2011	PM	L2	Haymarket to Stenhouse Dr	109%
	2026	PM	L1	Craigleith to Shandwick Place	118%
	2026	AM	L2	Broomhouse Rd to Princes St W	170%
	2026	PM	L2	Princes St W to Broomhouse Rd	145%
Investment Enhancement	2011	AM	L2	Stenhouse Dr to Haymarket	111%
	2011	PM	L2	Haymarket to Balgreen Rd	103%
	2026	AM	L1	Craigleith to Haymarket	112%
	2026	AM	L2	Broomhouse Rd to Princes St W	152%
	2026	PM	L2	Princes St W to Stenhouse Dr	126%

For the purposes of this analysis, capacity was defined as a crush capacity per tram of 300 passengers. This is a best estimate at this stage, based on the following evidence:

- Typical standing densities outlined in concessionaire agreements from other UK tram schemes include that:
    - At least 30% of the total tram capacity is for seated passengers;
    - The standing density does not exceed 4 passengers/m^2, other than in the hour of highest demand when standing density of 5 passengers/ m^2, shall be permitted (this is, therefore, a 25% increase in capacity (although the internal layout of the tram will play a part on the eventual crush capacity per tram)).
- A 40m, 2.4m wide, tram typically has a standard capacity of 264.

Given a 'standard' capacity per tram of 264 (say 30% seated = 79 seated and therefore 185 standing) based on a standing density of 4 passengers/m^2, then a 25% increase in standing density would increase the number of standees to 231. This would give a total crush capacity per tram of 310. This is based on a tram that is 2.4m wide and the Edinburgh trams are currently assumed to be 2.6m wide, thereby providing further capacity for standees. Thus, whilst issues such as actual internal layout will obviously play a part on the eventual crush capacity per tram, our estimate of 300, given the evidence above, was considered to be slightly conservative.

From Table 1, it is clear that the highest recorded demand is on Line 2 eastbound in the AM peak hour along the Murrayfield/ Haymarket/ Shandwick place section. By 2026 there is an average 510 passengers per tram on the busiest link (170% average load factor). Line 1 experiences overcrowding in the AM peak hour by 2026 on the western section of the loop in an anti-clockwise direction. The Investment Enhancement option reduces the extent of overcrowding (in terms of a smaller number of links experiencing a problem, plus lower average load factors), which reflects the fact that there are 7 trams per hour on Line 2 in this option.

Addressing the Issue

The issue of under-capacity can be addressed in a number of ways, including:

- Capacity enhancements:
    - Increase service frequency (more tram sand drivers required, issues relating to operational capacity (eg can all the trams be accommodated along Princes St? Can the extra trams be accommodated in the depots? etc) plus this would generate additional demand)
    - Increase the length of the trams (more trams required (can depots accommodate them?), tram stops would need to be lengthened);
- Managing demand:
    - Marketing to encourage peak spreading (additional operating expenditure and not guaranteed to succeed)l;
    - Development of a tram fare strategy (options could include pricing off demand in the peaks by raising fares, reducing fares in the shoulder peaks, etc);
    - Do-nothing = suppression of demand (transfer of trips back to other modes, tram revenue reduced).

Each of these could be considered on their merits as the project is taken forward and the involvement of the appointed operator is harnessed. For the purposes of this sensitivity analysis though, and given the timescales available, it was decided to assess the impact on revenue of trip suppression. This was on the basis that the capacity enhancement options would involve considerable changes to the capital, operating and lifecycle costs, the marketing option would require additional operational costs and would be difficult to model the possible effect on demand, and changing the tram fare strategy would involve significant changes to the demand forecasting models.

A sensitivity analysis was thus specified to determine what the potential loss in revenue would be if there were no capacity enhancements or specific marketing initiative planned. In other words, the sensitivity analysis would assume trip suppression. This work took account of the capacity by adjusting the peak hour tram trip demand matrix used to calculate the tram revenue. For the purpose of this analysis, it was assumed that only when the peak hour capacity is exceeded by the peak hour demand would passengers be lost to another mode. The tram trip matrix was adjusted to capacity on a link-by-link basis by identifying the first link where peak hour capacity is exceeded and then adjusting demand for all movements using the corresponding boarding tram stop until demand on that link matched supply. This process would then be repeated for the next overcrowded link, until all the overcrowded links had been addressed.

This methodology allowed us to re-calculate tram revenue based on the suppression of demand within the DAM PT model. The wider implications relating to where these 'lost to tram' trips go (in terms of re-instated bus trips – which buses, which routings?) was a more difficult issue to resolve, as the DAM model does not deal with separate bus and tram demand matrices. Therefore, it was not possible to measure the wider economic impacts (changes in relative travel time savings, the impact on bus revenues, etc) and hence the results of this sensitivity analysis could only be related to the financial analysis for tram.

Results of the Sensitivity Analysis

Table 2 sets out the 30-year revenue profile comparison for the base Case option and includes the effects of ramp-up in the first three years.

Table 2: Base Case Option Annual Revenue Profile (2003 prices)

	2009	2010	2011	2012	2013-2025	2026 & beyond
Original	£8.18m	£9.55m	£10.99m	£11.90m	Straight line growth from 2012 to 2026	£16.56m
Revised	£7.94m	£9.26m	£10.64m	£11.50m		£15.76m
Difference	-2.9%	-3.0%	-3.2%	-3.4%		-4.8%

Over the 30 year scheme life, the total undiscounted revenue for the Base Case option reduces by 4.4%. The effect of the trip suppression exercise is diluted when all the time periods are taken into account as the impact during the AM peak in 2026 demonstrates. In this period, revenue actually reduces by 10%.

One result of this change in revenue is that the operating surplus now generated does not cover all of the lifecycle costs (operating surplus is £77m, lifecycle costs are £89m). During the actual peak hour periods, demand and revenue reduces by up to 10%.

Table 3 sets out the 30-year revenue profile comparison for the Investment Enhancement option and includes the effects of ramp-up in the first three years.

Table 3: Investment Enhancement Option Annual Revenue Profile (2003 prices)

	2009	2010	2011	2012	2013-2025	2026 & beyond
Original	£9.90m	£11.48m	£13.11m	£14.10m	Straight line growth from 2012 to 2026	£18.27m
Revised	£9.89m	£11.42m	£13.01m	£13.95m		£17.50m
Difference	-0.1%	-0.5%	-0.8%	-1.1%		-4.2%

Over the 30 year scheme life, the total undiscounted revenue for the Base Case option reduces by 3.3%. Again, the effect in the actual peak hours is more marked – revenue during the 2026 AM peak hour reduces by 9%.

The result of this is that the operating surplus now generated has reduced from £119m to £102m, but this is still enough to cover the estimated lifecycle costs for the option (lifecycle costs are £92m).

Conclusions

This sensitivity analysis had demonstrated that the impact of suppressing demand to match capacity in the peak hours reduces total revenue by between 3% and 4.5%. The effects within the peak hours are greater (up to 10% reduction), but as the off peak revenue is unaffected and constitutes the larger proportion of the total annual revenue, the impact is reduced in totality. In the Base Case Option one impact is that estimated lifecycle costs are now not 100% covered by the operating surplus generated. The ability of the operating surplus to cover the lifecycle costs in the Investment Enhancement option remains unaffected.