The impacts of a sustainability appraisal on transport strategy selection

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Dr Greg Marsden (ITS),
Mary Kimble (ITS),
John Nellthorp (ITS),

Executive Summary

There is great concern about the long-term 'sustainability' of the transport sector both nationally and globally. Much work has focussed on the development of indicator sets to monitor changes in the sustainability of transport over time (Litman, 2005). However, in reviewing indicators for sustainability in 2003 Gudmundsson concluded that "Even a perfect indicator system for sustainable mobility may be of little relevance if it has no bearing on actual decisions taken". The research described in this paper attempts to answer these concerns by bringing together modelling tools to try and forecast the impacts of a range of transport strategies across the three pillars of sustainability (economy, environment *and* social).

The paper begins by defining key concepts and describing the framework for sustainability appraisal, including how it differs to existing frameworks. The framework was presented to 14 key stakeholders including four central government departments (transport, planning, finance and environment), practitioners and pressure groups. The outcomes of these discussions and modifications made to the proposed framework are presented.

A practical implementation of the framework has subsequently been undertaken for a large Metropolitan area in England. Three scenarios examining differing levels of investment in the transport system, degrees of behavioural change and demand management measures are presented. Of particular interest is the attempt to link a strategic land-use transport interaction model to a GIS-based model of accessibility and social deprivation.

The findings suggest that there are serious gaps in our capabilities in capturing sustainability impacts under economic, social and environmental headings. Despite this, the process proposed identified some conflicts between the types of scenarios scoring positively under current appraisal methods and those proposed. This suggests the need for a broader consideration of the impacts of strategies, including the long-term direction of change such as that proposed.

Introduction

Sustainability or Sustainable development has been commonly defined as "Economic and social development that meets the needs of the current generation without undermining the ability of future generations to meet their own needs" (WCED, 1987). This definition brought together what is now known as the three pillars of sustainable development; economic development, social development and ecological development under one societal goal of sustainability.

The United Kingdom has recently developed its second sustainable development strategy. The 2005 strategy recognised that "although the 1999 strategy stressed that these objectives had to be pursued at the same time, in practice, different agencies focused on those one or two most relevant to them. So a new purpose is needed to show how government will integrate these aims and evolve sustainable development policy" (DEFRA, 2005, p15). The revised principles are:

- "Living within environmental limits
- Ensuring a strong, healthy and just society
- Achieving a sustainable economy (*Ibid.*, p16)

Principles of good governance and the responsible use of sound science are also put forward which aligns itself with the global state of art (Ref).

In the July 2004 Transport White Paper (DfT, 2004), the Department for Transport put in place a commitment to ensure that its appraisal techniques somehow capture the complexities of sustainable development in its broadest sense:

> "…an important underlying objective of our strategy is balancing the need to travel with the need to improve quality of life. This means seeking solutions that meet long-term economic, social and environmental goals. Achieving this objective will clearly contribute to the objectives of the UK sustainable development strategy. For example, we are working hard to deliver improvements in design and technology to improve air quality and reduce greenhouse gas emissions; and ***we will ensure that the wider impacts of future developments are reflected in appropriate appraisal methodologies***." (DfT, 2004, p14, emphasis added)

This statement suggests that the current methods of assessing strategies and schemes do not capture the full range of sustainability concerns. The next section reviews the current approach and suggest enhancements that are necessary to meet the goals of sustainability assessment. The process for developing the assessment framework and the framework are then presented before the results of an application of the proposed and existing frameworks are given for some alternative transport strategies in a UK metropolitan area. We then draw some conclusions about the impact that the principles of sustainability might have on transport strategy selection.

Current UK Practice

Current UK appraisal practice has evolved gradually from the cost-benefit analysis (CBA) approach applied to early projects such as the M1 motorway and the Third London Airport. Initially, great efforts were made to monetise all relevant effects and the cost-benefit method was used to rank alternative schemes, however, from the late 1970s onwards it was recognised that there were significant environmental and social effects of transport projects which not only could not always be monetised, but were of interest to decision makers in their own right (ACTRA, 1977). Work then started in earnest on the development of Environmental Assessment for major projects, which has been presented alongside the CBA from the mid 1980s through to the present (Highways Agency *et al*, 1994; DfT, 2004a,b).

In 1997, the new Labour government asked that the appraisal information be brought together in a form that is useful for decision makers, and also that the scope of the appraisal reflect the government's five objectives for transport policy, namely safety, economy, environment, accessibility and integration. The framework developed to meet these needs, and portentously called the New Approach to Appraisal (or NATA), was the first objectives-led appraisal framework in UK national appraisal practice. Its first application was to the Trunk Roads Review, which selected projects for inclusion in a smaller, lower-budget 'Targeted Programme of Improvements'. These new developments were documented and analysed by Price (1999) and Nellthorp and Mackie (2000). The latter attempted to identify whether decision makers had in fact made any use of the wider set of evidence now placed before them, and whether their use of it was consistent with expectations. The findings were broadly positive: a statistical analysis suggested that the new information on reliability impacts and regeneration, for example, had played a significant role in the decisions made; the decision makers had placed significant weight on environmental factors too – in particular noise, landscape and heritage impacts; and the weight placed on the traditional cost-benefit items was broadly consistent with expectations.

The 'NATA' approach has since been promulgated for regional strategies (DETR, 1999) and forms the framework for appraisal at a national level for any scheme >£5m (DfT, 2006). There have been issues with its application to strategies however – whilst it does allow preferred strategies to be identified these are not necessarily sustainable (Marsden, 2005).

"Under the Planning and Compulsory Purchase Act 2004, Sustainability Appraisal is mandatory for Regional Spatial Strategies (RSS), Development Plan Documents (DPDs) and Supplementary Planning Documents (SPDs) (see Figure 1)." (ODPM, 2004, p9). Regional Transport Strategies, part of the Regional Spatial Strategy, are therefore subject to a sustainability appraisal. A recent review of how sustainability appraisals have been applied to the Regional Transport Strategy in Yorkshire and the Humber suggested that despite the guidance, "a regional approach to sustainability, particularly with respect to transport, needs to be produced" (Ferrary and Crowther, 2005). The current approach consists of the development of a large series of qualitative indicators of progress based, in part, on quantitative research.

In local transport planning, a slightly different approach has been adopted in which the local authority sets targets on a range of indicators (many related to national policy goals). DfT's assessment of these plans and the authorities' delivery performance plays a significant role in determining funding (DfT, 2004c). Major schemes (>£5m) are subject to the same 'NATA' style assessment as those generated at regional or national level.

There is a significant philosophical and presentational difference between the current approach to transport appraisal and one which reflects sustainability impacts. For policy relevant sustainable development decision-making the implications of a scheme or strategy are required to be understood over the period of the assessment as with current appraisal. However it is also essential to understand fully the position and direction of change of indicators of success at the end of the assessment period. This position may need to be understood relative to current conditions (for example in the consideration of equity) or some forecast future benchmark position (for example where a target for the reduction of climate change emissions has been set). These differences are highlighted below in Figure 1. The figure shows the impacts of a strategy on a form of toxic emissions. The dark-line indicates measured data, the thick dashed line the forecast level of emissions under some 'do-minimum' scenario and the thick dotted line the forecast level with the strategy. The black dots represent the current year position (A), the forecast position with the strategy implemented (B) and the position in the assessment year under 'do-minimum' (C). An assessment of the worth of the scenario would show that B < C and therefore the scenario has an emissions benefit. However as B > A there is an implied environmental degradation which may compromise the sustainability of the strategy.

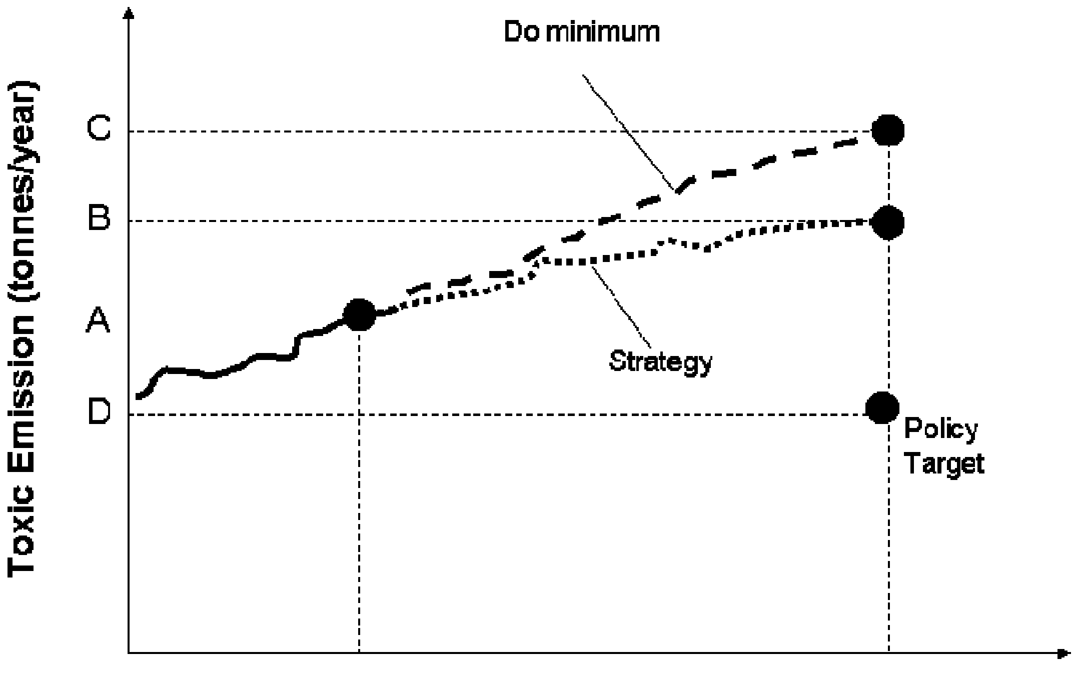

Figure 1: Do-minimum and intervention assessment

Of course, the assessment of sustainability is not as simple as comparing performance in the future with current performance. Alongside every indicator of sustainability there must be an indication of the direction of change from the current position that constitutes progress. In some cases there is a scientific basis on which a particular end goal can be quantified (e.g. number of days of moderate or high air quality), for others (e.g. increasing community participation) an end goal is less clear but a direction of change relative to past trends can be stated. In the case of the former, not only is it possible to state an end goal but it is often the case that time periods over which the government wishes to move to achieve these goals are set (targets). The policy relevant information is, in such cases, the difference between the assessment year value and the policy trajectory value – shown as B – D on Figure 1. We do not propose to wade into the arguments on the relative merits of targets as there is a substantial literature on ‘weak’ and ‘strong’ sustainability (Pearce, 2000). However, we note that there is a focus on outcome targets as a means to monitoring and managing government progress within the UK (Marsden et al., 2006).

Table 1 summarises the current assessment frameworks that are required to operate for different types of strategies within the UK. It is worth asking the question: “Do we need another sustainability assessment framework?” There are a number of overlaps between current assessment processes and there is scope for a more standardised framework to replace or bring together existing practice so that the appraisal of sustainability is considered as an integral part of the decision-making process rather than a new ‘bolt on’.

Table 1: Appraisal Procedures and Scope for framework application

Strategy Level	Assessment Procedure			
	New Approach To Appraisal	Mandatory indicators and targets	Strategic Environmental Assessment	Sustainability Appraisal (DCLG)
National Transport Policy	✓✓			
Regional Spatial Strategy (Regional Transport Strategy)	✓		✓✓	✓✓
Local Transport Plan	✓	✓	✓✓	

✓✓ Requirement
✓ Influences

Developing a Sustainability Appraisal Framework

It is essential to have a clear idea of the goals of sustainable development. Indicators can then be selected to proxy progress towards those goals. A review of the principles of sustainable development has been conducted (Kelly, 2005) to ensure that different perspectives on sustainability have been considered. Ultimately however it was felt that the project needed to be consistent first and foremost with the UK Sustainable Development strategy (DEFRA, 2005) and secondly with an interpretation of what this might mean for transport. For this, we took the European Council of Ministers definition of sustainable transport (ECMT, 2001).

The indicators in the UK sustainable development strategy were developed to perform a monitoring role rather than to be used in ex-ante appraisal. There was therefore a need to identify for each of the three pillars (and where relevant overlapping between pillars) a comprehensive suite of indicators. The first element of the indicator selection was to take a first principles look at the relationships between transport and the environment, economy and society, ensuring that all of the aspects described by the UK sustainable development strategy and ECMT definition were covered.

Whilst for many of these relationships, the evidence base is well understood (e.g. the link between vehicle use, emissions, pollutant concentrations and health), for others it is the subject of pioneering research work (e.g. modelling the impacts of transport interventions on economic growth (see Oosterhaven and Elhorst, 2003 and Bröcker et al., 2004). For some, the relationship is intuitive but the evidence base flimsy or non-existent (e.g. the impact of car use on social interactions). An approach was adopted to limit the selection of indicators to those areas where a strong relationship existed. Where this was the case, where possible, existing indicators were used. Where this was not possible, indicators were derived on the basis of best practice in the area (Marsden et al.,2005).

The range of indicators and the approach proposed were then taken to a range of stakeholders for discussion and review. The following stakeholders participated in the research:

- Department for Transport
- Department of Environment, Food and Rural Affairs
- Office of the Deputy Prime Minister
- HM Treasury
- Sustainable Development Commission
- Transport 2000
- Friends of the Earth
- Campaign to Protect Rural England
- Yorkshire Forward
- Yorkshire and Humber Assembly
- Government Office for Yorkshire and Humber
- Passenger Transport Executive Group
- Environment Agency
- Confederation of British Industry

Table 2 shows the summary list of indicators produced as a result of the initial work and consultations. Full details of the derivation of the indicators and the process for agreeing the framework can be found in Marsden et al., 2005; Kelly and Nellthorp, 2005; Lucas and Brooks, 2005 and Marsden, 2005.

There are two key areas of difference between the NATA indicators and those put forward within this project:

- The sustainability framework covers the efficiency of environmental resource use which is not reflected in NATA. Pearce (2000) suggests that the efficiency of resource use is a common goal across proponents of both weak and strong sustainability approaches.
- The coverage of social issues is far more comprehensive within the framework than is currently the case within NATA. These indicators are only meaningful when used as direct measures of change (rather than comparators with do-minimum figures).

It is worth noting that NATA also includes the integration indicators which we have discounted and measures of physical fitness, journey ambience and increased option values. Journey ambience should be captured through actual (rather than theoretical) accessibility but current approaches are someway off from being able to achieve this. Option values are again partly covered by accessibility although the degree to which these are really reflected warrants further research.

Table 2: Indicators suite for sustainability appraisal

Environment			
Area of Progress	**Indicator of Progress**	**Disaggregation**	**Direction of change**
Pollutant Absorption Capacity	Total CO_2 emissions	-	Down – 20% cut by 2010 compared to 2000 levels and 60% by 2050
	Cumulative Total CO_2 emissions	-	Down compared with existing annual rate played forward
	Total NO_x emissions	-	Down – UK total to be 1,167 thousand tonnes by 2010 EU National Emissions Ceiling Directive
Resource Efficiency	Total non-renewable energy by all transport	-	Down
	Energy use per person-trip	Personal travel only	Down
	Energy use per tonne-km	Freight only	Down
Direct impacts on health	Exceedences of air quality objectives (NOx and/or PM10)	At risk groups (e.g. % of people suffering Chronic Heart Disease)	Down (standards set for 2005 and 2010)
Local quality of life	Number of residences exposed to aircraft noise above 57 LAeq,T		Down
	Number of residences exposed to noise above 55dBA		Down
Environmental Capital	Qualitative environmental capital score (7 point scale)	Landscape Townscape Heritage of Historic resources Biodiversity Water Quality	Cumulative impact of policies neutral or beneficial
Economy			
Area of Progress	**Indicator of Progress**	**Disaggregation**	**Direction of change**
Standard of Living	Real GDP per Capita based on: • *In the short term* – proxied by net benefits measured in the transport sector using WebTAG methods • *Long term aspiration* - Direct modelling of GDP using multi-sectoral models	Business User Benefits Consumer User Benefits Reliability Safety* Operator Gains Public Finance Balance	Increasing (strictly Non-decreasing)

Society			
Area of Progress	**Indicator of Progress**	**Disaggregation**	**Direction of change**
Poverty	Average real cost of journey to key destinations	By car and public transport	Reduced ratio between car-based and public transport options
Accessibility	Weighted journey times[1] to: • key centres of employment; • primary, secondary & further educational facilities; • primary health care provider[2] & general hospital[3]; • key food shops	By car and public transport[4]	Reduced ratio between car-based and public transport options
Safety	Killed and Seriously Injured	Disaggregate by index of deprivation, teenage deaths by driving and child pedestrian deaths	Reduce number KSI by 40% (50% child KSI) by 2010 compared with the average for 1994-98 plus reduced disparity between social groups
	Recorded incidences of crime on public transport	None	Down overall and improved perceptions of safety
Walkability	Percentage of residents living within 1000m or 15-minute 'safe walk'[5] to key destinations (e.g. health, educational, leisure and cultural facilities, food shops, post office, etc.)	Can be disaggregated by particular relevant groups (e.g. primary school by % of children under 11 years).	Up
Housing	Real lowest 10% value of house prices within x minutes (based on average local journey times to employment) of: a) The town centre and b) Key centres of employment	Disaggregated by public transport and car	Down

[1] It may be advisable to also include cost of journey to these destinations with some indication of costs over e.g. £1 being non-affordable for low-income households and highlighting disparities in cost between car and public transport

[2] Doctor's surgery, health centre, NHS walk-in centre

[3] Hospital offering A&E and other key services

[4] Can also be disaggregated by particular relevant groups (e.g. health care facility by % of people suffering Chronic Heart Disease; primary school by % of children under 11 years; etc.) and also by housing tenure (the latter may be particularly in rural areas where low-income households are more likely to have higher levels of car ownership).

[5] Determined by an official safe route. A safe cycle route to these destinations could also be included

We also highlight in the table the role that wider economic impacts have in NATA in the form of Economic Impact Assessments. There is no well developed science for predicting the economic impacts of transport interventions as noted earlier. Stakeholders suggested to us that there may be many types of economic impacts that could not be captured through our proposed short-term approach. We believe that in most cases, the majority of the benefits would be well represented by our approach but cannot rule out the need for further assessments being required.

Implementation of the Framework

The framework was tested on the development of long-term local transport strategies for a major metropolitan area within the UK. This section describes the tools available briefly and the scenarios examined.

Modelling tools available

The metropolitan area employs a strategy planning model based on the DELTA-START land-use transport interaction modelling suite that was commissioned in 1996. The model allows for adjustments to choice of trip frequency, destination, mode and time of travel and location of business and residential activities. Actors in the model can choose to expand or contract their activities, change location (home and business) in response to changes in accessibility and environmental quality. Public transport operators can also respond to patronage changes via fare, frequency and vehicle size changes. The model is spatially aggregate with 47 zones covering the metropolitan area. It included a high degree of detail for trip purposes (10) and modes of travel (8). Freight trips, while included in this model remain at a constant growth rate from 1991 and are not dealt with in target interventions.

The model has a 1991 base year and runs for each scenario provided data for years 1991, 1996, 2001, 2006, 2011, 2016, and 2021. Our chosen sustainability appraisal year is 2021. Other data such as accidents, environmental quality and accessibility is available for 2005 so 2006 was considered as the base year for the sustainability appraisal. In addition to the strategic model traffic runs we were also provided with data on the costs and profile of costs of the interventions for each of the scenarios.

The land-use transport interaction model provided the majority of outputs for us to employ. A number of the social indicators were calculated using the Accession™ software suite. This software combines an access database of all public transport stops, services and timetables with GIS mapping capabilities. This program was commissioned by DfT to provide a means of auditing accessibility by investigating the links between transport provision and participation in key activities by individuals or groups.

Accession™ allows for location details to be assigned to a centre line road network of the area and accessibility via all modes can be calculated. Geo-demographic data can be joined to origin points, thus giving a picture of what classes of the population are affected by poor accessibility to basic services such as food shops, schools, GPs and centres of employment. Results such as contour maps and average journey times to destinations give the user an overview of the scale of journey times. 2006 data on population characteristics, service locations and public transport provision were provided. Assumptions were made about changes to public transport on the basis of the data provided for each of the three scenarios. Service locations remained fixed over time which is considered to be a substantial limitation.

Scenarios

Three different model runs were provided as the basis for our analysis. The three runs contained differing degrees of public transport investment and demand management and, as such, provide a reasonably realistic panorama of policy futures. However, in selecting any three scenarios they cannot be fully representative nor do they reflect preferred policy paths.

Scenario A

The first test, A represents a baseline scenario with the forecast of full implementation of the Local Transport Plan 2 programme and implementation of all committed major schemes. The main implementation of this was modal constant adjustments made to represent information and quality investment of -1.0 minutes for bus, -1.5 minutes for rail, -.25 minutes for walk and -0.5 for cycle. This test also included low assumptions on the effectiveness of behavioural change measures (such as car sharing and teleworking schemes on commuting trips and home shopping). These were implemented via direct adjustments to the highway travel demand matrices and vehicle occupancy to approximate impacts on car use.

Scenario B

Scenario B represents all of the content of Scenario A plus major public transport investment from 2006 onwards. Major investments in bus and rail frequency and capacity were made in 2011 with additional increases in rail capacity in 2016. The modal constant adjustments implemented in the baseline at 2011 were increased by 50% at 2011 to reflect increased expenditure in Public Transport in four priority corridors. In 2016, these improvements were extended to the eleven other transport corridors. In addition an extension of current light rail was made, the addition of a tram-train and a core busway network were added from 2011 onwards.

Scenario C

Scenario C includes all of the public transport investment plus behaviour change as Scenario B but also includes an area-based charging scheme. All vehicles within the intermediate Ring Road formed around the Regional Centre would be required to pay £4 per day in 2016, rising to £5 per day in 2021 (1991 prices). Households living within the charging area were exempt from paying the full charge and paid 10% of the full charge.

Results

A brief summary of the main transport impacts is provided in Tables 3 and 4 and Figure 2 before the Appraisal Summary Tables for both the sustainability appraisal and the New Approach to Appraisal are presented.

Table 3: Total kms/day by scenario by year

Scenario	Year	Car kms (M)	Public transport kms (000s)	Freight kms (M)	Total kms (M)
A	2006	30.3	487.7	13.7	44.4
	2011	31.0	459.5	14.4	45.9
	2016	32.1	466.7	15.1	47.7
	2021	33.2	514.4	15.8	49.6
B	2006	30.3	487.7	13.7	44.4
	2011	31.0	535.4	14.5	46.0
	2016	30.7	589.0	15.3	46.6
	2021	31.8	640.2	16.0	48.4
C	2006	30.3	487.7	13.7	44.4
	2011	31.0	535.4	14.5	46.0
	2016	30.0	589.8	15.3	45.9
	2021	30.9	641.0	16.0	47.5

Table 4: Daily Trips by mode (000s) by scenario 2006-2021

Scenario	Year	Car trips	Rail trips	Walk Trips	Cycle trips	Bus trips	LRT Trips	Freight Trips	Total Trips
A	2006	8371	287	1457	118	2482	143	966	13824
	2011	8573	320	1380	111	2505	150	1017	14055
	2016	8870	343	1360	110	2492	172	1062	14408
	2021	9172	359	1359	111	2494	188	1110	14794
B	2006	8371	287	1457	118	2482	143	966	13824
	2011	8551	324	1362	109	2485	289	1017	14137
	2016	8801	353	1329	107	2502	386	1062	14540
	2021	9086	371	1327	107	2518	430	1110	14949
C	2006	8371	287	1457	118	2482	143	966	13824
	2011	8551	324	1362	109	2485	289	1017	14137
	2016	8533	382	1354	109	2642	409	1062	14491
	2021	8781	397	1353	110	2676	445	1110	14872

Scenario A has the highest number of motorised kms, largely as a result of having more car kilometres than the other two scenarios. Total trips are however lowest in this scenario, reflecting in particular the greater attraction of public transport in Scenarios B and C after the investments in 2011. Total trips from scenario C are only slightly above those from scenario A as a result of the introduction of road pricing. Total walk and cycle trips and walk and cycle trips as a percentage of total trips are higher under Scenario A, again reflecting some abstraction of walk and cycle journeys to public transport.

There is a decline in the average speed across the whole metropolitan area. The decline is more marked, as would be expected from the trip and vehicle km statistics, for the baseline scenario A than for the more proactive public transport scenario B. Scenario C with road user charging provides for only a small decline in overall average speed.

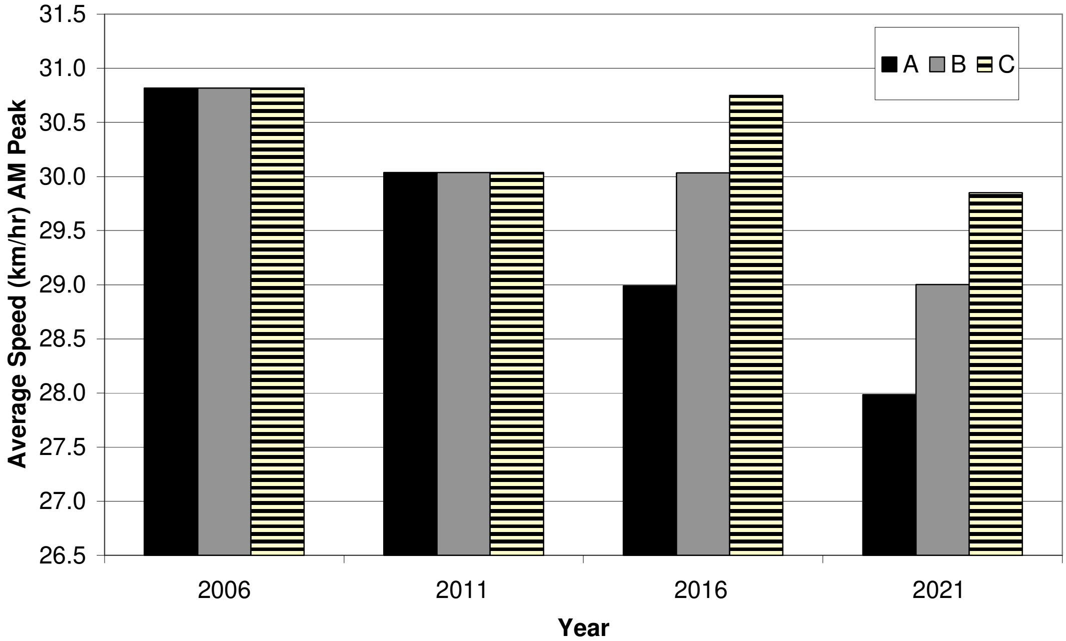

Figure 2: Average Speed changes for scenarios 2006-2021

At this stage it is worth acknowledging that the assumptions surrounding freight kilometres and surrounding walk and cycle trips are limited. No investments in walk and cycle are included and the trip totals therefore reflect changes in their attractiveness as a result of interventions in other modes. Nonetheless, a slight decline in walk and cycle without further intervention remains a possible policy outcome. The freight model does not include a detailed set of assumptions about commodity flows and business development within the area and as such is a crude representation of freight changes in response to economic growth and other changes on the transport network.

Appraisal comparison

<u>Sustainability Appraisal</u>
The sustainability appraisal framework presents the results of each of the three scenarios relative to current year levels (2006) or, where available, future policy targets. A separate appraisal table is produced for each scenario and these are shown in Tables 5 to 7.

The principle differences between the scenarios are those of economic performance, carbon dioxide emissions and safety impacts. Other differences between the scenario outcomes exist, but not to the extent where the qualitative score is affected. Air quality exceedences for example are reduced across all three scenarios for example such that the level of difference between the scenarios is of less importance. Energy use per trip does vary across the scenarios but by a relatively small amount (0.1MJ/trip) compared to the overall reduction (around 0.9MJ/trip) and all would therefore score positive as no target yet exists for the energy efficiency of journeys.

Table 5: Scenario A Sustainability Appraisal

OPTION	DESCRIPTION	Appraisal Year	
Test A	**Proposed Baseline test for LTP2 with added behavioural change.** Widening of the M?0 J? to J?. 33% increase in capacity on the B to A LRT line. Implementation of Quality Bus Corridors for 30% of buses leading to reliability and speeds improvements. Information and quality investment improvements for bus, cycle, walk and rail. Car sharing and teleworking schemes on commuting trips. Home shopping on shopping trips.	2021	

OBJECTIVE			QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ENVIRONMENT	Pollutant Absorption Capacity	Total NOx Emissions	NOx emissions falling in line with technological improvements	2006= 47 tonnes; 2021 = 25 tonnes	positive
		Total CO2 emissions	Total traffic levels rising by 7%	2006=11651; 2011=11443;2016=11735; 2021=12062 Levels taken from continuation of current trends (option 1)	positive
		Cumulative Total CO2 emissions	Emissions falling	186215 Tonnes (calculated 5 year rates assumed for intermediate years between model runs) 186416 Tonnes (existing annual rate played forward)	neutral
	Resource Efficiency	Energy use per person-trip	levels slightly falling	2006=6.71; 2011=603; 2016=5.89; 2021= 5.78	positive
		Energy use per tonne-km	levels slightly increasing	** 2006=136.54; 2011=136.91; 2016=137.22; 2021=137.41	negative
	Direct impacts on	Noise	High levels of traffic noise levels along the motorway network and certain sections of the trunk road network. No mention of noise reducing road materials in plan.	N/A	N/A
		Exceedences of Air quality objectives (NOx)	Air quality management plan calls for reductions in 2005 to be about 30% in town centres and central urban locations to meet guidelines.	2001=7; 2006=4; 2021=0	positive
	Environmental Capital	Landscape	No significant impact	N/A	neutral
		Townscape	No significant impact	N/A	neutral
		Heritage of Historic Resources	No significant impact	N/A	neutral
		Bio-diversity	No significant impact	N/A	neutral
		Water Environment	As road traffic increases the risk of larger amounts of pollutants entering watercourses also increases	N/A	neutral
ECONOMY	Standard of Living	Net Benefits			
SOCIETY	Poverty	Average real cost of journey to key destinations	no data available		
	Accessibility	Weighted Journey times to Key destinations by Car and public transport.	Accessibility is already quite good for area. Conditions for car drivers deteriorate slightly with congestion. Public transport conditions slightly improved	**average journey times PT/Car 2021:: 2006** Employment= 39/23: 39/19 Supermarket =40/24 : 40/20; GP= 40/23: 40/20;Primary= 40/24: 40/21; Secondary= 39/24 :42/21; FE= 41/24: 41/21	neutral
	Safety	Slight Casualties	Estimate of change in accident rate given increase in flows to keep casualties constant (Current rate =3.40e-08)	-16% change in accident rate to keep KSI constant to 2006	neutral
		Killed and Seriously Injured	Estimate of change in accident rate given increase in flows to keep KSI constant (Current rate =.000369667)	-46% change in accident rate to keep KSI constant to 2006	neutral

Table 6: Scenario B Sustainability Appraisal

OPTION	DESCRIPTION	Appraisal Year	
Test B	**This test represents major PT investment from 2006 onwards with previous behaviour change measures.** Bus and Rail service capacity and frequency improvements; extension of a LRT system, a tram train implementation as well as a bus way network.	2021	

OBJECTIVE			QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ENVIRONMENT	Pollutant Absorption Capacity	Total NOx Emissions	NOx emissions falling in line with technological improvements	2006= 47 tonnes; 2021 = 27 tonnes	positive
		Total CO2 emissions	Total traffic levels rising by 8%	2006=11640; 2011=11669;2016=11890; 2021=12208 Levels taken from Webtag (option 1)	negative
		Cumulative Total CO2 emissions	Emissions falling	188240 Tonnes (calculated 5 year rates assumed for intermediate years between model runs) 186240 Tonnes (existing annual rate played forward)	slightly negative
	Resource Efficiency	Energy use per person-trip	levels slightly falling	2006=6.68; 2011=6.24; 2016=5.95; 2021= 5.82	positive
		Energy use per tonne-km	levels slightly increasing	2006=136.54; 2011=137.11; 2016=139.12; 2021=139.29	negative
	Direct impacts on	Noise	High levels of traffic noise levels along the motorway network and certain sections of the trunk road network. No mention of noise reducing road materials in plan.	N/A	N/A
		Exceedences of Air quality objectives (NOx)	Expansion of PT, tram lines especially have no street level pollutants.	2001=7, 2006=4 2021=0	positive
	Environmental Capital	Landscape	No significant impact	N/A	neutral
		Townscape	No significant impact	N/A	neutral
		Heritage of Historic Resources	No significant impact	N/A	neutral
		Bio-diversity	No significant impact	N/A	neutral
		Water Environment	As road traffic increases the risk of larger amounts of pollutants entering watercourses also increases	N/A	neutral
ECONOMY	Standard of Living	Net Benefits	Benefits in time savings for users and operator revenues outweigh the investment costs	£46 million benefit	positive
SOCIETY	Poverty	Average real cost of journey to key destinations	No Data available		
	Accessibility	Weighted Journey times to Key destinations by Car and public transport.	Accessibility is already quite good for area. Conditions for car drivers deteriorate slightly with congestion. Public transport conditions slightly improved	**Average journey times PT/Car 2021::2006** Employment= 39/22 :: 39/20 Supermarket =40/22::40/20; GP= 40/23::40/20 ;Primary= 40/23::40/21; Secondary= 39/23::42/21; FE= 41/23::41/21	neutral (slight improvement from baseline)
	Safety	Slight Casualties	Estimate of change in accident rate given increase in flows to keep casualties constant (Current rate =3.40e-08)	-12% change in accident rate to keep Slight casualties constant to 2006	neutral
		Killed and Seriously Injured	Estimate of change in accident rate given increase in flows to keep KSI constant (Current rate =.000369667)	-43% change in accident rate to keep KSI constant to 2006	neutral

Table 7: Scenario C Sustainability Appraisal

OPTION	DESCRIPTION	Appraisal Year	
Test C	**This test is as B (PT investment plus behaviour change) but also includes an area-based charging scheme.** All vehicles within the intermediate Ring Road formed around the Regional Centre would be required to pay £4 per day in 2016, rising to £5 per day in 2021 (1991 prices). Households living within the charging area were exempt from paying the full charge and paid 10% of the full charge.	2021	

OBJECTIVE			QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ENVIRONMENT	Pollutant Absorption Capacity	Total NOx Emissions	NOx emissions falling in line with technological improvements	2006= 47 tonnes; 2021 = 26.7 tonnes	positive
		Total CO2 emissions	Total traffic levels rising by 8%	2006=11640; 2011=11669;2016=11775; 2021=12075 Levels taken from continuation of current trends (option 1)	positive
		Cumulative Total CO2 emissions	Emissions falling	187501 Tonnes (calculated 5 year rates assumed for intermediate years between model runs) 186242 Tonnes (existing annual rate played forward)	slightly negative
	Resource Efficiency	Energy use per person-trip	Levels are slightly decreasing	2006=6.68; 2011=6.24; 2016=5.86; 2021= 5.72	positive
		Energy use per tonne-km	Levels are slightly increasing (more than baseline)	2006=136.54; 2011=137.11; 2016=138.91; 2021=139.03	negative
	Direct impacts on	Noise	High levels of traffic noise levels along the motorway network and certain sections of the trunk road network. No mention of noise reducing road materials in plan.	N/A	N/A
		Exceedences of Air quality objectives (NOx)	Congestion charging can help to eliminate slow/idling traffic in built up areas thus improving traffic speeds and pollution emissions.	2001=7, 2006=4, 2021=0	positive
	Environmental Capital	Landscape	No significant impact	N/A	neutral
		Townscape	No significant impact	N/A	neutral
		Heritage of Historic Resources	No significant impact	N/A	neutral
		Bio-diversity	No significant impact	N/A	neutral
		Water Environment	As road traffic increases the risk of larger amounts of pollutants entering watercourses also increases	N/A	neutral
ECONOMY	Standard of Living	Net Benefits	Toll revenue and user time savings outweigh toll operation costs and motoring costs.	£82 million benefit	positive
SOCIETY	Poverty	Average real cost of journey to key destinations	Charging scheme will increase cost of journey for users.		
	Accessibility	Weighted Journey times to Key destinations by Car and public transport.	Accessibility is already quite good for area. Charging scheme can improve journey times by reducing congestion on roads.	**Average journey times PT/Car 2021::2006** Employment= 39/21:: 39/20 Supermarket =40/22::40/20; GP= 40/22::40/20 ;Primary= 40/22::40/21; Secondary= 39/22::42/21; FE= 41/22::41/21	neutral (slight improvement from baseline)
	Safety	Slight Casualties	Estimate of change in accident rate given increase in flows to keep casualties constant (Current rate =3.40e-08)	-9.6% change in accident rate to keep Slight casualties constant to 2006	slightly beneficial (requires the least change in rate)
		Killed and Seriously Injured	Estimate of change in accident rate given increase in flows to keep KSI constant (Current rate =.000369667)	-42% change in accident rate to keep KSI constant to 2006	neutral

The economic impact of Scenario B is expected to be positive £46 million in year 2021, whilst Scenario C including road pricing is expected to be positive £82 million. This is consistent with a large body of economic research which indicates that well-designed road pricing schemes can have a positive net economic impact (DfT,2004b) and that road pricing as part of a package including public transport enhancements is particularly effective (May, 2003). Note that these results are based on ballpark estimates of investment and operating cost provided by an independent consultant and estimates of revenues and user benefits from the LUTI model and TUBA. Net results for 2021 were obtained by amortizing the capital costs.

For carbon dioxide emissions, none of the scenarios is able to provide a reduction in CO_2 from 2006 levels. This reflects the increase in vehicle kilometres over the period and the relatively conservative assumptions about vehicle technology that WebTAG guidance provides (Unit 3.5.6). Of the three scenarios, Scenarios A and C perform broadly similarly whilst the high public transport investment scenario alone shows a more substantial increase in CO_2 levels. As none of the pathways show progress towards any of the domestic CO_2 targets they must be scored as negative.

On safety, the reduction in car kilometres brought about by Scenario C relative to B and A implies less investment required to keep casualty rates at a level consistent with targets for reducing casualty and killed and seriously injured accidents.

NATA Framework Results

One of the principal aims of this project has been to demonstrate the differences in outcomes that might be seen as a result of applying a different approach to appraisal to NATA. This section therefore provides a NATA appraisal of the same three scenarios to enable this comparison to be made.

To develop a NATA appraisal it is essential to specify a clear base case scenario against which the scenarios are to be compared. In this instance it was decided that Scenario A should act as the base case as it essentially comprised of already agreed projects and Local Transport Plan commitments with a relatively low level of behaviour change assumed. Two results are therefore presented for Scenario B vs. Scenario A and for Scenario C vs. Scenario A. The results are presented in Tables 8 and 9.

Table 8: Scenario B AST

OPTION	DESCRIPTION	Assessment year	
Scenario B	**This test represents major PT investment from 2006 onwards with previous behaviour change measures.** Bus and Rail service capacity and frequency improvements; extension of a tram system, a tram train implementation as well as a bus way network.	2021	

OBJECTIVE		QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ENVIRONMENT	Noise	No Data available		
	Local Air Quality	NOx emissions increased slightly to baseline	2 tonnes additional emissions	slightly negative
	Greenhouse Gases	Traffic levels increase slightly, with accompanying increase in CO2 emissions	Increase of 1.97% in 2011, 1.32% in 2016 and 1.20% in 2021 CO2 levels	slightly negative
	Landscape	no significant impact	N/A	N/A
	Townscape	no significant impact	N/A	N/A
	Heritage of Historic Resources	no significant impact	N/A	N/A
	Bio-diversity	no significant impact	N/A	N/A
	Water Environment	no significant impact	N/A	N/A
	Physical Fitness	from 2011 reduction in walk and cycle journeys from reference case	Walk: 2011-1.27%, 2016, -2.24% 2021,-2.39% Cycle:: 2011 , -1.84%, 2016 -3.10% 2021 -3.76%	negative
	Journey Ambience	new public transport lines and upgrading of facilities		moderately beneficial
SAFETY	Accidents	Estimate of change in accident rate given increase in flows to keep slight casualties and KSI constant	KSI 3% less change than reference needed. Slight 4% less change than reference needed	slightly beneficial
	Security	—		
ECONOMY	Public Accounts	government costs for operating, investments in infrastructure, and indirect tax	-£179 million	negative
	Business Users & providers	operator revenue	£39 million	positive
	Consumer users	time savings	£186 million	positive
	Reliability	No Data available		
	Wider Economic Impacts	overall balance for costs and benefits	£46 million	positive
ACCESSIBILITY	Option Values	increased choices w/ new tram, LRT and train lines		beneficial
	Severance	—		
	Access to Transport System	Car journey times increase, PT remains constant to reference.		slightly negative
INTEGRATION	Transport Interchange	improvement of PT services		beneficial
	Land-Use Policy	—		
	Other Government Policies	—		

Table 9: Scenario C AST

OPTION	DESCRIPTION	Assessment year	
Scenario C	**This test is as B (PT investment plus behaviour change) but also includes an area-based charging scheme.** All vehicles within the intermediate Ring Road formed around the Regional Centre would be required to pay £4 per day in 2016, rising to £5 per day in 2021 (1991 prices). Households living within the charging area were exempt from paying the full charge and paid 10% of the full charge.	2021	

OBJECTIVE		QUALITATIVE IMPACTS	QUANTITATIVE MEASURE	ASSESSMENT
ENVIRONMENT	Noise	No Data available		
	Local Air Quality	NOx emissions increased slightly to baseline	1.7 tonnes additional emissions	slightly negative
	Greenhouse Gases	Traffic levels increase slightly, but are followed with steady decrease in CO2 emissions	ncrease of 1.97% in 2011, 0.35% in 2016 and 0.10% in 2021 CO2 levels	slightly beneficial
	Landscape	no significant impact	N/A	N/A
	Townscape	no significant impact	N/A	N/A
	Heritage of Historic Resources	no significant impact	N/A	N/A
	Bio-diversity	no significant impact	N/A	N/A
	Water Environment	no significant impact	N/A	N/A
	Physical Fitness	from 2011 reduction in walk and cycle journeys from reference case	Walk: 2011-1.27%, 2016, -0.46% 2021,-0.44% Cycle:: 2011 , -1.84%, 2016 -0.55% 2021 -1.12%	slightly negative
	Journey Ambience	new public transport lines and upgrading of facilities		moderately beneficial
SAFETY	Accidents	Estimate of change in accident rate given increase in flows to keep slight casualties and KSI constant	KSI 4% less change than reference needed. Slight 6.4% less change than reference needed	slightly beneficial
	Security	—		
ECONOMY	Public Accounts	The cost of setting up the toll system is outweighed by the collected fees	£94 million	positive
	Business Users & providers	revenues from the running of toll and PT system	£71 million	positive
	Consumer users	the cost of toll outweighs the time savings benefit for users	-£82 million	negative
	Reliability	No Data available		
	Wider Economic Impacts	the overall benefits outweigh the costs	£82 million	positive
ACCESSIBILITY	Option Values	increased choices w/ new tram, LRT and train lines; congestion charging could have potential negative effects on low-income drivers		beneficial
	Severance	—		
	Access to Transport System	Car journey times increase slightly, PT remains constant to reference.		slightly negative
INTEGRATION	Transport Interchange	improvement of PT services; congestion charging can stimulate modal shift		beneficial
	Land-Use Policy	—		
	Other Government Policies	—		

Discussion

This paper has sought to ask whether looking at the position and direction of change of a range of sustainability indicators makes a difference to the type of transport strategy chosen.

The findings suggest that using amortisation of economic costs and comparing this to benefits in various appraisal years does not alter the ranking of alternatives between NATA and the proposed sustainability appraisal. Option C, with the inclusion of substantial public transport investment and charging performs the best. By contrast, the carbon emissions performance of a strategy reliant on public transport enhancements without restraint (Option B) leads to a negative impacts in both frameworks whilst Option C (with charging) appears neutral in NATA but still negative in the sustainability appraisal. This indicates that the Option C may be broadly similar to Option A in carbon outcomes but it still does not set the city on a path to carbon reductions.

The social sustainability of the strategies proved difficult to assess with the tools currently available. The assumptions required to assess the accessibility of the population to key services are substantial in the current year. In future years there will be changes to the pattern of commercial provision and to the location of key services. These were not able to be assessed. A more detailed discussion of the shortcomings of the social assessment can be found in Lucas et al., 2007). This places a spotlight on the current problems that exist in promoting a meaningful sustainability assessment that really captures progress on the three pillars. We would also note the difficulty in assessing issues such as physical fitness (as shown in the NATA AST). The strategic model does not contain any walk or cycle networks and there are currently no interventions modelled. The assessment provided does not include the walk elements of public transport trips for a lack of data and this perhaps also negatively skews this finding.

One of the difficulties that we encountered in differentiating between strategies related to technological improvements. Although recently improved[6], the Webtag scenarios discuss uncertainty in the future emissions of the vehicle fleet without providing clear guidance on how this should be implemented. The National Atmospheric Emissions Inventory was also helpful for current technologies but not future scenarios. In particular we found that the comparatively high per-km emissions from public transport offset some large reductions in the km travelled by car. We performed some sensitivity tests on the emissions values for the three scenarios as shown in Figure 3.[7] It shows that the assumptions about future technology matter more to the carbon emission outcomes than the differences between the transport

[6] Note that our results were calculated before the changes to vehicle fleet efficiency in Webtag were introduced. This would change the comparative position of Webtag and current trends but the issue raised remains the same.

[7] This analysis did not extend to feeding the efficiency improvements back into vehicle operating costs which would lead to some extra traffic. These results can therefore be seen as top end estimates.

strategies proposed. This suggests a need to reconsider the advice on the future emissions of all modes.

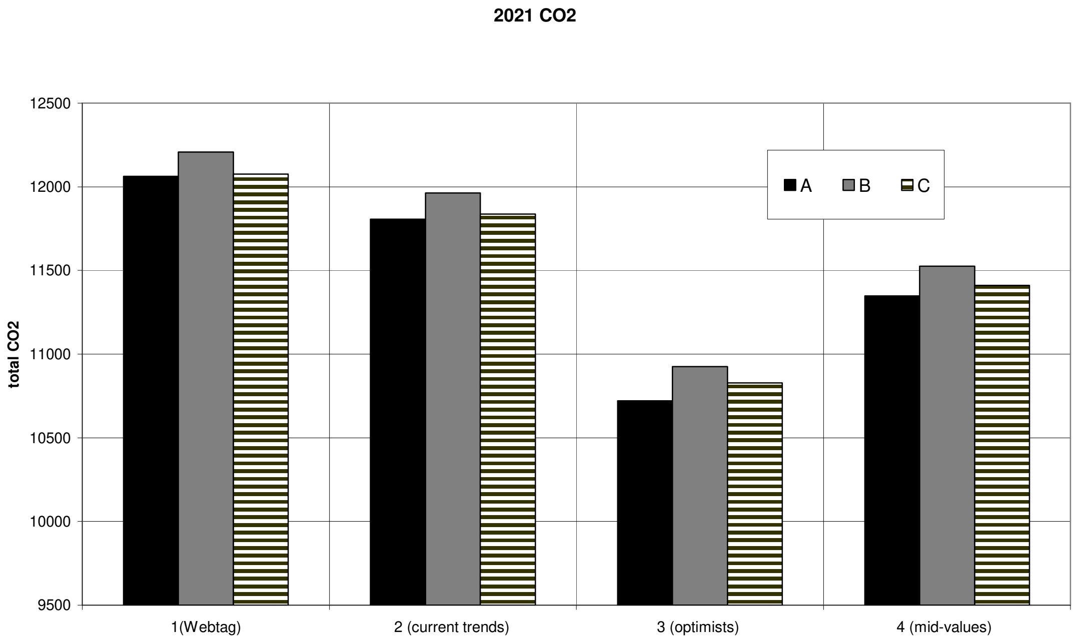

Figure 3: CO_2 emissions by test and technology scenario

In conclusion, the proposed new methodology for sustainability appraisal does not alter the ranking of the strategies we examined. If some of the other shortcomings of the appraisal approach can be overcome then we suggest that applying this technique to a broader range of schemes and strategies would prove the wider transferability of the approach to see under what conditions this holds true. Importantly, the sustainability appraisal does highlight those strategies which score positively in Webtag (relative to the do-minimum scenario) but which continue to work against key environmental objectives.

The research has highlighted a number of shortcomings in our capabilities of modelling economic, social and environmental progress. If we are to assess the sustainability of transport strategies then these shortcomings need to be overcome or the assessments we conduct will be flawed and the comfort we draw from them misplaced.

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