



**EDINBURGH TRAM NETWORK**

**STAG2 Appendices: Line One**

**28 November 2003**



**tramtime**

on route to a 21st century travel system



# **Edinburgh Tram Line One, Northern Loop New Transport Initiative**

## **STAG 2 Appraisal Appendices November 2003**

**Report No. 203011/0101/D**

**28 November 2003**

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## Appendix A: Demand and Revenue Modelling

### A.1 Introduction

This Appendix sets out the detailed approach to the modelling of Edinburgh Tram Line 1 and the results obtained therein. In essence, this will cover the following:

- The modelling framework;
- Modelling and revenue assumptions; and
- Model results.

As noted in the Main appraisal report, the modelling work is based on a design freeze of July 2003. Since that time, design work on the alignment has continued and there has consequently been a divergence from this, notably on the alignment along Princes Street. The design freeze layout assumed the westbound traffic on Princes Street is retained; the current design, which is reflected in all the qualitative analysis, has Princes Street as entirely public transport.

### A.2 Modelling Framework

The modelling framework employed was the Land Use and Transport Interaction (LUTI) Model developed by MVA for the City of Edinburgh Council. This model was commissioned in December 2000 and developed over the ensuing 18 months.

The following sets out the basic functionality and geographic coverage of the model; however, for full details the reader should consult the relevant MVA model documentation (MVA, 2002).

The model comprises a hierarchic structure. At the top level, there is a strategic land use – transport interaction model, consisting of the TRAM (Traffic Restraint Analysis Model) transport model and the DELTA land use model. This operates at a 88 zone level covering the Edinburgh, Lothian and South Fife area and models at a spatially aggregate, but at a temporal and functional detailed level. This considers the full range of travel responses to transport and land use changes, including trip frequency, destination, mode and time of day. The land use model, operating interactively with the transport model, forecasts the levels of land use and associated population and employment levels. This is based on the baseline scenario at 2001 and forward looking planning policy inputs (the level of allowable development permissions by zone and year).

Whilst LUTI is sufficiently detailed to forecast plausible high level responses to transport interventions, it does not contain sufficient network detail to identify individual road, junctions or public transport services. On this basis, detailed assignment models (DAM) were developed covering the same geographic area as the TRAM model. These are based on cordoned CSTM3A networks, but have added detail in the LRT corridors. The DAM models (for highway and for PT) sit below the TRAM/DELTA models, with a disaggregation module being used to pass the forecasts down to the DAM models.

The modelling process used in the development of Edinburgh Tram employs the full functionality of the LUTI model, with the TRAM/DELTA models being used to forecast the high level responses to the introduction of the LRT. The DAM models are then used to forecast detailed patronage estimates for Edinburgh Tram and the associated impacts on the bus network and the highway network.

Figures A.1 and A.2 set out the model structure and zoning system (TRAM and DAM), respectively.

Figure A.1: Model Hierarchy

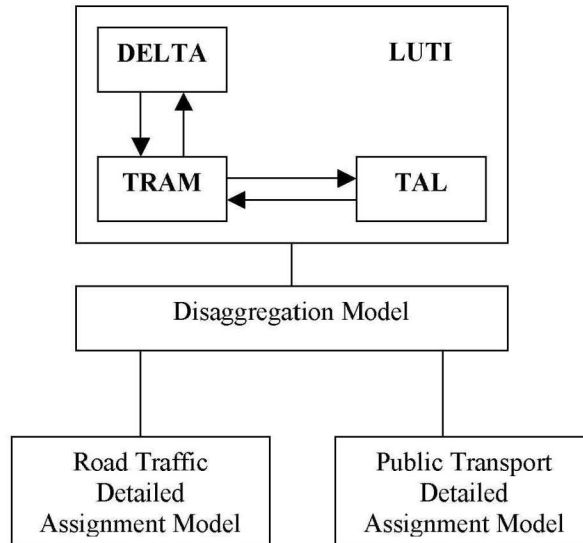
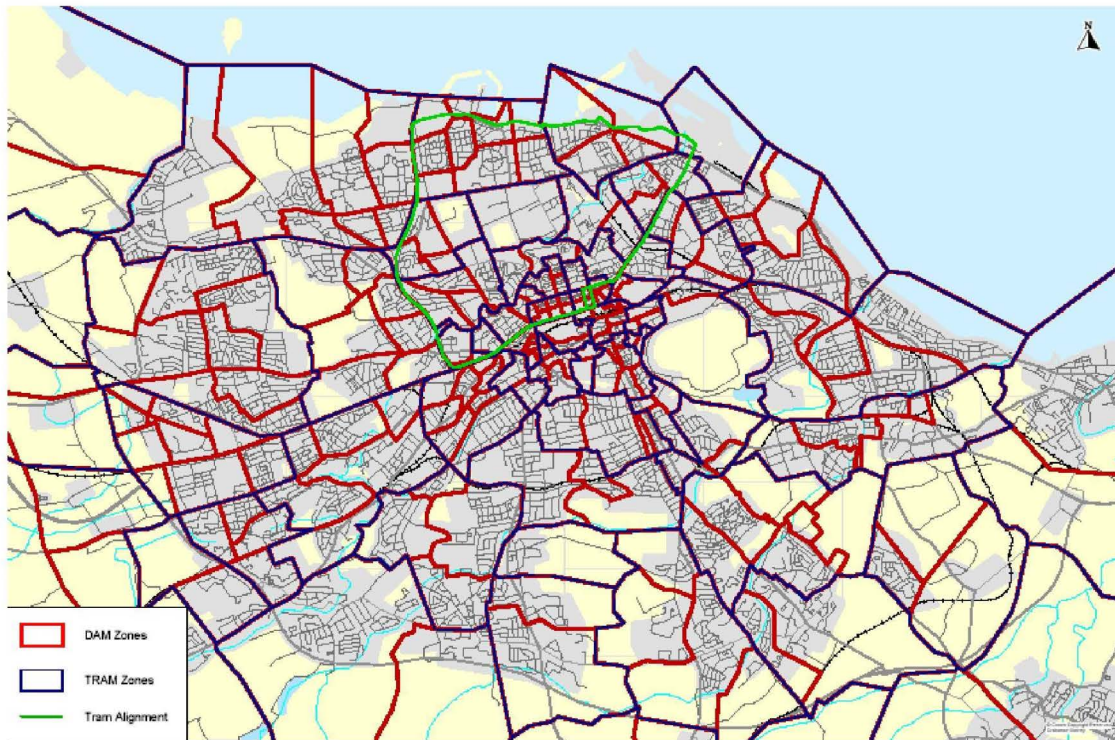


Figure A.2: Zoning System





### A.3 Modelling and Revenue Assumptions

#### A.3.1 Model Parameters

The MVA reports detail the model parameters and assumptions used in the TRAM and DELTA models. This section concentrates on the model parameters and assumptions employed in the DAM network models, notably the PT model. For consistency, the TRAM and DAM models employ the same parameter values where appropriate. In broad terms, the PT model parameters are the same as CSTM3, but are summarised here:

- Walk time weight = 1.6
- Wait time weight = 1.8
- Interchange penalties:
  - Bus to Bus, Bus to train, Bus to LRT = 10 minutes
  - Train to Train = 5 minutes
  - LRT to Rail = 5 minutes
- In vehicle time:
  - Bus = 1.1
  - Rail = 1.0
  - LRT = 0.8
- Mode Constants: None used
- Fares: Tram fares equal to bus. All fares are 2001 based.
- Value of time: 629.8p/hr in 2011 and 851.3 p/hr in 2026 (2001 prices and values)

#### A.3.2 Model Periods and Networks

The Base year for the model is 2001, with forecast years of 2011 and 2026. The model periods are the AM Peak Hour (08:00 to 09:00), an average Interpeak hour and the PM Peak Hour (16:30 to 17:30).

The future year Reference Case networks (Do-minimum) have the following schemes and revisions added to the 2001 base:

- Extension to controlled parking zone;
- West Edinburgh Busway (WEBS);
- Straiton-Leith Quality Bus Corridor;
- Newcraighall station;
- Edinburgh Park station; and
- Update of bus network to reflect the Spring 2003 network.

### A.3.3 Model PT demand

The public transport demand within the LUTI model is based on CSTM3 data and given its age and lineage, a review was undertaken to establish the robustness of the current public transport demands being forecast by the model. This involved a comprehensive programme of bus passenger counts in all three of the Edinburgh Tram corridors and comparison with the Base Year model forecasts. Whilst there was variability across all the count sites and corridors, the Line 1 study area had a systematic under forecasting of bus demand.

On this basis, the Line 1 results presented here and the associated economic and financial analysis has assumed a 10% uplift to all public transport demand, revenue and benefits.

### A.3.4 Annualisation

Annualisation factors have been derived from detailed analysis of the Scottish Household Survey Travel Diary data, which gives a breakdown of volume of travel by time of day and mode. This is combined with assumptions concerning the treatment of evening and weekend 'benefits' ie how we use the modelled 12 hour time period information to inform 'benefits' out-with this time period, ie weekends and evenings in particular.

For PT, demand and benefits to users are assumed to be proportional to the service patterns of the tram. So evening benefits are a function of the evening frequency versus the daytime frequency etc. Benefits are assumed for all the time which the service is running.

For highway demand, factors were derived from actual demand profiles derived from the household survey. For highway benefits, the assumption is that there are highway benefits / disbenefits on a Saturday equivalent pro-rata to a week day inter peak. No benefits / disbenefits are assumed for Sundays or any evening. In addition, public holidays are regarded as being a mix of Saturday and Sunday conditions.

The values, reflecting the service pattern assumptions for Line 1 and Line 2, are as shown in Table A.1.

**Table A.1 Annualisation factors**

Period	PT	Car - demand	Car - benefits
AM Peak	557	977	585
Inter Peak	2,425	2,635	2,288
PM Peak	563	1,115	656

### A.3.5 Line 1 Revenue Estimation

Revenue estimates for Line 1 utilise LRT demand and fare matrices from the respective model hours of the DAM model. These are then annualised and converted to net revenues as follows:

- Annualisation:
  - AM = 557
  - IP = 2425
  - PM = 563

- Ticket type allowance (this represents the difference between adult single fares (modelled) and average yield (through the use of travel cards, return tickets, etc). Analysis of ticket type data supplied by Lothian Buses has produced factors:
  - AM Peak = 0.92
  - IP and PM Peak periods = 0.87
- Fare evasion = 5%
- Opening year and appraisal period: 2009 for 30 years to 2038
- Revenue profile: to produce a 30 year profile, it is necessary to apply the average annual growth between 2011 and 2026 (the modelled forecast years). The existing revenues are assumed to remain constant beyond 2026. For the period between 2009 and 2011, a backwards extrapolation is applied, subject to appropriate ramp up of demand and revenue being applied (see below);
- Ramp up period: this represents the period between scheme opening and reaching steady state. It is assumed it lasts 3 years with the opening year (2009) experiencing 75% of steady state demand and revenue, 85% in year 2 (2010) in 95% in year 3 (2011);
- Generated trips: no additional allowance is made for generated trips beyond that estimated within TRAM. (However, this is based on changes in generalised cost and it is considered that this may be a conservative estimate of the potential for generated trips.)

#### A.4 Bibliography

CEC Land Use and Transport Interaction Model, Functional Specification, MVA, June 2002

CEC Land Use and Transport Interaction Model, Base Year Calibration and Validation Report, MVA, June 2002

#### A.5 Modelling technical papers

The following sections provide a summary of the Modelling and Appraisal Group (MAWG) technical papers produced by all the consultants involved in the modelling of Edinburgh Tram. The objective of this is to convey the level of detailed technical discussion and development that took place during the preparation of the STAG reports relating to the tramlines. The data records the extended periods of time and resources allocated to the model development, enhancement and refinement as well as recording the high level of technical discussion and experience that existed within the MAWG forum throughout this period.

Each consultant is dealt with in turn. For context, each was involved as follows:

- Steer Davies Gleave – Line 1 modelling and appraisal
- FaberMaunsell - Line 2 modelling and appraisal
- MVA – development of TRAM and DAM transport modelling tools
- David Simmonds Consultancy – development of DELTA land use model



### A.5.1 Steer Davies Gleave

Doc	Author	Date	Title	Context	Issue	Resolution
1	Steer Davies Gleave	18/10/2002	Interface between junction modelling, network modelling, operations and appraisal	To outline the Interface between junction modelling, network modelling, operations and appraisal. Sets out the relationship between the 4 factors, and their relevance to design or appraisal.		
2	Steer Davies Gleave	01/11/2002	Testing Programme	To specify an initial pair of tests, and to set out an indicative testing programme for the development and assessment of Line 1	Assumptions contained: for transfer penalties treat LRT as per rail; implement a penalty of bus over LRT of 15min in AM peak and 10min in interpeak (unclear about boarding penalties); LRT fare is 33% above bus	
3	Steer Davies Gleave	25/10/2002	Design Objectives and Principles	Technical note outlining different type of tram operations, requirements for passing places, turn-around facilities, depot location etc	none	
4	Steer Davies Gleave	20/01/2003	STAG 2 Appraisal Requirements	Sets out the requirements and process to complete STAG2 for Line 1		
5	Steer Davies Gleave	08/11/2002	Consultation	Sets out the consultees which SDG will lead with, and others that SDG would participate in. Also undertakes to conduct business surveys		

A-1

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6	Steer Davies Gleave	20/01/2003	Modelling and Appraisal - Draft v2	Sets out a proposed approach to issues of modelling and appraisal. Topics covered are: Do-Min specification; Networks; Model Parameters; Fares and Bus Networks; and Land Use Forecasts	Description about what will/won't be included in networks for testing. 2 issues raised under Model Parameters. 1) is lack of mode constraints under CSTM3 and 2) Parameter value for TRAM are different to Network values	1) use values from the OBC, namely 15min in AM peak and 10min Interpeak - a review can then be carried out to establish an agreed value 2) as a default assumption, use network model values for in-vehicle time and interchange penalties
7	Steer Davies Gleave	11/11/2002	Modelling Enhancements	Following Client Progress Meeting, TIE indicated a preference for a City wide model upgrading which would be suitable for appraising the three lines identified. This paper sets out the costs and timescales associated with such model enhancements	none	
8	Steer Davies Gleave	02/12/2002	Scheme Development, Consultation and STAG	notes that the Public Consultation has been deferred to June 03, impacting on proposed completion of STAG2 by 18 June. Discusses how options and sub-options can continue to be sifted so that a prompt turn-around can be achieved after Consultation.	none	
9	Steer Davies Gleave	18/12/2002	Stop Locations	Provides comments on Stop Locations identified in drawings issued on 19/11/02	None relating to modelling issues	
10	Steer Davies Gleave	04/02/2003	Modelling and Appraisal Working Group - Surveys	Sets out a scope and methodology for undertaking travel demand surveys to enable updating of the	None relating to modelling issues	



				LUTI model. It considers 3 main areas - public transport, highway and mode choice parameters		
11	Steer Davies Gleave	29/01/2003	STAG Planning Objectives v2	A consideration of CEC planning objectives which need to be considered in STAG appraisal, and relates them to LTP.	None relating to modelling issues	
12	Steer Davies Gleave	14/03/2003	Planning Assumptions	Sets out current planning assumptions, the forecast take up of space, and how these fit with the development plans of Waterfront Edinburgh and Forth Ports	Assumes Leith Docks = TRAM 40+41, Granton =TRAM 42+44 Take up of development space is variable, can 'force' model to uptake of space. Also, can model reflect 'quality' of development? JIFGRO uses CEC supplied data through CSTM3A, DELTA uses more recent data from Lothian Structure Plan. Differences between predicted populations, households and employment data between Base and 2016	If possible, revise JIFGRO to reflect changes forecast by DELTA, possibly selectively introduced to areas of major change. Might entail revision to waterfront areas only. As minimum, update JIFGRO data to reflect new Structure Plan and be consistent with DELTA inputs.
13	Steer Davies Gleave	07/04/2003	TUBA Economic Evaluation - DRAFT	Details the approach and parameters used for TEE appraisal for STAG2. TEE uses TUBA software, based on outputs from PT and highway DAM models, with higher level of functionality provided by TRAM/DELTA, with growth applied via JIFGRO	Assignment parameters set out, also economic inputs for TUBA, using defaults or recommending where more detailed, local data should be substituted. Initial year = 2009	
14	Steer Davies Gleave	14/05/2003	Initial Model Results	Initial modelling results indicate substantially reduced tram patronage in MVA AM peak compared to that reported in WP1	OBC and WP1 forecasts were broadly consistent, but current modelling shows peak period demand about half previously	OBC and WP1 modelling assumes full masterplan development at Leith and Granton, LUTI shows substantially lower growth, LUTI

				and the OBC - off peak is comparable Note sets out current and previous forecasts, and explores reasons for the decline.	stated, overall impact is 25% reduction in annual patronage. Although models used in OBC and WP1, and the LUTI model share same origins (CSTM3) the application differs in respect of background growth and planning assumptions, and mode constant.	also shows decline in background PT demand. Also, fewer trips are assigned to tram due to decision at MAWG to reflect modal preference through In-Vehicle Time at 1.1 for bus and 0.9 for tram. Use of DELTA is likely to continue to produce more conservative outturn land use patterns than aspirational Masterplan assumptions. MAWG to address Mode Preference issue
15	Steer Davies Gleave	27/05/2003	Fare Tests (Version 1) Draft for Comment	Baseline assumption that Line 1 fares would be 33% above bus. Using PT demand matrices from MVA with this assumption, and with tram=bus, two intermediate matrices produced, with tram=bus+10% and +20%	DAM PT model was run for these tests (with no other differences) to test patronage level, showing inverse relationship between fares and patronage (higher fares = lower patronage) Annual revenue also considered	Sensitivity testing only, no issues or resolutions
16	Steer Davies Gleave	09/06/2003	Revenue and operating cost risks	Identifies a register of principal tasks associated with operating costs and revenue for Line 1. Only the areas of risk have been identified, significance, timescale, responsibility and mitigation will be identified as scheme progresses	none	none
17	Steer Davies Gleave	09/06/2003	Operating Cost Reconciliation	Compares the operating costs prepared for STAG Appraisal and the previous figures used in OBC, and explains reasons for differences	Differences include - conductors on board vehicles, relatively pessimistic journey times, slight differences in operating frequencies and slightly different 'spare vehicle' assumptions. Also	Three quarters of difference in cost is due to inclusion of on-board conductors and pessimistic running times; other differences in assumptions have minor effect. Concludes that new estimate is

					OBC used flat rate of £3.00 per vehicle kilometre, new figures have more refined cost structures	compatible with OBC within the accuracy of the forecasts.
18	Steer Davies Gleave	13/06/2003	Model Updates	Sets out the revisions proposed for the assignment process to enable appraisal and analysis to be undertaken		
19	Steer Davies Gleave	17/06/2003	Design Freeze Assumptions	To set out the design freeze assumptions required to enable a final LUTI model run to feed into STAG2. In 2 stages, Stage 1 (TRAM/DELTA) to model at strategic level, Stage 2 (DAM) using Stage 1 matrices to provide detailed information on loadings, journey times etc	Areas of potential improvement are: decline in developed office space at Waterfront (review being undertaken, but material improvement not anticipated); Change in modelling approach to tram preference (substantial discussion at MAWG, values now fixed for STAG2) and Increase in running time due to junction delay (revised journey time by Babties producing loop time of 40.5 minutes, excluding layover).	Assumptions made for Stage 1 are: Princes Street and railway corridor (not Telford Road), stop locations as per consultation leaflet, fare = bus+33%, 8tph rather than 10tph, LUTI set at 1.1 and 1.0 for bus and rail, tram set at 0.9, planning data to be discussed with CEC officials, revisions to bus network set out in a table, and Babtie junction delay times (set out in Table) included in the run time model.
20	Steer Davies Gleave	18/06/2003	Issue to be resolved: Operational issues relating to closures on Princes Street	identifies 4 areas of concern relating to closures of Princes Street due to Special Events	1) Operation of tram with marches in adjacent streets, 2) Operation when Princes Street is completely closed, 3) Special risks from revellers while street is closed, and 4) other/general risks	1) Police crowd control, with operational marshals along the route, 2) Turn-arounds proposed at St Andrew's Square and Haymarket, 3) anti-vandalism measures, potential to isolate power supply, height of banners etc, 4) open top bus services need behaviour restraint, possibility of slip hazard when pedestrian levees very congested



21	Steer Davies Gleave	30/06/2003	Waterfront Planning Data Review v2	Sets out the expectations for development by 3 developers,	Lattice (all within TRAM zone 44 and DAM zone 134), Forth Ports (TRAM 40, 41 and 42, DAM 45,47,50 and 51), and Waterfront Edinburgh Ltd (TRAM 42, DAM 299 and 45 {to be confirmed}) Data prepared for LUTI model	Concludes that while overall development levels are comparable with previous work, office space has declined by 21%, residential increased by 31% and retail space has nearly doubled
22	Steer Davies Gleave	09/07/2003	Modelling Results and Issues	Sets out the results of sensitivity testing undertaken to support the development of Line 1, to be read in conjunction with the 'design freeze' above Current business case has operating costs of £6.1m, with revenues of £6.7m in 2010 and £9.6m in 2026	Tram fares show greatest degree of sensitivity	Tabular presentation of revenue and demand under different testing scenarios
23	Steer Davies Gleave	09/07/2003	Run Times: Changes to Baptic Input Assumptions	Run time model testing	3/7/03 run uses latest Babcie junction delays, which reduce total time from 46.4min to 43.0min. SDG make assumptions on where more tram priority is reasonably feasible, and achieve further reduction, from 43.1min to 40.5min	Summing the delay times shows just under 2 min of the 2.6min saving is due simply to reduced standing time, the remainder being due to reduced acceleration/deceleration delays
24	Steer Davies Gleave	15/07/2003	Modifications to Bus Network	Considers the effect on bus provision in the corridors served by tram, and to a lesser extent, in parallel corridors. Sets out a revised network of bus services and calculated the saving in vehicle miles and costs	How will bus operators react to tram?	Lothian Buses considered unlikely to launch head-on attack. First could introduce competition, but thought unlikely as it might re- ignite the bus-war. Tram likely to be operated by one of the local majors (Lothian, First, Stagecoach or Arriva), so outcome is difficult to predict. Overall likely to see



						structured reduction of Lothians services to reflect the abstraction of passengers to tram, and reduction of bus priority on Leith Walk
25	Steer Davies Gleave	15/07/2003	Mode Preference	This note reviews the use of tram IVT of 0.9 (see SDG 19)	Mode constant using 0.9 gives range between 2.1 and 4.6 minutes. Using 0.8 gives 2.9 to 6.6 minutes. The values derived are, sometimes, substantially less than values derived from SP surveys and employed elsewhere. SP results are not readily transferable. In addition there are mitigating reasons for being conservative. However Edinburgh's higher than average income may confer a higher preference for tram	IVT of 0.8 for Edinburgh tram is a reasonable assumption, given lack of local SP data. This should be collected as part of the general data refreshing of the LUTI model planned for Autumn 2003
26	Steer Davies Gleave	15/07/2003	Testing of 'Horseshoe Line One'	To consider sensitivity testing of a horseshoe Line One, with no service between Newhaven Road and Lower Granton Road. This was done using the Design Freeze preferred case for 2011, P22, but journey time for the 'missing' section coded as 10 hours to make it unattractive	In summary, this option would reduce annual revenue by £1m, reduce annual patronage by 1.2m, reduce initial construction costs by £25m and reduce annual operating costs by £60,000 pa	The decrease in revenue of £1m pa suggests the scheme would not cover its operating costs until well beyond 2011, making it unprofitable to any potential operator
27	Steer Davies Gleave	23/07/2003	Princes Street	To consider the desire for segregated running on Princes Street or for mixed running, given the demands for space	Observed bus journey times are around 2 minutes higher than modelled for Line 1. If mixed running, tram times will be longer,	Goes on to discuss operational interaction between bus and tram operations, but does not resolve the issue of segregated or mixed



					therefore 2 tests were undertaken to add 3 and 6 minutes respectively to tram running time. Adding 3 minutes reduces demand and revenue by 8%, adding 6 minutes reduces revenue and demand by 13%, operating costs increase, and an additional 2 vehicles are required	running on Princes Street
28	Steer Davies Gleave	31/07/2003	Operations Update	Sets out various updates to the input to operational assumptions, run times and operating costs to date, as a result of design and development work	Run Times - OBC 37.4min, Max Priority Assumption 33.6min, Full signal delays with no priority from Babtie 15/5/03 46.4min, Modified signal delays as supplied by Babtie 15/5/03 43.0min, as modified by SDG to reflect expected priority 40.5min	40.5min is basis of current evaluation
					Fare Collection Method - onboard conductors were not assumed in the OBC, but are included in all subsequent tests - as a measure of sensitivity of operating costs to the provision of conductors, tests have been carried out for at-stop machines	On-board conductors assumed
					Service Frequencies - OBC and initial tests used 10tph in each direction, more recent tests use 8tph as the peak frequency. It has been generally assumed that this frequency will operate in the Monday-Friday peak and	For operating cost estimation, time periods have been standardised, and Table 1 defines the time periods and the frequency assumed for each

	interpeak, and during Saturday shopping hours	
	Short Sections of Single or Interlaced Track - discusses the possibility of using sections of single track, with associated delays entering and leaving same, due to crossing turnouts. A test using the run time model has been carried out for 2 possible cases on an 80km/h section, where the effect would be greatest	Testing shows delays of 10 and 17 seconds respectively. Unlikely to have a significant effect on resources, but several occurrences could result in an extra tram being required in each direction. RevSigDel8 is particularly sensitive to small increases in run time, due to 'squeezing' of layover time.
	Operating Cost Model -	Loop route is now modelled as 2 separate services, clockwise and anticlockwise
	Operating Cost Model - differentiates between conductor operation and ATMs in terms of several variables	New version compared with old, and results are within 2.5%, well within the accuracy of the forecasts
	Operating Cost Results - details a series of Scenarios which have been tested, and the resulting operating costs and fleet size.	Current central case is RevSigDel8, with operating cost of £5.91m. Comparisons made between this and other scenarios
	Reconciliation with OBC Operating Costs - explains differences between RevSigDel8 and OBC, and tabulates incremental effects of changes since OBC	Current run time = 40.5min, was 37.4min; peak frequency = 8tph, not 10tph; now assumed conductors on board, rather than ATMs. Additionally current case uses more detailed model, whereas OBC used flat rate of £3.00 per vehicle kilometre.

29	Steer Davies Gleave	28/06/2003	Revenue Calculations	Summarises the methodology, assumptions and parameters used in the estimation of revenue totals for Line 1	Considers Annualisation, Generated Demand, Ramp-up Period, Fare Evasion and Ticket Type	Annualisation factors AM=557, OP=2335, PM=563. Generated demand = 15% of off-peak revenues. Ramp-up period lasts 3 years with opening year (2009) experiencing 75% of steady state demand and revenue, 85% in year 2 and 95% in year 3; Fare evasion - assumed 5% of revenues lost through fare evasion; Ticket type allowance - the difference between adult single fare (modelled) and average yield (travel cards, season tickets etc). Awaiting data from Lothian Buses, currently using 80%; Adjust price base - conversion of May 2001 to April 2003, using 1.5% per annum increase (as per Bus & Coach Stats 2001-02)
30	Steer Davies Gleave	30/07/2003	Review of DELTA Planning Forecasts	Reviews revision to planning assumptions and DELTA parameters, and aspirations of Waterfront developers (as set out in Note 21). Data received from MVA setting out DELTA floorspace forecasts - Reference Case and Development Case (only for Office - other sectors have single set of assumptions) Both scenarios show much increased rate of office development - Waterfront zones having	Why does zone 42 differ so much in take-up between the 2 scenarios, when both have exogenous input, and why does zone 44 not have any exogenous input under the Reference Case scenario (a 10,000sqm office is currently under construction Also notes residential permissions are fully utilised by 2006, however the total level of permissions by 2026 is 35% lower than previously. States key	Issues raised, not resolved in this paper

				<p>additional 136,782sqm and 308,743sqm of office in 2011 and 2026 under Reference Case, compared to 26,259sqm and 43,224sqm previously. In Development Case, growth is substantially higher at 217,057sqm and 454,782sqm. Development Case broadly matches aspirations of Waterfront developers, although skewed towards zone 40, to the detriment of the remainder.</p>	<p>issues as being 1) distribution of permissions, hence take-up, is sometimes materially different from the Waterfront data 2) some omissions of both exogenous and permissions inputs, 3) differences in the office space take-up in Zone 42 under the two scenarios, and 4) fundamentally, which of the two scenarios should be the central case for scheme development</p>	
31	Steer Davies Gleave	13/08/2003	Public Transport Trip Rates	<p>New PT Demand matrices received from MVA on 30th July. Reviewed to understand changes since last set of matrices were issued in April. Of particular interest is the demand from the Waterfront areas where LUTI model is forecasting materially increased office space but only marginal changes to PT demand matrices. Trip rates were produced at TRAM zone level for origins and destinations in the AM peak for 4 scenarios (new 2001, old 2011 (R10), new scenario 1 2011 (R1C) and new scenario 2 2011 (R1D))</p>	<p>Typically trip rates are in the region of 0.5, and overall seem sensible. Significant variation in trip rates between zones, with up to 6.5 origin trip rates in city centre. Biggest change appears as large increase in Origin PT trip rates in city centre, despite the fact that new matrices are based on lower resident populations. Significant variation in origin trips from Waterfront zones</p>	<p>Waterfront variations explained by a change of character of area due to regeneration, and old data. Generally new matrices show large increase in city centre as a trip generator, population forecasts for Waterfront area have been revised and are now significantly lower than before, and Granton destination trip rates are lower in 2011, with minimal changes from 2001 demand, considering the level of development taking place</p>
				<p>Using same procedure, trip rates for 2026 AM peak for Scenarios 1 and 2 were generated</p>	<p>Total trip rate for Edinburgh is again around 0.5, and PT shares are around 25%, as in 2011.</p>	<p>Overall the modelled origin trip rates seem reasonable, destination trips are underestimated</p>

				and 2 were generated	Overall population increases by 11% yet number of PT originating trips falls, PT share falls in both scenarios by up to 3% and trip rates and PT share both fall in the inner city zones while increasing slightly further out. Scenario 2 sees Zone 42 experience a doubling of jobs, but only producing 22 additional PT trips	trips are underestimated
32	Steer Davies Gleave	13/08/2003	Forth Ports Alternative Route - Draft for Comment	Considers the merits in revising Preferred Alignment to serve Forth Ports development of Western Harbour area	Proposal increases route length by 250m, adds one new stop. Additional run time = 42 seconds, with 10 sec dwell time at stop. This is taken as a reduction in layover time, therefore no change in operating costs, but operating plan is weakened in robustness. Additional capital cost = £2.5m No explicit model run undertaken to evaluate Reduced through demand of 0.06m in 2011 (=£0.06m in revenue)	None - Draft for Comment
33	Steer Davies Gleave	22/08/2003	Yield Calculations v2	So far, a factor of 0.8 has been used to estimate the average yield (use of season tickets etc).	Lothian Buses has produced data on ticket range by time of day and ticket type	Line 1 will use yield factor of 0.92 for AM modelled period and 0.87 for OP and PM modelled periods (post dates Faber Maunsel Note 14)
34	Steer Davies Gleave	20/08/2003	Updated operating costs	Sets out the impacts on operating costs of adopting a consistent set of assumptions between Lines 1 and 2.	Comparisons between SDG original position, and Semaly proposal for 1)Management, Finance and Admin staff,	SDG to adopt Semaly approach for Insurance and Policing as a service-km run based on annual vehicle kilometres. Compromise

					2)Operations Staff, 3) Maintenance and Engineering Staff, and 4) Insurance and Policing	position set out for other categories, but no agreement at this stage
35	Steer Davies Gleave	03/09/2003	Operating Costs and Revenue Forecasts	Provides latest operating cost and revenue estimates for the Business Case as required by Grant Thornton. Supercedes all previous estimates	Operating Costs - best estimate on current information. Revenue - NOT final estimates, based on latest demand data but using earlier modelling information	Operating costs - Assumptions and parameter values have been generally agreed with Semaly/Faber Maunsell, but assumes marginally higher levels of staffing, therefore slight inconsistency with Line 2. Revenue - still need to run latest demand data provided 29th Aug through the latest network modelling information.
36	Steer Davies Gleave	01/09/2003	Revenue Calculations	Note 29 set out the Line 1 revenue estimation process. Following discussions with MAWG and Faber Maunsel this note sets out an agreed approach for the consistent estimation of tram revenue		Annualisation factors AM=557, IP=2425, PM=563. Ticket Type Allowance AM=0.92, IP and PM = 0.87 Fare Evasion = 5% of revenues lost due to fare evasion. Opening Year and Appraisal Period 2009 for 30 years to 2038 Revenue Growth - to produce a 30 year profile, necessary to apply average annual growth between 2011 and 2026, the modelled years, assumed to remain constant after 2026, and backward extrapolation to 2009-2011 Ramp-up period 2009=75%, 2010=85% adn 2011=95% steady state demand and revenue for Business Case, fare price base



						converted from May 2001 to April 2003 using 1.5% per annum. Line 1 previously applied 15% uplift to IP demand and revenue to reflect generated demand, this is no longer applied due to LUTI model outputs
37	Steer Davies Gleave	12/09/2003	Sensitivity Testing	Sets out the proposed model sensitivity tests for Line 1. Purpose is to assess the sensitivity of the Central Case results at three levels 1) forecasting assumptions, 2) Robustness of overall case and 3) Regeneration.	Key issue is the appropriate level for the tests, given the hierarchic nature of LUTI model, with the TRAM/DELTA strategic tool providing mode split, distribution and other functionality and deriving matrices for the DAM model	Where a test is unlikely to have material impacts at the strategic level (notably mode split) the use of DAM assignment model will be employed. Table shows proposed level of testing, with 5 LUTI runs proposed, and two DAM only runs

**A.5.2 Faber Maunsell**

Doc	Author	Date	Title	Context	Issue	Resolution
1	Faber Maunsell	22/01/2003	Edinburgh Tram Modelling v1.2	To assist MAWG to develop a consistent approach to deriving tram demand for Line 1 and Line 2 (for discussion, not prescriptive)	Model Enhancements - size of CSTM Zones, age of public transport service definitions and age of demand data	Disaggregation of tram catchment area zones to enumeration districts with catchment area network enhancements. Full survey programme proposed, although not in time for STAG appraisal
					Mode Choice methodology - SDG raised issue of a mode choice model to operate between LUTI and the detailed model. FM consider inappropriate to carry out mode choice by assignment	No mode constants in TRAM, future year LUTI output aggregated to single total travel market matrix, mode choice model developed between LUTI and detailed models
					Modelling fare regimes - difficult to model. 3 types Distance based, Zonal, and Fare Stages	If bus service definitions are not updated, distance based should be used, updated to current fares - if updated, should introduce Stage-based regime to provide a proxy for Zonal regime for tram lines
					Overall modelling methodology - notes previous discussion about consistent approach between the 2 Lines	9 point bulleted list of additional steps to be taken
					Bus Operator Competition - agrees with SDG interpretation of 3 potential responses - Competition, Complementary, and Neutral	Not appropriate to update the modelled public transport service definitions in either the do-minimum or do-something models. Standard practice to maintain current bus routes unchanged and run sensitivity tests to assess the effect of competitive reaction.
2	Faber	03/02/2003	Tram Fares	A review of single cash fare and	Notes difficulties in making	Broad pattern of around 25-40%

	Maunsell			weekly pass single fare equivalent from other tram systems in UK	comparisons due to wide range of ticket types etc	for premium fares. Accepts SDG assumption of 33% premium on Line 1 fares, to be reviewed later during sensitivity testing.
3	Faber Maunsell	12/03/2003	Demand and Revenue Forecasting	A paper to set out the modelling requirements, and to identify the appropriate level of detail required at each stage of the process, namely Development of Policies and Strategies, Scheme Design and Appraisal, and Procurement of Funding	The more detailed the model, the more rigorous the level of detail and data is required, and an appropriate balance between market segmentation and spatial disaggregation is found. Notes LUTI has high market segmentation but low spatial disaggregation	Mode Choice (at both main and sub levels) should be dealt with using mode choice models, and not by LUTI (main mode) or by assignment in the PT network model (sub)
4	Faber Maunsell	10/04/2003	Airport Demand	Considers how data from heavy rail studies to Edinburgh (and Glasgow) Airport can best be used to inform the Edinburgh Line 2 Study SKM data regarding airport employment and demand data, both historical and forecast (believed better than that used in DELTA and CSTM, and patronage forecasts for heavy and light rail	How to best use the SKM data in the LUTI and CSTM models (a long term objective), and considers 5 more pragmatic approaches to incorporate SKM data into PT Detailed Assignment Model (PT DAM)	Recommends using SKM forecasts, including heavy rail, to replace airport trips in the PT DAM model. All three matrices are combined and PT DAM used to assign between bus, tram and train.
5	Faber Maunsell	06/05/2003	Interim Patronage and Revenue Forecasts	Report, detailing all work undertaken to date, and is still 'work in progress'. Introduces the Line 2 Route, sets out Modelling Assumptions, identifies Changes to the Model, reports Model Runs and Model Results (annual patronage and annual revenue), considers Newbridge Spur and Airport Heavy Rail, undertakes Sensitivity Tests and Comparisons with other UK LRT schemes	This is a full report	Assignment parameters used: Tram fare = 1.33x urban Bus fare, walk time weight = 1.6. Wait time weight = 1.8, Bus ride time weight = 1.1, Rail ride time = 1.0, Interchange penalty = 10min. Urban Bus Fares 2001 Lothian Buses (50p up to 800m ride, 80p up to 7km ride and 90p up to 15km ride
6	Faber	07/05/2003	Model Changes	Memo to summarise changes	No changes made to LUTI model	LUTI model should represent the



	Maunsell			made to the models for use with the Line 2 Study		particular scenario under test. TRAM should be coded to provide the equivalent to the TRIPS scenario coding
					Changes incorporated into the FaberMaunsell and SDG DAM models	Changes presented in tabular form, with assessment of scale of impact
					Changes incorporated into the FaberMaunsell PT DAM model	Changes presented in tabular form, with assessment of scale of impact
					Changes yet to be incorporated into the DAM models	Changes presented in tabular form, with assessment of scale of impact
					Changes to be considered for incorporation into the DAM models	Changes presented in tabular form, with reason for consideration
					Proposed changes to the production of demand for the DAM models	Changes presented in tabular form, with assessment of scale of impact
7	Faber Maunsell	15/05/2003	Employment and Trip Growth	To consider known developments along Line 2 corridor, and compare them with current LUTI model values	LUTI zones are large, and some contain several developments. Those examined are LUTI 46, 52 and 53. Then considers the LUTI growth to produce growth for PT DAM model, which has smaller zones. Growth in highway and PT trips to some areas are very low, and trips to one zone appear to be at the expense of its neighbour	LUTI has problem in predicting these developemnts because they are not the result of organic growth, and require adding as exogenous growth
8	Faber Maunsell	15/05/2003	Model Changes - Update	An update of doc 6 (above)	None of doc 6 changes have been implemented as yet, some more changes have been added to the list as a result of problems found on the Line 2 and Network Effects work. Additionally one change to LUTI model has been noted	As per doc 6, all changes presented in tabular form, with assessment of scale of impact or reason for consideration

9	Faber Maunsell	30/05/2003	Line 2 Matrix of Runtimes (minutes)	A matrix showing run times between stops on Line 2		
10	Faber Maunsell	04/06/2003	Line 2 Sensitivity Tests	A request to MVA to produce models and demand for a series of sensitivity tests, with necessary coding instructions	Asks if Congestion charging has been tested in LUTI and DAM, and if there is some accepted coding for that. Requests adjustment of wait time on Competitive Bus by specific formula	
11	Faber Maunsell	18/06/2003	Airport Growth	This note compares demand matrices used by SKM for the 'Rail Links to Glasgow and Edinburgh Airport Rail Study' and the Detailed Assignment Model (DAM) matrices produced by MVA	SKM data was coded in CSTM zones, with no easy way to convert to DAM zones	Time consuming derivation and where necessary, aggregation undertaken
					Direct comparisons between DAM matrices and SKM matrices is not simple. SKM are daily or annual, while DAM are hourly periods	Attempts at factoring and interpolating show there is not much similarity between the matrices
					DAM model shows inclusion of Line 2 to Airport reduces the number of trips to/from the Airport, while PT modeshare remains constant	May be a LUTI model effect or the result of disaggregation of LUTI zones to DAM zones
					SKM survey matrix is over 5 times larger than 2001 DAM matrix. Do-minimum SKM forecasts has almost 9 times more PT trips than the 2011 DAM	DAM matrices use Scottish Household Survey Travel Diary annualisation factors, which may not be representative of trips to/from an airport
					According to SKM, adding a rail and a tram link leads to 70% increase in PT trips, adding Line 2 to DAM produces little or no effect	MVA to examine
12	Faber	24/06/2003	Comparison of	Babtie conducted bus occupancy	Line 1 (summary examination)	Overall, some large discrepancies

	Maunsell		Model with Bus Surveys	surveys for all 3 lines in May 2003. These have been compared to the latest version of the model provided by MVA	number of buses passing through screenline is of the right order, flows of passengers are low, except for AM peak, which is high	found which need further investigation. Noted that it is difficult to constantly update changes to bus network. There appears to be scope to improve calibration. Suggests matrix estimation could be applied
					Line 2 Dalry Screenline has significantly more buses inbound than observed, outbound of the right order	
					Line 2 Ring Road screenline all bus flows are low except Calder Road outbound in the peaks	
					Line 3 data tabulated but no commentary	
13	Faber Maunsell	03/07/2003	Tram Framework Report Forecasts	Line 2 forecasts under development note that patronage forecasts are low when compared to Final Tram Framework Report (FTF) (16/1/03). The difference between revenue forecasts is even greater	FTF concludes that average tram fare is 42% higher than maximum bus fare (£1) yet also reports that tram fares are assumed to be the same as bus fares. Bus fares quoted in FTF are similar to 2003 Lothian Buses fares. Error arises in Modelling of Fares, with assumption of 50p+10p/km, meaning modelled fare is generally higher than actual fare. Serious errors arise when this fares function is used to calculate revenue	FTF fare representation is less inaccurate for shorter ride lengths, so Lines 1 and 3 are less affected, however only Line 1 covers its own operating costs. Neither FTF or current work has considered the issue of return fares, fare evasion or travel passes, so reference valuse are an overestimate.
14	Faber Maunsell	14/08/2003	Patronage and Revenue Assumptions.	To compare issues resulting from separate notes from Line 1 and Line 2	Annualisation factors	M&AWG agreed on compromise between 1 and 2, and all work to use same values AM=557, OP=2450, PM=563 (Line 1 had used OP=2335)
					Off Peak generated revenue	M&AWG didn't discuss. Line 1 used 15% added to off-peak for