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1. INTRODUCTION

Over the last decade the concept of integrated transport strategies for urban areas and a means of evaluating them have been developed and widely accepted into practice by major studies of cities such as London (May and Gardner, 1990), Birmingham (Wenban-Smith et al, 1990) and Edinburgh (May, Roberts and Mason, 1992). The development of integrated transport strategies (May, 1991) has been based on the identification of synergy between transport policy instruments (May and Roberts, 1995). These concepts led indirectly, particularly through experience in Birmingham, to the introduction by the Department of Transport of the Package Approach for urban transport funding (May, 1994a) and more directly to the development of the Common Appraisal Framework for assessing Package Approach bids (MVA et al, 1994). It is now generally accepted that transport strategies designed to meet the objectives of economic efficiency and sustainability will require a combination of measures to manage the existing infrastructure more effectively, to provide selective enhancements to that infrastructure and to impose appropriate pricing mechanisms on both public and private transport. In a recent study, funded by EPSRC, we have developed a methodology for identifying optimal specifications for such strategies, and have shown that their performance is particularly sensitive to the contribution of pricing measures such as fares and road pricing (May, Bonsall, Bristow and Fowkes, 1995).

However, while we are now able to formulate optimal transport strategies, very few studies have been able to demonstrate that transport policy measures alone will achieve a sustainable situation in which fuel consumption and emissions are maintained at or below current levels (May and Roberts, 1995). In most cases, land use changes will need to be co-ordinated with transport measures if sustainability is to be achieved, and recommendations for appropriate land use measures are beginning to emerge (DoE, DoT, 1993; DoE, 1994). An initial assessment of the potential for co-ordinating transport and land use strategies was carried out using the results of the Edinburgh study (Still, 1992), and showed that the preferred transport strategy would be up to 10% more effective in achieving sustainability when combined with a concentrated land use strategy. However, that study assumed no feedback from transport measures to land use effects. Literature reviews and interviews have demonstrated that the impact of transport on land use is perceived as a serious gap in policy understanding. Interviews also revealed that land use-transport models are treated with some scepticism, because there is insufficient understanding of the relationships within them and because the existing models are perceived as unduly complex (Still, 1996).

As a result of this lack of understanding, there is a danger that impacts of transport on land use might have counter-productive effects on the land use - transport strategy. For example, road pricing, which may be a key element in a sustainable transport strategy (May, 1994b), may reduce accessibility by private car, and hence lead to outmigration of business, thus producing a less sustainable land use pattern. Conversely it could enhance the city centre environment, and hence encourage certain firms to relocate to the centre. These twin impacts of transport policy on accessibility and on environmental quality are the key elements in predicting the resulting location decisions of individuals and firms, and need to be better understood if sustainable land use - transport strategies are to be developed.

The principal objectives of the project are :

(i) to increase our understanding of the impact of accessibility and environmental quality on individuals' and firms' location decisions;

(ii) to use the findings of (i) to enhance a newly developed strategic transport and land use interaction model;

(iii) to use the enhanced model to assess the implications for urban sustainability of the impact of transport policy on location choice;

(iv) to use the enhanced model to assess the relative performance of different combinations of transport and land use strategy.

The research is divided into six tasks :-

1) Literature review
2) Integration of START and DELTA and initial matrix of tests
3) Edinburgh household survey and analysis
4) Edinburgh business survey and analysis
5) Incorporate estimated coefficients from tasks 3 and 4 into START-DELTA and carry out a range of tests
6) Dissemination and final report

This report describes work completed on Task 2; a companion paper (Wardman et al, 1997) describes work on Tasks 3 and 4. Previous work had been carried out for a study area consisting of Edinburgh, East and West Lothian, and Southern Fife using the strategic planning model START, developed by The MVA Consultancy (Roberts et al, 1995). START assumes a fixed land use in a future year and predicts the transport effects of different strategies for this future year. This fixed land use approach provides a base for comparison with the dynamic land use model developed in this study. The main modelling development underlying the project has been to integrate the current START model of Edinburgh and Lothian with the dynamic land use model DELTA, developed by the David Simmonds Consultancy (Simmonds, 1997). DELTA is a dynamic land use model incorporating sub-models of development, employment, location, transitions and area quality. The location response has been enhanced to include responses to changes in the transport system via changes in accessibility and transport-related environmental output calculated by START. This integration was carried out by The MVA Consultancy and The David Simmonds Consultancy. The models are run sequentially in ten two year periods effectively creating a varying land use scenario in which land use location responds to the transport strategy through reaction to changes in accessibility and transport-related environmental conditions.

This paper is concerned with the results of the initial matrix of test strategies applied in the second task using the integrated START-DELTA model. The aim of the paper is to describe the performance of a range of transport and land use strategies for Edinburgh, based on first estimates of a set of relationships, for different types of household and business, between location choice and attributes of accessibility and environmental quality. The results will provide a base for assessing the outputs produced for the same strategies simulated with updated estimates of the response relationships being developed from the analysis of stated preference work in tasks 3 and 4 above (Wardman et al (1997)).

Section 2 introduces the coefficients of accessibility and transport related environmental quality and the response scenarios tested. Section 3 describes the seven transport strategies to which these scenarios were applied. Section 4 presents the results in terms of transport and land use indicators for the horizon year, 2011. Section 5 gives a summary and describes future work.

2. COEFFICIENTS OF ACCESSIBILITY AND TRANSPORT-RELATED ENVIRONMENTAL QUALITY

The land use model DELTA contains a location sub-model which locates and relocates households by maximising their utility of location. The model responds to changes in utility of location and to the amount of space available. The change in utility of location is defined as follows :-

$$\Delta V_{ti}^{h} = \theta^{hU}(U_{ti}^{h} - U_{(t-l)i}^{h}) + \theta^{hA}(A_{ti}^{h} - A_{(t-l)i}^{h}) + \theta^{hQ}(Q_{ti}^{h} - Q_{(t-l)i}^{h}) + \theta^{hR}(R_{ti}^{h} - R_{(t-l)i}^{h})$$

where

V_{ti}^{h} = utility of location for households of type h locating in zone i at time t

U_{ti}^{h} = utility of consumption for households of type h locating in zone i at time t

A_{ti}^{h} = accessibility of zone i for households of type h at time t

Q_{ti}^{h} = quality of housing areas for households of type h in zone i at time t

R_{ti}^{h} = transport-related environmental quality as perceived by households of type h in zone i at time t

l = time lag (number of modelled periods) - can vary between variables and between household types

θ^{hU} = coefficient of response to change in utility of consumption for households of type h

θ^{hA} = coefficient of response to change in accessibility for households of type h

θ^{hQ} = coefficient of response to change in area quality for households of type h

θ^{hR} = coefficient of response to change in transport-related environmental quality for households of type h

Note that U is a utility value of consumption and describes the utility-maximising mixture of floorspace occupied and other goods and services consumed, conditional upon locating in zone i, given the household's income and prevailing rent. This rent is itself a function of the demand for housing during the period in question, and thus completes a feedback loop such that households can influence one another through the property market.

This paper is concerned with the effects of changes in the coefficients of accessibility θ^{hA} and of transport-related environmental quality θ^{hR}. For the initial matrix of tests these coefficients are varied as follows :-

Response 0 : both accessibility and transport related environment coefficients set to zero giving no transport related response in the land use location model i.e. $\theta^{hR} = \theta^{hA} = 0$.

Response 1 : best estimates of all the coefficients from the literature review conducted in task 1 : at present $\theta^{hR} = \theta^{hQ}$ which is set so that a 1% change in area quality should result in a 1% change in rent for that area; $\theta^{hA} = -0.001n$ where n is related to the size and income of household type h.

Response 2 : twice the coefficients used in response 1.

Response 3 : the same as response 1 for the accessibility coefficient but with zero response to the transport related environmental indicators i.e. $\theta^{hR} = 0$.

Response 4 : the same as response 1 for the transport related environmental indicators but with zero response to the accessibility coefficient i.e. $\theta^{hA} = 0$.

Task five will report the results for response 5 which will be coefficients derived from the stated preference surveys conducted in tasks 3 and 4.

3. Strategy Tests

Seven basic transport strategies were tested in task 2 with three levels of location response to accessibilities and environmental indicators in five combinations described above.

The seven strategies were based upon:-

- do-minimum (described below);
- do-minimum plus Light Rapid Transit (LRT), involving two lines North-South and East-West with a high frequency of 30 trains per hour;
- do-minimum plus two way road pricing cordon around the city centre with a charge of £1.50 per crossing in either direction;
- do-minimum plus a reduction in bus fares of 50%;
- do-minimum plus LRT and road pricing as above;
- do-minimum plus bus fare reduction and road pricing;
- do-minimum plus LRT, bus fare reduction and road pricing.

The do-minimum strategy has the following features: SCOOT traffic control, M8 extension, increases in city centre parking charges, switch from private to more public parking spaces, greenways on major radials (corridors with significant bus priority and traffic calming), fare inflation of 1.29 over 20 years, and earnings index 1.8 over 20 years.

3.1 Other assumptions

Zero change in toll on the Forth Road Bridge for all periods i.e. toll increases with earnings index

Operator sensitivity set to zero as justified in note SPS6

Linear growth factors assumed.

3.2 Land Use Scenario

The land use model inputs and scenario used is described in detail Simmonds (1997). Essentially the elements of the land use scenario can be summarised as follows :-

(i) The rates of in and out migration and rates of employment change by sector.
(ii) The rates of change of people's income over the forecast period.
(iii) The amount of floor space under construction for the base period 1991, for each floorspace type.
(iv) The supply of floorspace, i.e. the amount of planning consents granted.
(v) The land use policies of granting consents over time.

4. Presentation of Results

4.1 Format of Presentation

Each run produces output for ten separate years over a 20 year period. For a global comparison of results it is not wise to view the results in too much detail. The first analysis concentrates on a set of final year (2011) indicators for transport-related variables and for land-use related variables. The transport related indicators were chosen as total trips further split by car, bus and LRT; total trip-km again split by car, bus and LRT and fuel consumption by cars. The land use indicators were chosen as housing rents, population, households, resident workers and floorspace (office and other) all of which were reported for the centre of Edinburgh and the centre plus the rest of Edinburgh.

Table 1 gives a summary of the codes used for the response levels 0-4. Tables 2-20 consist of six columns per strategy, each table shows the changes in 2011 output compared to the do-minimum strategy with response level 0 i.e. no response to accessibility and the environment. The top left cell (do-min 0) contains the absolute value of the measure whilst the other cells show the percentage change from that value for each strategy for the following responses/effects : -

1. the zero response R0, i.e. no response to accessibility or environment, which enables a direct comparison of the strategy effects which are by definition zero in tables 7 and 8;
2. the effect of introducing the accessibility response, labelled A: Access (response 3 - response 0);
3. the effect of introducing the environmental response, labelled B: Env (response 4 - response 0);
4. these two responses added together (A+B) (labelled Test);
5. the true effect of combining the accessibility and environmental responses, labelled combined (response 1 - response 0);
6. and the effect of doubling responses (response 2 - response 0) labelled Double.

These last three columns are used to determine:
(a) is the system additive? i.e. does Combined = Test ?
(b) is the system linear? i.e. does Double = 2*Combined ?

4.2 Comparison Of Transport Indicators

Table 2 : Total Trips
The different transport strategies have very little impact on trip making; the greatest change is a 1.4% reduction with road pricing. With only the accessibility response included, there is a reduction of around 1% with those strategies which exclude light rail, and an increase of around 2% to 3% with those which include light rail. Only the light rail responses differ from that for the do-minimum. This could be the effect of additional infrastructure providing extra capacity and encouraging relocation, which in turn allows more trips to be made. Alternatively it could result from in-migration to central zones due to increases in accessibility where implicit trip rates are higher. With only the environmental response included there are small reductions (of up to 0.6%) for all strategies. The results are broadly additive. For most strategies the combined effect of the accessibility and environmental responses is reasonably linear. However, for strategies including light rail a doubling in response more than doubles the increase in trips. This is presumably a reinforcement of the effect hypothesised above.

Table 3 : Car trips
While the strategies have little effect on overall trips they do, as expected, change modal shares. Road pricing achieves a 10.5% reduction in car trips, fare reduction 3.2% and light rail 2.1%, and these effects are broadly cumulative in combined strategies. By contrast, the effects of adding accessibility response are small; a reduction of around 1% for those strategies which exclude light rail, and an increase of under 1% for those which include light rail. The latter response is counter intuitive, but too small to merit further consideration. The effects of adding environmental response are also small, with reductions of under 1% for all strategies. The results are additive except for road pricing, where the combined effect is around 80% of the sum of the two effects, and light rail, where the effects are small and of different sign. The effects

are non linear for those strategies which include light rail, and in the case of the combined strategy change sign when the response is doubled; this appears to occur because the accessibility and environment effects of light rail are of opposite sign. However, all effects are small in percentage terms.

Table 4 : Bus trips
The strategies also have large effects on bus trips (from response 0), with road pricing achieving a 15.7% increase, fare reduction an 11.2% increase, and light rail a 23.2% reduction. As with the impact on car trips, these effects are broadly cumulative in combined strategies; with the exception of the total combined strategy which has a greater than expected increase. The effects of adding the accessibility response are to reduce the impact of the strategies, by 1.4% for road pricing, 2.2% for fare reduction and 3.0% (implying here a smaller reduction) for light rail. These effects are not cumulative for pairs of strategies, but they are for all three combined. The effects of adding the environmental response are in all but one case a reduction of under 1% in bus trips. The one exception is the road pricing strategy, where there is a 0.2% increase. This effect is probably due to the improved environment in the city centre caused by road pricing which then attracts more people to the centre which has a higher level of bus service. The two effects are broadly additive, except for road pricing, where the combined effect is twice as great, and for the combined strategy, where it is of opposite sign. While the effect of including both responses is linear as response is increased for some strategies, it is more than linear for responses to road pricing alone, and to all strategies involving light rail. With the combined strategy doubling the response more than quadruples the increase in bus trips.

Table 5 : Light Rail trips
The effects of the strategies on LRT trips are as expected; their numbers are higher with road pricing and lower when bus fares are reduced. In all cases the effect of including the accessibility response is to increase light rail trips by 10% or more. This suggests that activities are relocating to benefit from the high level of accessibility provided by light rail. In contrast the effects of adding the environmental response are very small. These effects are broadly additive, except for the combined strategy, where the combined effect is only just over half the sum of the elements. Doubling the response produces a broadly linear effect for all of the strategies.

Table 6 : Total trip-km
The effects of the strategies on trip-km are, as with those on trips, small. For light rail and fare reduction the effects on trip-km are virtually identical to those on trips; for road pricing trip-km fall by less than trips, suggesting a small increase in trip-length. This effect is reflected also in the combined strategies, all of which include road pricing. Introduction of the accessibility response has a lower impact on trip-km than on trips, implying a small increase in trip-length with road pricing and fares reduction, and small reduction with light rail. Introduction of the environmental response has an effect virtually identical to the (small) impact on trips. With the exceptions of the LRT and combined strategy the effect of doubling the response is roughly to double the impact.

Table 7 : Car trip-km

In all cases the strategies reduce car-trip-km by less than car-trips, thus resulting in an increase in trip length. Once again the effects are broadly additive. The effects of introducing both the accessibility and environmental responses are small, but of similar magnitude to those on car trips. In some cases those for accessibility are of opposite sign from those for car trips, suggesting small changes in trip length. In the cases of road pricing with or without a fare reduction, the effects of doubling the response are much less than linear. When responses are introduced the strategies show no evidence of being cumulative.

Table 8 : Bus trip-km

The strategies have very different impacts on bus-trip-km from those on bus trips. Light rail reduces bus-trip-km by less than bus trips, while road pricing increases them more; both imply an increase in trip length. A fare reduction increases bus-trip-km by double the amount that it increases bus trips, thus substantially increasing trip length. Once again these effects are broadly cumulative in the combined strategies. Introducing the accessibility response has similar increases in bus-km and in bus trips for strategies involving light rail, but with road pricing and fare reductions the effects on bus-km are lower than on bus trips. As with bus trips the effect with the combined strategy is surprisingly small. The effects of introducing the environmental response are similar on bus-km and bus trips. While the effect of including both responses is linear as response is increased for some strategies, it is more than linear for responses to road pricing alone, and to all strategies involving light rail. With the combined strategy the sum of the accessibility and environment responses is of opposite sign to the combined response and doubling the response more than quadruples the increase in bus trips compared to response 1. Again it would be useful to investigate the reasons for this.

Table 9 : Light Rail trip-km

The effects of strategies and responses are very similar to those for light rail trips, and the comments on Table 5 apply here also.

Table 10 : Fuel consumption - cars

The effect of the strategies is to reduce fuel consumption by cars, with road pricing being most effective, producing a 7.4% decrease. The effects are broadly additive when strategies are combined. The effect of introducing the accessibility response is to further decrease fuel consumption marginally for all strategies which exclude light rail; for those which include light rail the fuel consumed increases, which is in line with the pattern produced for car trips, though the increase in car trips is generally less than 1%. The effect of introducing the environmental response is of similar scale to that of accessibility providing a further reduction in fuel consumed. With the exception of road pricing and the combined strategy, the effects are broadly additive. The effect of doubling the response is broadly linear, though light rail alone and the combined strategy are more than linear and road pricing alone is less than linear.

4.2 Comparison of Land Use Indicators

First of all the response 0 is for an effective fixed demand i.e. the land use output does not change with a change in strategy hence all land use indicators are the same as for the do-minimum response 0 and there is no strategy effect for this column.

The indicators presented are shown for the Centre of Edinburgh (zones 1,2 and 12) and the Centre plus the Rest of Edinburgh (zones 1-14,16 and 21). The Rest of Edinburgh figures alone can be a little mis-leading as changes in these figures can imply in or out-migration. For example the road pricing results showed an out-migration from the city centre compared to the do-minimum but with a smaller decrease in population in the rest of Edinburgh compared to the do-minimum. Obviously there are more people relocating in the rest of Edinburgh from the city centre with road pricing than without road pricing. The following analysis therefore takes the city centre results and the city centre plus the rest of Edinburgh.

Table 11 : Housing rents in the city centre
Introducing the accessibility response causes rents to decrease by 2.1% in the do-minimum scenario, 4.2% with road pricing alone and 1.5% with a fare reduction. However, those strategies which include LRT result in increases in rents of 12.5% for LRT alone to 13.7% for combined strategies. There is no evidence to suggest that the strategies are cumulative, in fact combined strategies including LRT have larger increases in rents when a lower figure than for LRT alone might have been expected. In general the effect of response to environment is to increase rents by a further small percentage apart from those strategies which include road pricing where the increase is around 2.5% which is in contrast to the response to accessibility where rents are decreased. All the above changes are tied closely to the changes in population in the centre.

The two coefficients are additive in that the test A+B=R1-R0 is met for all strategies. The effect of doubling the response is linear for all strategies apart from those which include LRT where the response is more than linear. With LRT alone, response level 2, the rent increase is 36% or the equivalent of £140 per month per 100m^2 of property. Larger increases can be seen for combined strategies.

Table 12 : Housing rents in the city centre plus the rest of Edinburgh
Once again introducing the accessibility response causes rents to decrease in the centre plus the rest of Edinburgh by 2.8% in the do-minimum scenario, 3.3% with road pricing alone and 2.5% with a fare reduction. However, those strategies which include LRT result in increases in rents of 3.3%. There is no evidence to suggest that the strategies are cumulative. The effect of the environment is to increase rents by less than 1% for most strategies except for the do-minimum, LRT and fare reduction alone which result in small rent decreases. The effects are broadly linear with the exception of strategies which include LRT as an element which are more than linear.

Table 13 : Population in the city centre
Introducing the accessibility response causes population in the city centre to decrease by 3.8% in the do-minimum scenario, 7.9% with road pricing alone and 2.9% with a fare reduction. However, those strategies which include LRT increase population by more than 20%. There is no evidence to suggest that the strategies are cumulative, in fact combined strategies including LRT have larger increases in population when a lower figure than for LRT alone might have been expected. The effect of introducing response to the environment is very small (practically zero) for strategies which do not include road pricing. Those which do include road pricing increase population by 2.5%. This suggests that road pricing is the only strategy which can significantly improve the environment in the city centre. The effects are broadly linear with the exception of strategies which include LRT as an element which are more than linear. With LRT alone and response level 2 the population rises by 63.5%, an increase of 26000, even larger increases can be seen for the combined strategies.

As mentioned earlier the road pricing cordon causes a population shift out from the city centre; it is interesting then that the combined road pricing and LRT strategy results in a greater in-migration than does LRT alone for R1 and R2. To understand this apparent synergy the individual strategy response must be explained. When LRT is implemented the accessibility by origin and destination of the central area is significantly improved and the change in overall accessibility is dominated by the public transport change for the better. The central zone has the greatest improvement in accessibility to and from all other zones as a result of the LRT system, it is easier to access **all** other zones from the centre of the LRT system than from the outer areas. There is some evidence of increased population around the park and ride sites at zones 9 and 5 but not at zone 16. This centralisation of the population in response to a more accessible city centre seems to be contrary to popular expectations; it is suggesting that people should live at the centre of the LRT system so that they can access all four directions more easily, assuming that all four directions have equal weight to each individual rather than one route (e.g. work route) being dominant. It may also come about as a result of the way in which the location model reacts to changes in accessibility, obviously the greatest change in accessibility is for the central zones when the LRT system is introduced.

With the introduction of the two-way road pricing cordon the accessibility by car to and from the city centre is lower (worse) and all trips from the city centre crossing the cordon are charged twice, once outwards and once on return. (NB inbound only and permit systems have been attempted and will be discussed later). This charging of trips from the city centre results in the population shifting away from the centre to outside the cordon where more trips can be made without charge. Again this is contrary to other research but is perhaps a result of modelling a two-way charge rather than some sort of permit scheme. However with road pricing there is a slight improvement in public transport accessibility (not shown in this note) to/from the city centre which must be by bus or heavy rail. This improvement is perhaps due to the fact that there are fewer cars in the centre so that buses can speed up. The improvement is by far outweighed by the worsening in accessibility for car traffic and so the overall measure is dominated by car in this case.

This improvement in public transport accessibility is important when considering the combined road pricing and LRT strategy which is dominated by public transport improvements which are greater than LRT implementation alone resulting in synergy and a greater centralisation of the population. Again it is not clear whether the improvement in the accessibility measure is a result of improved speeds for buses or of the fact that road pricing results in more public transport users in total.

The bus fare reduction policy which applies to the whole study area has less of an effect on population migration but does begin to reverse the decline of the city centre compared to the do-minimum scenarios.

The total combined strategy performs in a similar way to road pricing plus LRT in terms of land use indicators reinforcing the results that area wide measures such as fare reductions have less effect on land use patterns; but in terms of transport indicators they may have very different effects, for example in terms of numbers of trips by LRT as mentioned earlier.

Table 14 : Population in the city centre plus the rest of Edinburgh
Introducing the accessibility response causes population in the city centre plus the rest of Edinburgh to decrease by 2.9% in the do-minimum scenario, 2.4% with road pricing alone and 2.9% with a fare reduction (same as the do-minimum). However, those strategies which include LRT increase population by 2.1% for LRT alone, 1.5% for LRT plus road pricing and reduce population by 0.3% for the combined strategy. There is no evidence to suggest that the strategies are cumulative. The effect of response to the environment is to reduce population in the city centre plus the rest of Edinburgh by around 1% for all strategies. The effects are broadly linear with the exception of strategies which include LRT as an element which are more than linear. The exception to the rule is the combined strategy where a doubling of the response causes a population increase rather than decrease as for R1. This can be explained by the more than linear response in the city centre attracting more people from the rest of Edinburgh which leaves the rest of Edinburgh more attractive to those from outside Edinburgh. A strategy must have LRT as a component to increase population in the city centre plus the rest of Edinburgh.

Table 15 : Households in the city centre
The changes in households are in the same direction as the changes in population only with a smaller percentage change indicating a change in average occupancy or people per household thus resulting in a different distribution of household types depending on the strategy implemented. For example, the population with LRT response level 2 increases in the city centre by 63% whilst the number of households increases by only 26%; the number of people per household increases from 1.5 to 1.9 as a result of implementing LRT in the city centre.

Similar comments can be made here about linearity as for table 13.

Table 16 : Households in the city centre plus the rest of Edinburgh
The changes in households are in the same direction as the changes in population only with a smaller percentage change indicating a change in average occupancy or people per household thus resulting in a different distribution of household types depending on the strategy implemented. Similar conclusions can be drawn for the whole of Edinburgh as for the city centre.

Similar comments can be made here about linearity as for table 13.

Table 17: Resident workers in the city centre
The changes are very similar to the changes in population for all strategies hence similar conclusions can be drawn as for table 13 above.

Table 18 : Resident workers in the city centre plus the rest of Edinburgh
The changes are broadly similar to the changes in population for all strategies hence similar conclusions can be drawn as for table 14 above.

Table 19 : Floorspace "office/other" in city centre
In terms of floorspace for office and other in the city centre the results for response to accessibility tend to follow the population and rent results in that LRT causes centralisation and road pricing causes decentralisation but with much smaller percentage changes. The effect of response to the environment is zero change in floorspace in the city centre. The effects are broadly linear with the exception of strategies which include LRT as an element which are more than linear.

Table 20 : Floorspace "office/other" in city centre plus the rest of Edinburgh
In response to accessibility only strategies which include LRT have a noticeable effect on floor space increasing it by around 2%. The response to environment has no effect on floor space in Edinburgh. The effects are broadly linear with the exception of strategies which include LRT as an element which are more than linear.

4.3 Summary

The most striking result in terms of strategies is the response to LRT strategies. The LRT system as modelled here provides better alternatives to bus and some car routes for a majority of OD pairings within the Edinburgh area; it also provides limited park and ride facilities for some of the outer zones. The response to this increased accessibility is to centralise the population within the centre of Edinburgh where the changes in accessibility are greatest. This results in higher city centre rents and as a result of this the larger households, who are more sensitive to changes in accessibility, tend to dominate the city centre. This results in total trips increasing with LRT strategies; it is not clear whether this increase in trips is a trips rate issue (with more people in the high trip rate zones). Another possible explanation for increases in trips is the elastic demand response of START which will in any case allow more trips when generalised costs decrease for some trip purposes.

The other major finding is that for strategies which include LRT the doubling of the coefficients results in a greater than double response in terms of output indicators. This more than doubling response for LRT strategies is difficult to explain. The accessibilities do not vary significantly between response 1 and response 2 for LRT strategies which suggests that the response should be approximately double. However as the LRT strategies are the only strategies which increase the population in the city centre with large rent increases it is possible to weight the response towards larger households, more sensitive to changes in accessibility, thus producing more than double the population, resident workers, and households with rents responding accordingly to increased density. This then has knock on effects to floor-space.

It is then possible to explain the more than double change in transport indicators by the fact that more people live in the central zones which have a higher implicit trip rate. The exceptions to this are more difficult to explain. The LRT trips and trip-km only double relying on mode switch from current modes. The car trips more than double whilst the car trip-km only double, this could be due to some additional park and ride car trips in the outer areas coupled with the fact that car availability in the central area will limit the trip rate issue for the car mode.

In terms of response to the environment only road pricing can improve the city centre environment significantly and so cause in-migration; unfortunately this is outweighed by the decentralising effect of the response to accessibility for road pricing strategies when the coefficients are combined.

5. Comparison to a Fixed Land Use - 20 Year Leap

This section compares the land use interaction START-DELTA model results with those produced by the START model alone i.e. with a fixed land use produced for the year 2011. Note that there are slight differences in structure between the START model used with DELTA and that being used for the 20 year leap, the main difference being that the commute trips were disaggregated by SEG for the land use model DELTA. Also, it must be kept in mind that the demand in 2011 for the do-minimum scenario will not be exactly matched due to an update of land use assumptions when building the DELTA model and the fact that the demand in DELTA has been allowed to evolve in two year steps.

When drawing comparisons between the START-DELTA results and the START 20 year leap it is best to concentrate on the differences generated by the introduction of strategies i.e. compare the changes in the measures from the relevant do-minimum scenario rather than the absolute figures produced by each model which will necessarily be different as described above.

5.1 Comparison of transport indicators

The tables 21-28 show the transport results in 2011 for the seven strategies with land use responses 0 and 1 as defined previously and for the static 20 year model. Along side each of the absolute figures is a column which shows the absolute difference in the measure for the strategy minus the relevant do-minimum. Percentage changes have not been used here as the base is different in each case. Response 0 is similar to using a static response in that the land use model produces a fixed demand in 2011 irrespective of the strategy implemented.

Table 21 : Total trips
The changes in total trips are very similar for response 0 and for the static results whereas the response 1 changes are greater and sometimes of opposite sign. There is a marked difference where a strategy includes LRT as an element.

Table 22 : Car trips
For total car trips the changes produced by all three approaches are similar with the exception of LRT response level 1 which reduces car trips by 3000 compared to a reduction of 17000 in the static case.

Table 23 : Bus trips
For bus trips the changes are similar for the approaches again with the exception of strategies which include LRT. Again there is a low base for bus trips with response level 1 but the responses to road pricing and fare reduction are similar to those predicted by the static model. The static model predicts a large decrease in bus trips for LRT plus road pricing compared to the response level 1. Obviously the bus and LRT systems are in direct competition and it is difficult to make any judgements on the results without a more detailed analysis of the demand in each case.

Table 24 : LRT trips
Note that the number of LRT trips generated with response level 0 is 10000 lower than in the static and level 1 response scenario which suggests that LRT trips are sensitive to the demand location. Otherwise the changes in trips are similar across models.

Table 25 : Total trip-km
The total-km table shows that the response 0 and static model produce similar changes whereas the response 1 gives greater changes in total-km as people relocate. In general the response 1 increases the total trip-km compared to the other scenarios.

Table 26 : Car trip-km
Within this total-km the car-trip-km table shows that all approaches are consistent and give broadly similar results.

Tables 27 and 28 : Bus and LRT trip-km
Viewing the bus trip-km with the LRT trip-km it can be seen that the results are most sensitive to the introduction of LRT and combinations such as LRT+road pricing. The static model has the highest base trip-km for both bus and LRT and the combination of road pricing and LRT produces an increase in LRT trip-km for the static model compared to a decrease for the dynamic models even though there is an increase in the number of LRT trips. This suggests that the location of demand is an important factor to be considered when analysing the trip-km tables.

From these results it is concluded that the competition between bus and LRT is sensitive to the original demand pattern used and to the location decisions produced by the dynamic model.

5.2 Summary

In conclusion the transport results show that the responses are broadly similar in terms of car use and that the major differences occur in the competition between the public transport modes. The dynamic model would not change the ranking of the strategies in terms of NPV compared to using the static model. (This is by instinct rather than actual figures but is based upon the fact that car use is similar so the mode switch is similar which seems to be a good substitute for ranking by NPV in the OPTIMA project given the same investment package).

There is no land use response to accessibility and transport related environmental variables for the static model by definition.

6. Sensitivity Tests

The road pricing scenario described above used a two-way cordon which resulted in a decentralisation of the population which is contrary to expectations. Two sensitivity tests were produced which try to produce a more realistic road pricing cordon which may encourage people to relocate within the cordon as follows:-

A. Residential Permits : This was applied by making all outbound trips from within the cordon free in both the a.m. and off-peak periods only and with all inbound trips in the p.m. peak free of charge. This has the required effect of charging through trips twice that of destinating trips.

B. Inbound plus through trips only : free outbound trips from within the cordon all day. This simulates a cordon which charges for inbound trips all day and charges through trips on entry and exit of the cordon as previously.

Without going into the results in too much detail both these strategies produced similar results to the original cordon and did not really encourage location within the cordon as might be expected. Part of the problem seems to be that in A trips in the p.m. peak which entered the cordon free of charge were not restricted to residents returning from a trip outside the cordon. In fact some purposes such as shopping increased in the p.m. peak compared to the do-minimum scenario. In the inbound cordon scenario B residents within the cordon are charged for returning to the city centre on all trips.

In both cases the accessibilities for zone 1 had a blip in 1997 which did not occur in the all day two-way cordon scenarios. Note that the blip is also present in tests of the fare reduction policy for response level 1 for some of the accessibility measures

Part of the problems above is due to the fact that the Edinburgh version of START only uses the generalised costs in the outward direction when calculating modal split and hence all results further up the choice hierarchy including accessibilities. Given the way in which the destination accessibilities are calculated, this means that accessibilities use only the generalised costs outward from the zone in question, whether it is an origin or a destination. This makes a permit type approach impossible.

7. Conclusions

The main points arising from the initial matrix of tests are :-

(i) at the response levels tested, the impacts of land use response are small in terms of trips, car trips and hence fuel consumption (with the impact on the last two an order of magnitude lower than that produced by integrated strategies, even with (R2-R0)).

(ii) However, the impacts on location are significant, particularly for strategies involving LRT. The impact is less on jobs than on population.

(iii) Similarly the impacts on choice of public transport mode with response to accessibility included are substantial, with marked differences between those with and without LRT as an element.

(iv) At the levels tested the accessibility impacts are greater than the environmental ones, but the latter are also important, and for LRT strategies act in the opposite direction.

(v) In terms of response to the environment, only road pricing can improve the city centre environment significantly and so cause in-migration; however, when the responses are combined this is outweighed by the decentralising effect of the response to reduced accessibility.

(vi) The effects on land use are not additive across strategies but are additive across responses to accessibility and environment; the effects on trip rates are broadly additive across strategies but not always across responses.

(vii) The effects are frequently non-linear, particularly when involving LRT.

(viii) The implication of using the responsive land use model rather than the fixed model is to change the distribution of public transport passengers between bus and LRT. The dynamic land use model does not change the overall ranking of the strategies in terms of transport indicators.

For all of the above conclusions it should be borne in mind that the land use response is limited in that the pattern of further development is very highly constrained, to represent planning controls and policies, and there is therefore very little scope for transport policies to influence the distribution of development.

Work is currently in hand on Task 5, in which the study will produce the updated set of response coefficients derived from the stated preference survey work (Wardman et al 1997) and run the same set of strategies for the same and amended land use development scenarios. Further work is also underway to look in detail at the changes produced by some of the strategies which caused exceptions to the normal results.

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Table 1 : Codes for land use responses

Response level	Accessibility coefficient	Environment coefficient
R0	0	0
R1	Best Estimate	Best Estimate
R2	Twice Best Estimate	Twice Best Estimate
R3	Best Estimate	0
R4	0	Best Estimate

Table 2 : Total trips (thousands) in 2011

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R0	R4-R0	A+B	R1-R0	R2-R0
Do-min (DM)	1060	-1.32	-0.57	-1.89	-1.89	-3.96
LRT (LT)	0.66	2.64	-0.57	2.08	2.36	6.23
Road Pricing (RP)	-1.42	-1.13	-0.47	-1.60	-1.51	-3.40
Fare Reduction (FA)	0.75	-1.13	-0.57	-1.70	-1.70	-3.30
LRT+RP (LR)	-0.85	2.74	-0.38	2.36	2.55	6.32
Fare +RP (FR)	-0.66	-0.75	-0.47	-1.23	-1.23	-2.74
LRT+fare+RP (A3)	-0.19	1.79	-0.38	1.42	1.60	5.09

Table 3 : Car trips (thousands) in 2011

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R0	R4-R0	A+B	R1-R0	R2-R0
Do-min (DM)	672.3	-1.01	-0.52	-1.53	-1.47	-3.14
LRT (LT)	-2.11	0.42	-0.48	-0.06	0.21	1.15
Road Pricing (RP)	-10.52	-1.03	-0.74	-1.77	-1.38	-2.47
Fare Reduction (FA)	-3.18	-0.95	-0.55	-1.50	-1.38	-2.75
LRT+RP (LR)	-12.76	0.19	-0.34	-0.15	0.01	0.74
Fare +RP (FR)	-13.94	-0.58	-0.36	-0.94	-0.97	-2.01
LRT+fare+RP (A3)	-15.44	0.42	-0.33	0.09	-0.13	0.59

Table 4 : Bus Trips (thousands) 2011

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R0	R4-R0	A+B	R1-R0	R2-R0
Do-min (DM)	332.4	-2.35	-0.90	-3.25	-3.28	-6.53
LRT (LT)	-23.23	2.98	-0.60	2.38	2.56	6.95
Road Pricing (RP)	15.67	-1.41	0.21	-1.20	-2.23	-6.14
Fare Reduction (FA)	11.22	-2.20	-0.99	-3.19	-2.98	-5.78
LRT+RP (LR)	-7.64	3.43	-0.51	2.92	3.07	8.03
Fare +RP (FR)	27.41	-1.53	-0.66	-2.20	-2.35	-5.29
LRT+fare+RP (A3)	7.91	-0.72	-0.54	-1.26	1.59	7.10

Table 5 : LRT Trips (thousands) 2011

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R0	R4-R0	A+B	R1-R0	R2-R0
Do-min (DM)						
LRT (LT)	102.40	10.35	-0.98	9.37	9.57	22.85
Road Pricing (RP)						
Fare Reduction (FA)						
LRT+RP (LR)	1.46	10.45	-0.49	9.96	9.96	20.90
Fare +RP (FR)						
LRT+fare+RP (A3)	-19.43	12.60	-0.29	12.30	6.84	13.87

Table 6 : Total km (thousands) in 2011

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R0	R4-R0	A+B	R1-R0	R2-R0
Do-min (DM)	14252	-0.12	-0.39	-0.51	-0.49	-1.01
LRT (LT)	0.72	1.65	-0.48	1.17	1.32	3.02
Road Pricing (RP)	-0.67	0.00	-0.32	-0.32	-0.36	-0.60
Fare Reduction (FA)	0.89	-0.11	-0.40	-0.51	-0.46	-0.85
LRT+RP (LR)	-0.13	1.94	-0.38	1.56	1.57	3.46
Fare +RP (FR)	0.02	0.06	-0.36	-0.30	-0.26	-0.34
LRT+fare+RP (A3)	0.55	1.82	-0.50	1.32	1.54	3.87

Table 7 : Car km (thousands) 2011

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R0	R4-R0	A+B	R1-R0	R2-R0
Do-min (DM)	10020	-0.18	-0.42	-0.60	-0.54	-0.86
LRT (LT)	-1.20	-0.33	-0.49	-0.82	-0.63	-1.46
Road Pricing (RP)	-6.42	-0.04	-0.62	-0.66	-0.44	-0.20
Fare Reduction (FA)	-2.70	-0.19	-0.45	-0.64	-0.52	-0.79
LRT+RP (LR)	-7.84	-0.44	-0.46	-0.90	-0.78	-1.59
Fare +RP (FR)	-9.28	0.14	-0.42	-0.28	-0.29	-0.10
LRT+fare+RP (A3)	-10.35	0.16	-0.53	-0.37	-0.44	-0.59

Table 8 : Bus km (thousands) 2011

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R0	R4-R0	A+B	R1-R0	R2-R0
Do-min (DM)	2428	-1.24	-0.78	-2.02	-2.10	-4.04
LRT (LT)	-19.48	3.09	-0.66	2.43	2.59	6.67
Road Pricing (RP)	18.33	-0.82	0.62	-0.21	-1.61	-4.45
Fare Reduction (FA)	23.39	-1.40	-0.86	-2.27	-2.18	-4.12
LRT+RP (LR)	-0.86	3.38	-0.74	2.64	2.84	7.45
Fare +RP (FR)	42.30	-1.40	-0.62	-2.02	-2.14	-4.45
LRT+fare+RP (A3)	25.08	-0.04	-0.70	-0.74	2.88	9.51

Table 9 : LRT km (thousands) 2011

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R0	R4-R0	A+B	R1-R0	R2-R0
Do-min (DM)						
LRT (LT)	603.10	10.30	-0.95	9.35	9.55	21.56
Road Pricing (RP)						
Fare Reduction (FA)						
LRT+RP (LR)	-0.86	10.89	-0.48	10.41	10.18	19.63
Fare +RP (FR)						
LRT+fare+RP (A3)	-21.52	12.90	-0.38	12.52	6.30	11.86

Table 10 : Fuel consumption (cars - millions litres)

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R0	R4-R0	A+B	R1-R0	R2-R0
Do-min (DM)	353.50	-0.68	-0.54	-1.22	-1.16	-2.29
LRT (LT)	-0.79	1.56	-0.57	0.99	1.16	2.69
Road Pricing (RP)	-7.44	-0.34	-0.76	-1.10	-0.79	-1.22
Fare Reduction (FA)	-3.48	-0.51	-0.51	-1.02	-0.93	-1.73
LRT+RP (LR)	-8.09	0.85	-0.48	0.37	0.48	0.82
Fare +RP (FR)	-10.83	-0.06	-0.48	-0.54	-0.48	-0.82
LRT+fare+RP (A3)	-10.95	1.27	-0.54	0.74	0.54	1.22

Land Use Outputs in 2011

Table 11 : Housing Rents in City Centre (£ per m sq per week)

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R1	R4-R1	A+B	R1-R0	R2-R0
Do-min (DM)	0.947	-2.1	0.0	-2.1	-2.0	-3.9
LRT (LT)	0	12.5	0.3	12.8	12.7	35.9
Road Pricing (RP)	0	-4.2	2.4	-1.8	-1.8	-3.3
Fare Reduction (FA)	0	-1.5	0.2	-1.3	-1.2	-2.4
LRT+RP (LR)	0	13.7	2.6	16.4	16.8	41.4
Fare +RP (FR)	0	-3.2	2.5	-0.6	-0.6	-1.3
LRT+fare+RP (A3)	0	13.7	2.6	16.4	16.5	43.4

Table 12 : Housing rents City Centre + Rest of Edinburgh

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R1	R4-R1	A+B	R1-R0	R2-R0
Do-min (DM)	0.875	-2.8	-0.5	-3.3	-3.2	-6.6
LRT (LT)	0	3.3	-0.3	2.9	3.2	10.8
Road Pricing (RP)	0	-3.3	0.3	-3.0	-3.0	-6.1
Fare Reduction (FA)	0	-2.5	-0.5	-3.0	-2.9	-5.7
LRT+RP (LR)	0	3.3	0.4	3.7	4.1	11.5
Fare +RP (FR)	0	-2.8	0.3	-2.4	-2.4	-5.0
LRT+fare+RP (A3)	0	2.8	0.4	3.2	3.4	11.6

Table 13 : Population in City Centre

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R1	R4-R1	A+B	R1-R0	R2-R0
Do-min (DM)	41016	-3.8	-0.1	-3.9	-3.7	-7.5
LRT (LT)	0	20.7	0.1	20.8	20.9	63.5
Road Pricing (RP)	0	-7.9	2.4	-5.5	-5.5	-10.0
Fare Reduction (FA)	0	-2.9	0.0	-2.9	-2.6	-5.5
LRT+RP (LR)	0	23.9	2.6	26.5	27.2	77.2
Fare +RP (FR)	0	-6.4	2.5	-3.9	-3.9	-7.4
LRT+fare+RP (A3)	0	23.1	2.6	25.7	26.0	77.4

Table 14 : Population City Centre + Rest of Edinburgh

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R1	R4-R1	A+B	R1-R0	R2-R0
Do-min (DM)	429643	-2.9	-1.1	-4.0	-3.9	-8.1
LRT (LT)	0	2.1	-0.9	1.1	1.6	4.9
Road Pricing (RP)	0	-2.4	-0.9	-3.3	-3.3	-6.9
Fare Reduction (FA)	0	-2.9	-1.1	-4.0	-3.8	-7.5
LRT+RP (LR)	0	1.5	-0.7	0.7	1.0	3.5
Fare +RP (FR)	0	-2.2	-0.9	-3.1	-3.1	-6.5
LRT+fare+RP (A3)	0	-0.3	-0.8	-1.1	-0.9	0.6

Table 15 : Households in City Centre

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R1	R4-R1	A+B	R1-R0	R2-R0
Do-min (DM)	27554	-1.9	-0.1	-2.1	-2.0	-4.0
LRT (LT)	0	9.1	0.1	9.1	8.9	26.4
Road Pricing (RP)	0	-4.3	1.7	-2.6	-2.4	-4.8
Fare Reduction (FA)	0	-1.4	0.0	-1.4	-1.3	-2.8
LRT+RP (LR)	0	10.5	1.8	12.3	12.4	34.7
Fare +RP (FR)	0	-3.3	1.7	-1.6	-1.5	-3.1
LRT+fare+RP (A3)	0	10.2	1.9	12.1	12.0	35.2

Table 16 : Households City Centre + Rest of Edinburgh

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R1	R4-R1	A+B	R1-R0	R2-R0
Do-min (DM)	227912	-1.5	-0.8	-2.3	-2.3	-4.8
LRT (LT)	0	1.0	-0.7	0.3	0.5	2.0
Road Pricing (RP)	0	-1.3	-0.6	-1.9	-1.9	-4.1
Fare Reduction (FA)	0	-1.5	-0.8	-2.3	-2.2	-4.3
LRT+RP (LR)	0	0.7	-0.5	0.1	0.3	1.5
Fare +RP (FR)	0	-1.1	-0.7	-1.7	-1.7	-3.6
LRT+fare+RP (A3)	0	-0.2	-0.6	-0.8	-0.6	0.1

Table 17 : Resident workers in City Centre

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R1	R4-R1	A+B	R1-R0	R2-R0
Do-min (DM)	20145	-3.7	-0.1	-3.8	-3.7	-7.5
LRT (LT)	0	20.3	0.2	20.5	20.5	60.9
Road Pricing (RP)	0	-7.7	2.5	-5.2	-5.1	-9.9
Fare Reduction (FA)	0	-2.6	0.0	-2.6	-2.3	-5.1
LRT+RP (LR)	0	23.7	2.8	26.4	27.2	74.8
Fare +RP (FR)	0	-6.1	2.6	-3.5	-3.4	-6.8
LRT+fare+RP (A3)	0	23.3	2.8	26.0	26.4	76.0

Table 18 : Resident workers City Centre + Rest of Edinburgh

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R1	R4-R1	A+B	R1-R0	R2-R0
Do-min (DM)	179552	-3.2	-1.2	-4.4	-4.3	-9.0
LRT (LT)	0	2.4	-1.0	1.4	1.9	6.0
Road Pricing (RP)	0	-2.7	-0.9	-3.6	-3.6	-7.7
Fare Reduction (FA)	0	-3.0	-1.2	-4.2	-3.9	-7.8
LRT+RP (LR)	0	1.8	-0.7	1.0	1.3	4.3
Fare +RP (FR)	0	-2.1	-0.9	-3.1	-3.1	-6.5
LRT+fare+RP (A3)	0	-0.2	-0.8	-0.9	-0.6	1.5

Table 19 : Floorspace "office/other" in City Centre (thousand m sq)

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R1	R4-R1	A+B	R1-R0	R2-R0
Do-min (DM)	1185	-0.2	0.0	-0.2	-0.2	-0.4
LRT (LT)	0	2.2	0.0	2.2	2.2	8.1
Road Pricing (RP)	0	-0.4	0.0	-0.4	-0.4	-0.8
Fare Reduction (FA)	0	-0.1	0.0	-0.1	-0.1	-0.3
LRT+RP (LR)	0	2.9	0.0	2.9	2.9	9.5
Fare +RP (FR)	0	-0.3	0.0	-0.3	-0.3	-0.6
LRT+fare+RP (A3)	0	2.7	0.0	2.7	2.6	8.3

Table 20 : Floorspace "office/other" City Centre + Rest of Edinburgh

		A:Access	B:Env	Test	Combined	Double
Strategy	R0	R3-R1	R4-R1	A+B	R1-R0	R2-R0
Do-min (DM)	3530	-0.1	0.0	-0.1	-0.1	-0.3
LRT (LT)	0	1.9	0.0	1.9	1.8	5.2
Road Pricing (RP)	0	-0.1	0.0	-0.1	-0.1	-0.2
Fare Reduction (FA)	0	0.0	0.0	0.0	0.0	-0.1
LRT+RP (LR)	0	2.2	0.0	2.2	2.2	6.0
Fare +RP (FR)	0	0.0	0.0	0.0	0.0	0.0
LRT+fare+RP (A3)	0	1.9	0.0	1.9	1.9	5.1

Comparisons to the fixed land use case (20 year leap)

Table 21 : Total trips (thousands) in 2011

Strategy	Response 0	strat-domin0	Response 1	strat-domin1	FIXED 20	strat-domin20
Do-min (DM)	1060		1040		1082	
LRT (LT)	1067	7	1092	52	1088	6
Road Pricing (RP)	1045	-15	1029	-11	1066	-16
Fare Reduction (FA)	1068	8	1050	10	1089	7
LRT+RP (LR)	1051	-9	1078	38	1072	-10
Fare +RP (FR)	1053	-7	1040	0	1073	-9
LRT+fare+RP (A3)	1058	-2	1075	35	1078	-4

Table 22 : Car trips (thousands) in 2011

Strategy	Response 0	strat-domin0	Response 1	strat-domin1	FIXED 20	strat-domin20
Do-min (DM)	672.3		662.4		686.4	
LRT (LT)	658.1	-14.2	659.5	-2.9	668.9	-17.5
Road Pricing (RP)	601.6	-70.7	592.3	-70.1	618.4	-68
Fare Reduction (FA)	650.9	-21.4	641.6	-20.8	665.4	-21
LRT+RP (LR)	586.5	-85.8	586.6	-75.8	602.6	-83.8
Fare +RP (FR)	578.6	-93.7	572.1	-90.3	598.3	-88.1
LRT+fare+RP (A3)	568.5	-103.8	567.6	-94.8	585.1	-101.3

Table 23 : Bus Trips (thousands) 2011

Strategy	Response 0	strat-domin0	Response 1	strat-domin1	FIXED 20	strat-domin20
Do-min (DM)	332.4		321.5		347.1	
LRT (LT)	255.2	-77.2	263.7	-57.8	255.9	-91.2
Road Pricing (RP)	384.5	52.1	377.1	55.6	397.2	50.1
Fare Reduction (FA)	369.7	37.3	359.8	38.3	384.7	37.6
LRT+RP (LR)	307	-25.4	317.2	-4.3	300.5	-46.6
Fare +RP (FR)	423.5	91.1	415.7	94.2	434.1	87
LRT+fare+RP (A3)	358.7	26.3	364	42.5	355.7	8.6

Table 24 : LRT Trips (thousands) 2011

Strategy	Response 0	strat-domin0	Response 1	strat-domin1	FIXED 20	strat-domin20
Do-min (DM)						
LRT (LT)	102.4		112.2		111.7	
Road Pricing (RP)						
Fare Reduction (FA)						
LRT+RP (LR)	103.9	1.5	114.1	1.9	114	2.3
Fare +RP (FR)						
LRT+fare+RP (A3)	82.5	-19.9	89.5	-22.7	91.5	-20.2

Table 25 : Total km (thousands) in 2011

Strategy	Response 0	strat-domin0	Response 1	strat-domin1	FIXED 20	strat-domin20
Do-min (DM)	14252		14182		13732	
LRT (LT)	14355	103	14543	361	13848	116
Road Pricing (RP)	14157	-95	14105	-77	13615	-117
Fare Reduction (FA)	14379	127	14313	131	13834	102
LRT+RP (LR)	14233	-19	14457	275	13720	-12
Fare +RP (FR)	14255	3	14218	36	13717	-15
LRT+fare+RP (A3)	14331	79	14550	368	13803	71

Table 26 : Car km (thousands) 2011

Strategy	Response 0	strat-domin0	Response 1	strat-domin1	FIXED 20	strat-domin20
Do-min (DM)	10020		9966		9922	
LRT (LT)	9900	-120	9837	-129	9733	-189
Road Pricing (RP)	9377	-643	9333	-633	9293	-629
Fare Reduction (FA)	9749	-271	9697	-269	9644	-278
LRT+RP (LR)	9234	-786	9156	-810	9114	-808
Fare +RP (FR)	9090	-930	9061	-905	9023	-899
LRT+fare+RP (A3)	8983	-1037	8939	-1027	8867	-1055

Table 27 : Bus km (thousands) 2011

Strategy	Response 0	strat-domin0	Response 1	strat-domin1	FIXED 20	strat-domin20
Do-min (DM)	2428		2377		2511	
LRT (LT)	1955	-473	2018	-359	1987	-524
Road Pricing (RP)	2873	445	2834	457	2941	430
Fare Reduction (FA)	2996	568	2943	566	3136	625
LRT+RP (LR)	2407	-21	2476	99	2371	-140
Fare +RP (FR)	3455	1027	3403	1026	3572	1061
LRT+fare+RP (A3)	3037	609	3107	730	3089	578

Table 28 : LRT km (thousands) 2011

Strategy	Response 0	strat-domin0	Response 1	strat-domin1	FIXED 20	strat-domin20
Do-min (DM)						
LRT (LT)	603.1		660.7		704.8	
Road Pricing (RP)						
Fare Reduction (FA)						
LRT+RP (LR)	597.9	-5.2	659.3	-1.4	712	7.2
Fare +RP (FR)						
LRT+fare+RP (A3)	473.3	-129.8	511.3	-149.4	571.5	-133.3