STAG Technical Database Section 9

Economy

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Transport Scotland

Version History

Changes since STAG Refresh, May 2008

Change number	Section updated	Date
1	9.3.1 Agglomeration economies	September 2008
2	New section 9.3.5.1 Agglomeration benefits – zonal method (previously 9.3.1)	September 2008
3	New section 9.3.5.2 Agglomeration benefits – APARC method (previously 9.3.5.1)	September 2008
4	New section 9.3.5.3 Competition Impacts (previously 9.3.5.2)	September 2008
5	9.5.18 Vehicle operating costs (fuel)	September 2008
6	9.5.19 Rates of change in fuel VOCs	September 2008
7	9.2.2.1 and 9.5.23 – Rail Appraisal – Road Network Effects	December 2008
8	9.3.6 – Reporting Wider Economic Benefits	December 2008
9	9.5.18 Vehicle operating costs (fuel)	April 2009
10	9.5.19 Rates of change in fuel VOCs	April 2009
11	9.5.22 Rail operating costs	April 2009
12	9.2.2.9 Reliability benefits	December 2009
13	9.2.2.8 Quality benefits	December 2009
14	9.2.2.4 User benefits – values of time	December 2009
15	9.3.3 Increased output in imperfectly competitive markets	December 2009
16	9.5.13 Forecast Growth in Values of Time	April 2012
17	9.5.18 Vehicle operating costs (fuel and electricity)	April 2012
18	9.2.2.2 Traffic growth	April 2012
19	9.2 Transport Economic Efficiency (TEE)	April 2012
20	9.5.13 Forecast Growth in Values of Time	November 2012
21	9.5.6 Units of Account	November 2012
22	9.5.18 Vehicle operating costs (fuel and electricity)	November 2012
23	9.2.2.3 Growth in Public Transport Patronage	November 2012
24	9.2.2.9 Journey Time Reliability Benefits	December 2013
25	Updates to WebTAG references relating to the release of TAG2. References to Transport Scotland Economy Spreadsheet added.	May 2014
26	Hyperlink to Economy Spreadsheet added	August 2014
27	Enhanced guidance on Driver Frustration and Rule of Half Clarification	January 2015
28	Update to fuel consumption parameters used in fuel consumption (FC) equation and forecast improvements in fuel efficiency	April 2015
29	Further clarification of indirect tax revenues.	April 2015
30	9.5.14 Car Occupancies	September 2016
31	9.5.18 Vehicle Operating Costs (Fuel and electricity)	September 2016
32	9.5.19 Rates of Change in Fuel VOCs	September 2016
33	9.5.7 Price Base Year and 9.3 new Wider Economic Impacts guidance replacing sections on Wider Economic Benefits and Economic and Location Impacts	March 2017
34	Update 9.4.12 to reflect new WebTAG values of time	August 2017

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9. Economy

The Part 2 Appraisal against the Economy Criterion has two sub-criteria which together should summarise the full extent of economic impacts. These are:

- Transport Economic Efficiency (TEE)- the benefits ordinarily captured by standard cost- benefit analysis- the transport impacts of an option (including the use of bespoke values if appropriate and subject to approval by Transport Scotland);
- Wider Economic Impacts (WEI) - impacts in non-transport markets that are either of importance from a policy or distributional perspective or which affect the net value that society attributes to the outcomes of a transport intervention.

9.1 Introduction

There are two elements to the Economy Criterion – improving the economic efficiency of transport and improving the efficiency of economic activities.

In general terms, economics is the analysis of scarce resources which have alternative uses. If an economic system is Pareto efficient, then it is the case that no one person or group can be made better off without another being made worse off. In the STAG Appraisal the Economy Criterion is concerned primarily with maximising the net benefits, in resource terms, of the provision of transport. This requires maximising consumer surplus by maximising the difference between the willingness to pay of transport users and the resource costs of the provision, operation and maintenance of transport facilities – consumer surplus being measured by the difference between the maximum which an individual transport user is willing to pay to travel and the actual cost of that journey. Therefore, consumer surplus is increased when travel time, operating costs and transfer payments, such as fares, are reduced and when more transport users are able to travel due to the reduction in costs.

The impact of a transport infrastructure project on the economy is assessed via a Transport Economic Efficiency Analysis (TEE) and a Wider Economic Impacts Analysis (WEI).

9.1.1 Transport Economic Efficiency (TEE)

The TEE analysis captures the main impacts of an option in terms of economic welfare, as represented by the main costs and benefits of users and operators of the transport system. These impacts are expressed in terms of monetary values, by Cost-Benefit Analysis (CBA), which are added together and discounted to produce a Net Present Value (NPV). Costs to the public sector are itemised separately (see Section 12 Cost to Government).

The TEE analysis presents the key effects disaggregated by particular groups, mode of transport, and by impact (time, vehicle operating costs etc.). In addition to a statement of aggregate impact (NPV, BCR), section 9.2.2.1 now requires the classification of journey time savings by the size.

A TEE analysis should be presented for each option and should demonstrate the change in costs and benefits for each option relative to the do-minimum case.

9.1.2 Wider Economic Impacts (WEIs)

Whilst the TEE analysis is designed to approximate the full economic impacts of a transport project in terms of economic welfare, there is an acceptance that the CBA fails to fully capture the wider benefits of improved transport provision to the economy. The

SACTRA (1999) report on Transport and the Economy explored the issue of how transport provision can contribute to economic development. This led to the inclusion within STAG of guidance that sought to quantify the benefits of transport investment that are not captured in the CBA.

The guidance that follows is based on research conducted in 2015 by Connected Economics for Transport Scotland to examine the latest evidence and research on the wider impacts of transport investment.

WEIs = impacts in non-transport markets that are either of importance from a policy or distributional perspective or which affect the net value that society attributes to the outcomes of a transport intervention.

Details on the methodology to be used is presented in Section 9.3

As with previous STAG advice on wider impacts, the results of the WEIs analysis should be treated as a sensitivity to the TEE results. The rationale of this approach is that it is difficult to monitor and evaluate the benefits captured by the WEIs analysis

9.2 Transport Economic Efficiency (TEE)

The Transport Economic Efficiency (TEE) Analysis provides guidance on how to assess the contribution which a transport option may have on economic welfare through consideration of the resultant transport costs and benefits. The transport costs and benefits captured by the TEE, and collated into an NPV, are intended to represent an acceptable approximation of the full economic impacts of a project, expressed in terms of economic welfare. It provides guidance on the principles which underpin the general approach to be followed and outlines issues and methodologies relating to different sub-criteria. Practitioners must follow this guidance and if required request advice from Transport Scotland on technical matters relating to the appraisal parameters. It should be noted that the method set out is broadly consistent with that previously specified by the Department for Transport (WebTAG) but has some key differences in the scope of impacts and in the interpretation of outputs.

Following the 1999 SACTRA report and work carried forward by DfT, the TEE analysis is now supplemented by Wider Economic Impacts (WEIs) analysis and this methodology is detailed in section 9.3.

9.2.1 Principles of TEE analysis

The central principle of transport economic efficiency analysis is to estimate the welfare gain which results from transport investment, as measured by the individual's willingness to pay for such an improvement and the financial impact on private sector transport operators. Willingness to pay should be consistent with the demand response to the improved transport opportunities.

The accepted best measure of welfare gain is the change in consumer surplus enjoyed by individuals and the change in producer surplus/deficit accruing to transport suppliers. Consumer surplus is defined as the benefit that an individual enjoys over and above the cost they would be willing to pay. In transport, cost is defined in money and time terms (usually called *generalised cost*). Thus, if an individual is currently willing to travel for 15 minutes to enjoy an activity and a transport option reduces that to 10 minutes then the time saving of 5 minutes is an accurate measure of their consumer surplus. However, if new users are attracted to use the facility (either by switching from another mode or by choosing to travel when otherwise they would not have) in response to this time saving, then it is not normally clear at what time saving they would have been willing to switch. Here, the convention is to assume that the switch would have occurred, on average, halfway between the do-minimum and do-something saving.

As the generalised cost of transport falls (from GC0 to GC1 in Figure 9.1) demand increases (from D0 to D1) along the demand schedule. The demand schedule (or demand curve) indicates the demand at different levels of generalised cost. The demand curve slopes downwards, as each additional unit of demand is generated through an incremental decrease in generalised cost.

The change in consumer surplus for each unit of induced traffic is, therefore, less than that experienced by existing users (D0). Furthermore, it becomes progressively less as each additional unit of demand is generated until, for the marginal user, the change in consumer surplus is zero. This is because the marginal user is indifferent between travelling to a new activity and undertaking the activity they were doing prior to the lowering of generalised cost.

It is unusual to know the exact shape of a travel demand curve and, therefore, it is difficult to calculate the exact change in consumers' surplus for a transport intervention.

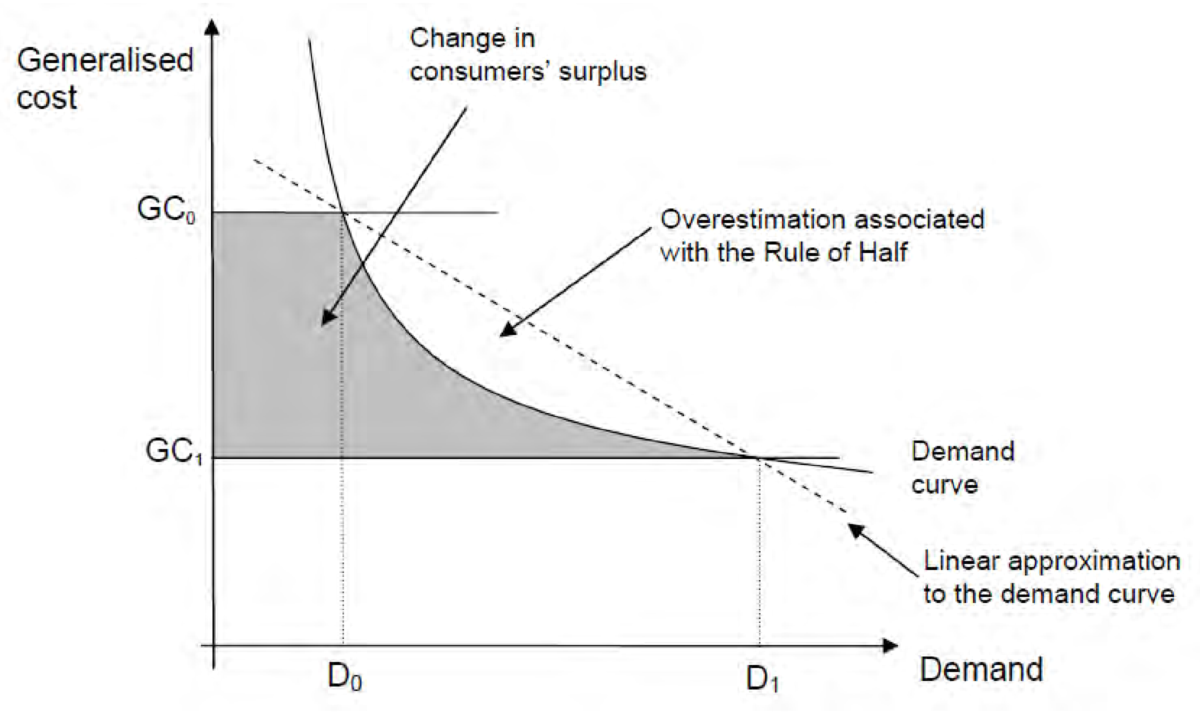
The convention, and that advocated by STAG, is, therefore, to assume the demand curve is linear. This is illustrated in Figure 9.1 Once a functional form for the demand curve has been assumed the change in consumer surplus can be calculated knowing only the generalised cost before and after the intervention, as well as the demand before and after. This approximation is known as the Rule of Half.

This approximation would attribute 2.5 minutes of benefit to new users in the above example.

An important point to note here is that the Rule of Half convention actually overestimates the change in consumer surplus. This is illustrated in Figure 9.1. The overestimation of benefit occurs as the demand curve is convex to the origin. The Rule of Half convention, therefore, assigns more value to induced traffic than it should. This is typically relatively insignificant and the methodology is still appropriate.

However, a limitation of this Rule of Half approximation is where the change in generalised cost is significant. In a mature transport network, large improvements to generalised cost are likely to be difficult to attain, however where transport networks are less developed, for example in rural areas, this is more probable. When cost changes are large the error of approximating the demand curve with a linear schedule becomes important, and so the appraisal practitioner should be aware there where changes in generalised cost are significant this overestimation is likely to be increased. The issues of large cost changes and the introduction of new modes are discussed in detail in Nellthorp and Hyman (2001)[1] and advice on how to address them is given in TUBA guidance.

Figure 9.1



1 NELLTHORP, J. and G. HYMAN. 2001. Alternatives to the rule of a half in matrix based appraisal, Proceedings of the European Transport Conference, 10-12 September, Cambridge. London: AET Transport

As in all aspects of STAG Appraisal, it is important to demonstrate, in several dimensions, the distributional impacts of a scheme within the overall TEE analysis. These include:

- Spatial impacts: how benefits and costs fall across the area of analysis or the modelled area. It should be noted that this is distinct from the spatial distributional impacts analysed in the EALI analysis.
- Socio-economic impacts: how benefits fall to different groups of the population.
- Provider/user impacts: how benefits/costs fall to public transport providers and/or users. For example, a rise in fares will reduce the consumer surplus of existing travellers (and discourage some from travelling by this mode) but will represent a benefit to the public transport provider, assuming demand is inelastic.
- User group impacts: how benefits and costs fall to motorists and/or users of public transport services.
- Time savings impacts: the distribution of journey time changes by size of those time savings.

The relative importance of different types of distributional effects will depend on the option being appraised. Where public transport operators are affected, the breakdown of costs and revenues by mode should be undertaken.

Presentation of journey time impacts by size of time saving is obligatory where a transport model has been undertaken to inform the appraisal.

The results of economic appraisals should be expressed in the market price unit of account (see section 9.5 Appraisal Parameters), i.e. including indirect taxes. This is consistent with the willingness to pay principle underpinning the calculation of benefits.

9.2.2 Calculation of TEE Inputs

Guidance for the calculation of TEE inputs is provided via the attached links.

9.2.2.1 Benefits to Transport Users

The economic benefits of transport projects are often captured through an analysis of the impacts on transport users. Benefits to users often fall into the following sub-groups:

- Transport users whose travel patterns do not change but who enjoy time saving and/or other benefits;
- Diverting users, who switch from other routes because of changes in relative (generalised) costs;
- Diverting users who switch mode in response to changes in relative (generalised) costs;
- Generated users, whose use was previously frustrated by, for example, traffic conditions on the option, route or service; and
- Redistributed users who may change their origin or destination in response to transport changes (for example, finding employment elsewhere).

Benefits typically arise from a combination of the following:

- Changes in the monetary costs of travel;
- Journey time savings achieved directly, for example by using a new road or bridge rather than the next best alternative;
- Improvements in journey time reliability or journey quality, which may be especially important for certain types of users such as delivery services;

- Improvements in journey time reliability or journey quality, such as comfort or reduction in number of interchanges.

Journey time benefits and disbenefits form a key component of transport user benefits. The process to be applied in quantifying and valuing journey time changes is well established and forms the basis for transport modelling. This is described in section 9.2.2.4 and values of time to be used in appraisal can be found in section 9.5.12.

It is acknowledged that this approach may overlook significant differences in the distribution of journey time (dis-) benefits over space and across transport users.

Economic Activity and Locational Impact (EALI) assessment seeks to understand the distribution of benefits over space.

To give greater transparency to the distribution of (dis-) benefits across transport users, appraisers should, in addition to reporting aggregate journey time (dis-) benefits as a component of overall TEE benefits or costs, present journey time changes (as savings) classified by size. Six size classifications are recommended. This data is produced by the UK Department for Transport's "Transport User Benefit Analysis" (TUBA) software program version 1.8 onwards. The information should be presented as shown below:

Size of time saving	**Total journey time savings (mins)**				**Total monetised journey time savings (£m, %, 2002 prices)**			
Classification	***Work trips***	***% total journey time***	***Non-work trips***	***% total journey time***	***Work trips***	***%***	***Non-work trips***	***%***
< -5 mins	** **		** **		** **		** **	
-5 to -2 mins	**		**		**		**	
>-2 to 0 mins	**		**		**		**	
0 to <+2 mins	**		**		**		**	
+2 to +5 mins	**		**		**		**	
>5 mins	**		**		**		**	

** Data should be provided for the 1st modelled year (after scheme opening) and for the entire appraisal period. These outputs are available from TUBA version 1.8 onwards.

While the classification and presentation of journey time changes by size provides the decision-maker with an understanding of the distribution or equity of journey time as savings among users, this does not exclude projects which do not offer journey time savings nor imply a preference for projects which result in a large number of small journey time savings. Furthermore, journey time savings should continue to be monetised using the standard equity values of time laid out in tables 9.2 and 9.3 until such time as the evidence for the value of small time savings versus large time savings is better established.

As transport projects form part of a system or network, network-wide effects should be considered. This can help show whether transport users of other modes or routes gain if an option is implemented. Network effects which will give rise to benefits to non users include:

- Reduction in journey times on other routes which arise because of some users of the other route(s) switching to the new route or switching mode;
- Improvements in journey time reliability and other aspects of journey quality, arising for similar reasons.

These impacts may be reduced as changes in travel conditions are likely to generate additional traffic on other routes, so that, for example, time savings generated as some users switch routes are reduced, while suppressed demand is released on the other routes. These effects also need to be assessed where they are likely to be significant.

These impacts, which occur outwith or external to the option under consideration, need to be identified at an early stage in the Part 2 Appraisal. Where these are likely to be important in relation to the costs and other benefits of the option, they should be quantified in the same manner as direct benefits and costs. Further guidance on how to calculate these effects is provided in Section 9.5.23.

9.2.2.2 Traffic Growth

The starting point for the assessment of road traffic growth should be the Scottish Trip End Programme (STEP) or, alternatively, the DfT database TEMPRO-NTEM. STEP provides local growth factors consistent with future land-use plans in Scotland. The socio-economic data which forms inputs to the model (population, employment etc.) and STEP are consistent with those used in TEMPRO-NTEM.

However, the factors highlighted in the following paragraphs will also need to be considered on a project specific basis.

It is necessary to make forecasts of traffic growth which distinguish and take account of:

- Growth in demand which will occur in the network whether or not the particular project is undertaken;
- Specific generated traffic growth, which should be treated where possible in a dynamic rather than static framework;
- Collateral traffic growth/generation, i.e. growth due to specific additional activity, defined below.

Provided land-use plans are not dependent on the transport option, then STEP should be the best source of information for the first of these forecasts.

Where forecasts are required to take account of generated traffic growth or in the presence of dependent housing or land use developments, it is recommended that practitioners consult the LATIS service.

If practitioners wish to adopt growth forecasts other than those derived from STEP or TEMPRO-NTEM, they should discuss alternative options with the Scottish Government, Transport Scotland or other relevant funding agency at the earliest opportunity.

In addition to the release and subsequent growth of demand (generated traffic or patronage), options may give rise to factors which alter the overall demand for travel at each level of generalised cost – a shift of the demand curve. This is here termed collateral traffic growth, in order to avoid confusion with the concept of induced traffic growth, which typically refers to direct or indirect generated traffic.

Collateral effects need to be identified and, where important, quantified. These effects are derived from a chain of cause and effect in which the transport option changes the parameters which determine the level of demand at local or national level, and can take place for a number of reasons, including:

- Land-use effects, for example where the transport investment would open up otherwise unavailable land resources for industrial, commercial and residential development;
- Mobile investment which is attracted because of improved accessibility, involving perhaps additional workers and/or the attraction of industries which raise local/regional incomes, leading to additional traffic.

These effects are traffic effects but take place through what are termed WEIs – Wider Economic Impacts. As discussed below in the section 9.3 on WEIs, the essential first step is to identify the WEIs and the rationale for them, then to assess their implications for demand for travel.

9.2.2.3 Growth in Public Transport Patronage

Projected trends in public transport patronage should be considered with particular reference to local time-series trends. Practitioners may also wish to take account of:

- Industry projections of growth (for example for the rail network); and
- Forecasts produced by multi-modal area-wide models, such as TMfS.

If growth in public transport patronage is of particular importance for the option under consideration, practitioners may wish to consider developing bespoke public transport growth models. In such circumstances practitioners should discuss their methodology with Transport Scotland or other relevant funding agency.

Where demand forecasting in rail is necessary, Transport Scotland believe that it is not reasonable to expect that demand will grow infinitely and that there should be a cap on rail demand growth. For the purposes of appraisal, demand should be capped in 2032, unless there is a clear argument and explanation of why a different cap has been used.

9.2.2.4 User Benefits - Values of Time

An important factor in the assessment of the transport options is the impact on the time spent travelling, for both personal travel and freight. In order to include these impacts in the estimation of user benefits, it is necessary to put a money value on time savings. In the appraisal process, the general premise is that the value of resources used or saved is reflected in their market prices. This is the principle underlying the valuation of working time savings. However, in the case of non-working time savings, in general there is no market in which time can be traded for money, and therefore no directly observable market price exists. Instead, values are derived from users' willingness to trade money for time, obtained from either revealed preference (RP) or stated preference (SP) surveys.

The standard values of time and the factors for up-rating them are presented in Section 9.5.12.

In a multi-modal or public transport context, there is the complication that non-business travellers do not value time spent walking to or waiting for public transport at the same rate as time spent travelling in the vehicle. This disutility is different for 'commuting' and 'other' journeys. Time spent waiting for public transport services should be valued at two and a half times the value of non-working 'commuting' and 'other' time respectively; time spent in interchange on journeys on public transport should be valued at two times the value of 'commuting' and 'other' time respectively. Where an option may be specifically designed to enhance the waiting environment (for example a bus station) then local surveys to measure disutility and willingness to pay for improvements may be valuable to modify this approach. This may be particularly useful where this represents the main justification for an option.

This issue of wait time is of particular importance when appraising changes to ferry services or their replacement with fixed links. Scheduling costs are defined as the welfare cost imposed upon activity scheduling by transport constraints. Scheduling costs arise as transport constraints prevent activities being undertaken at the desired time or for the desired duration. Such scheduling costs, like travel time costs, form an disincentive to travel and therefore improvements in transport quality – through improved frequency of service – can reduce scheduling costs and improve the overall economic benefit of a transport improvement option. Scheduling costs are more relevant where headways are long and operating hours are short (before the proposed transport improvement) than where services are reasonably frequent and operating hours are also reasonable. Restrictions in departure time choices that will be the primary driver for scheduling costs. Any change in time spent waiting, which is taken as half the service interval, should be included and valued as set out above.

There is also evidence that travellers are willing to pay to avoid interchange between modes in addition to the reduction in time spent waiting for the subsequent leg of the journey.

This 'interchange penalty' must be included in changes to benefits. The factor to allow for this disutility will normally lie in a range between 3 minutes and 15 minutes for urban travel, depending on the quality of the interchange and the distribution of perceptions of users, which can vary widely. Research commissioned by the Scottish Government derived values of 4.5 minutes for bus users and 8 minutes for rail users, each based on research in large cities.[2] For interurban rail travel, the value will be higher. The use of an appropriate value should be justified either through establishing local values through research or with recourse to comparable examples elsewhere. Practitioners should be careful not to double-count time spent waiting for a connecting service within an appropriate interchange penalty.

9.2.2.5 Indirect Taxation Adjustments

All costs and benefits should be quoted in market prices (see Appraisal Parameters Section 9.5.6). The market price values of time for working time include a mark up for indirect taxes of 19.0%, which is equivalent to the average rate of indirect taxation in the UK economy. For non-working time, the benefit is perceived by the individual and is therefore inclusive of indirect tax. These market price values should be used as set out in Section 9.5.6.

In disaggregating the impacts upon user groups, allocations of financial impacts between Government and others is required. For example, a saving in fuel costs for drivers should be valued at current market prices (i.e. including fuel duty), but on the other side of the equation the loss of tax revenue to Government needs to be taken into account. Practitioners should refer to Section 12 Costs to Government.

[2] Laird J., Review of Economic Assessment in Rural Transport Appraisal, (2009), http://www.scotland.gov.uk/Publications/2009/10/29110947/0

9.2.2.6 User Charges

In general terms, any additional charges paid should be treated as a cost to travellers (i.e. a negative value in the AST) and a reduction in charges should be treated as a benefit. For users who switch mode from car to public transport, the additional fare paid will be a disbenefit to the car user, but they will also make a financial gain in terms of savings in vehicle operating costs.

9.2.2.7 Changes in Vehicle Operating Costs

Transport proposals can generate changes in the operating costs incurred by the user. Vehicle operating costs are defined as costs that vary with vehicle usage and are based on vehicle-miles travelled. These costs include fuel, tyres, oil, maintenance, repairs, and mileage-dependent depreciation. This comes about due to changes in the volume of car travel, both through mode switching or induced traffic, and in the speed and distance travelled as a result of route changes.

Vehicle Operating Cost (VOC) calculations should be consistent with the parameters included in Section 9.5.17. This incorporates future changes in the resource cost of fuel and in vehicle efficiency.

9.2.2.8 Quality Benefits

Journey quality could be considered as an important determinant of travel behaviour. For example, it is reasonable to expect that poor journey quality could act as a deterrent to mode or route choice or as a disincentive to make a journey. Travel decisions may be based on the weakest link in the journey and addressing poor quality travel elements may therefore remove barriers to travel.

In transport appraisal there is a debate as to whether willingness to pay for quality benefits should be included in the TEE analysis. However, it is invariably the case that the costs of quality improvements are subsumed within option costs. By not including perceived benefits, there would be a problem of bias against those options that have an explicit objective to improve quality. Willingness to pay for quality benefits has been investigated through stated preference research but the absence of definitive values for quality improvements persists. Consequently, quality benefits should typically be assessed qualitatively in the TEE analysis.

An exception to this under certain circumstances is driver frustration. Depending on the nature of the appraisal and the existing problems, a quality benefit which may be appropriate to apply relates to how the transport interventions will relieve driver frustration. Driver Frustration relates to the psychological state that occurs when a driver is blocked from making progress towards the goals of their journey. The Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3, Part 9 lists driver frustration as one of the three components of driver stress. The remaining two components of driver stress are fear of potential accidents and uncertainty relating to the route being followed.

Research undertaken on the monetisation of driver frustration for a rural single carriageway A-class trunk road has found that there is a statistically significant value of time uplift relating to: the presence of oncoming traffic, the degree to which travel is below desired speed; and the number of HGVs in the platoon ahead. These relationships were derived from:

- an experimental study which involves road users watching bespoke computer-simulated video clips showing a range of variables, and accompanying questionnaires for road users to rate frustration on a scale; and
- a stated preference (SP) self-completion route choice exercise.

Values of time multipliers are derived from users' willingness to trade route choice options obtained from SP surveys. In most circumstances the value of time multipliers are not transferrable between routes and bespoke value of time multipliers should be applied. Outputs from microsimulation modelling relating to factors which may cause driver frustration by link and vehicle purpose for each time period can be used to apply the value of time outputs thus providing Present Value of Benefits (PVB) related to relieving driver frustration.

By comparing actual total link time and perceived total link time additional time perception can be quantified. Applying standard values of time allows the values to be monetised. It is necessary run and average a minimum of five seed runs of a microsimulation model to provide robust results. The monetisation of driver frustration applies only to drivers and not to passengers.

Caution should be exercised in applying value of time multipliers to reflect travel at below desired speed as the application of travel at below desired should apply to free flow time. Research is ongoing to refine to refine the range of values which are affected. Until this research is finalised it is recommended to present the monetisation of driver frustration as a sensitivity to the standard TEE analysis.

9.2.2.9 Journey Time Reliability Benefits

The measurement, assessment and valuation of journey time reliability has gained increasing recognition as the potential contribution of projects to improved journey time reliability has been realised, most notably, in the case of Intelligent Transport Systems (ITS) projects.

Travellers are sensitive to the consequences, such as prolonged waiting times, missed connections and arrival at the destination either before or after the desired or expected arrival time. Over time, there is evidence to suggest journey time unreliability, valued more highly than journey time, can itself become predictable and, correctly or incorrectly influence traveller mode or route choice.

Evidence suggests that travellers value changes in excess travel time (i.e. late running) higher than changes in scheduled travel time and that the value of journey time depends on the probability of delay.

Scoping
Transport Scotland recognize that the calculation of reliability benefits can be resource intensive, depending on the modelling tools which practitioners have available. As such, it is important that the need to undertake an assessment of reliability benefits is properly scoped at Part One Appraisal, to ensure that the resource dedicated to the analysis is proportionate to the requirements of the study and the scale of the expected impacts.

Definitions
Journey time reliability is defined as the variation in journey time that drivers or passengers cannot predict. It arises from random and non-random effects as follows:

- Day to day variability- variability in congestion in the same period every day;
- Variability due to random events including incidents, accidents etc.

Appraisal is normally concerned with journey time unreliability as a problem or issue to be measured and addressed. Conversely, the assessment of potential improvements to journey time reliability forms the basis for the evaluation of benefits associated with a project.

Public Transport Journey Time Reliability measurement and evaluation
Reliability in the context of public transport is conceived of in terms of "lateness" defined as the difference between travellers' actual and timetabled arrival times. Note, early arrivals are ignored in the valuation of public transport journey time reliability. In the case of rail, early arrivals are recorded but not used in the calculation of Passenger Performance Measures (PPM).

Two measures of lateness must be considered: average lateness; and the variability of lateness, measured by the standard deviation of lateness. To assess these and the number of passengers affected, data from a number of sources is required:

- Service timetables;
- Service headways;
- Recorded delay information;
- Passenger Performance Measures (PPM) for relevant rail routes and operators;
- Proportion of rail services subject to delay;
- Estimates of current and forecast passenger demand by origin-destination (or journey length) and journey purpose for relevant services and routes with and without the project.

A measure of rail performance must also examine the rate of cancelled services or reliability. To make allowance for the total lateness caused by cancelled trains we usually multiply the service interval by 1.5. This cancellation factor is in line with the notion that in this case the delay impacts on waiting rather than in-vehicle time. Waiting time incurs higher disutility than in-vehicle time because of the additional discomfort involved. The resulting lateness should then be multiplied by the lateness factor of 3 to capture the full costs of poor performance.

Therefore a central lateness factor of three, which includes the uplift of 20% for a change in variability, should be used in the general case. Where sufficient evidence can be provided to justify the application of a different lateness factor a value higher or lower than 3 should be adopted. In the general case one minute of average lateness is valued by passengers as being equivalent to three minutes of scheduled journey time. This conversion to scheduled journey time allows us to place a monetary value on reliability using the appropriate value of time.

Where no delay data is available for an intermediate station the analyst should use delay data from the final destination. In this case it may be appropriate to use a different lateness factor. But a robust rationale should be provided for any departure from the recommended central factor of 3.

The Passenger Demand Forecasting Handbook (PDFH) provides guidance for the measurement and valuation of lateness and unpredictable delay affecting rail passengers and the assessment of the impact of rail projects upon journey time reliability.

To estimate the monetised benefit of changes in the variability of lateness (for public transport), money values are needed. The concept of the reliability ratio enables changes in variability of lateness or of journey time to be expressed in monetary terms. The reliability ratio is defined as:

Reliability Ratio = Value of SD of lateness / Value of lateness.

Broadly, the value of average lateness for public transport is expected to be the same as the value of time spent waiting for public transport, that is, at 2.5 times the value of in-vehicle time; the value of the reliability ratio ranges from 0.6 to 1.5 for public and about 0.8 for private passenger travel.

For the purposes of appraisal, the recommended reliability ratio values are shown below:

Journey Purpose	**Mode**	**Reliability ratio**
All	Train	1.4
All	Bus/Tram/Metro	1.4

If the reliability ratio has a value of, for example 0.5, then a 1 minute reduction in the standard deviation of delay is equivalent to a 0.5 minute reduction in mean delay.

Given that it is rare that we ever have a complete knowledge of the delay distribution with which to calculate the standard deviation of journey time, an alternative method can be used. 'The Valuation of Reliability for Personal Travel', Transportation Research Part E 37, Bates, J., Polak, J., Jones, P and A. Cook (2001) suggested that it is the "pure" lateness effect which tends to dominate the calculations, because the effect of variability is less important given that rail passengers have already made some "compromises" in selecting arrival or departure time of their preferred scheduled train.

Indeed, as noted earlier, some travellers may find that variability brings them closer to their preferred arrival time than an "on-time" arrival would. Consequently a 20% uplift of the lateness factor is an acceptable proxy for the additional disutility incurred as a result of variability in delay.

Road Journey Time Reliability measurement and evaluation

The preferred measure of journey time reliability for drivers and passengers on the road network is the standard deviation in travel time for a particular hour/period of the day. This, by definition, assumes travel times are normally distributed. Reliability can be usefully stated as the coefficient of variation; the ratio of the standard deviation of journey time and average journey time for a particular hour/period of the day. This can be complemented by an assessment of reliability, which may reflect:

- the consequences for subsequent activities should unexpected variability arise;
- the likelihood of encountering an incident which reduces capacity and
- other implicit effects which cause unreliability and variability in the average journey times.

The current standard deviation of journey times on a route-by-route basis can be calculated using observed data from a range of sources including bluetooth and floating vehicle journey time data and from data automatic traffic counters (see section 2.4.1)

The appraisal of transport schemes or policies should aim to place a value on any changes to unpredictable journey time variability because of the extra costs it incurs on drivers and passengers. To estimate the monetised benefit of changes in the variability of journey time (for private road vehicles), money values are needed. The concept of the reliability ratio enables changes in variability of lateness or of journey time to be expressed in monetary terms. The reliability ratio is defined as:

Reliability Ratio = Value of SD of travel time / Value of travel time

Using a standard value of time, the value of the standard deviation of journey times can be calculated using the recommend reliability ratio values below.

Journey Purpose	Mode	Reliability ratio
Commuting/Business/Other	Car	0.8

The way in which the change in the level of JTV is forecast will, in the light of current knowledge, vary according to the context. Different methodologies have been developed for inter urban motorway and dual carriageway roads, urban roads, and other roads, as discussed below.

In appraising travel time reliability on highway schemes, it is important to distinguish whether the scheme being appraised is an Urban Road (defined usually as having a speed limit of 30 or 40 miles per hour) or Inter Urban Road (which usually have a speed limit of 50 plus miles per hour). On Inter Urban Roads it is also important to further distinguish between Motorway roads; Dual carriageway roads and single carriageway roads.

Inter Urban Motorway and Dual Carriageway Variability

Research has shown that as long as demand is below capacity, incidents will be the main source of JTV, and DTDV is much less important except in urban areas where the two effects cannot be readily separated. The additional delays caused by congestion unrelated to incidents and any associated variability can be assumed to be allowed for in the journey time forecasts. However, in the case of delays due to incidents a separate element for average delays will usually need to be added to the variability element.

INCA (Incident Cost Benefit Analysis) enables the estimation of the monetised benefits of measures affecting journey time variability covering incidents on motorways and dual carriageways. INCA requires substantial inputs from a suitable transport or traffic model of the scheme being appraised. The INCA model derivation assumes a dual carriageway layout and the parameters are based on data for motorways only. It is therefore not suitable for single carriageways, though the model may be used for dual carriageways as well as motorways. The resulting estimates of benefits cannot be taken to be as robust as those for time savings or accident reductions, for example.

The outputs of INCA reflect how delays caused by incidents may vary according to the severity and length of the incident, the number of lanes blocked and the volume of traffic at the time. Changing the number of lanes available to traffic changes both the probability of encountering an incident (or its aftermath) and the delays caused by incidents

For motorways and dual carriageways, alternative routes avoiding particular sections usually have limited capacity making it difficult for large numbers of drivers to divert if they encounter delays due to an incident. In the absence of significant "transient excess demand" (temporary periods of demand exceeding capacity), incidents are the main source of unpredictable variability and INCA should be used. Practitioners should refer to the latest release note and model documentation prior to use.

Urban Road Variability

Models predicting journey time variability from all sources have been developed for urban areas. In such areas alternative routes are more readily available than on motorways and there are many ways for drivers to divert away from incidents which reduce capacity on a particular route. This affects the relative importance of incident and day to day variability (DTDV) effects.

A generalised model has been developed which permits the forecasting of the Standard Deviation of Journey Time for urban roads.

The model takes, as input, forecast Journey Time (t) and Distance (d) for each origin to destination flow. These can be estimated or taken from a suitable transport or traffic model. The model is subject to the assumption that the distribution of trip distances (alternatively, Origin-Destination distances within the demand matrices) and free-flow speeds do not change as a result of the scheme.

The change in journey time variability (represented by $\boldsymbol{\Delta\sigma_{ij}}$) is given by:

$$\boldsymbol{\Delta\sigma_{ij} = 0.0018\,(t_{ij2}^{\;2.02} - t_{ij1}^{\;2.02})\,d_{ij}^{\;-1.41}}$$

Where

- $\mathbf{t_{ij1}}$ and $\mathbf{t_{ij2}}$ are the journey times for the journey from **i** to **j** (seconds) between the Do Minimum/Reference Case ("before") and the Do Something ("after").
- $\boldsymbol{\Delta\sigma_{ij}}$ is the change in standard deviation of journey time for the journey from **i** to **j** (seconds) between the Do Minimum/Reference Case ("before") and the Do Something ("after").
- $\mathbf{d_{ij}}$ is the journey distance from **i** to **j** (km)

The reliability benefit applying the rule of a half is therefore calculated using:

$$Benefit = -\sum_{ij} \Delta\sigma_{ij} * \left(\frac{T_{ij2} + T_{ij1}}{2}\right) * VOR$$

Note that the value of reliability (VOR) is obtained by multiplying the value of time by the reliability ratio and $\mathbf{T_{ij1}}$ and $\mathbf{T_{ij2}}$ are number of trips before and after the change.

The model permits the calculation of reliability benefits for travellers with different journey purposes and corresponding trip length distributions.

Although the model above can be used to estimate the effect of schemes and their reliability benefits in urban areas, a locally calibrated model or at least a local validation is preferable.

Other Road Types

For journeys predominantly on single carriageways outside urban areas, it is not currently possible to estimate monetised reliability benefits.

Assessing journey time reliability benefits in multi-modal environments

For multi modal studies, highway and public transport reliability should be measured and appraised separately, employing the methods currently available for each mode.

Reporting Reliability

Journey time reliability benefits should be identified separately from the standard TEE benefits, and not included as part of the core NPV or BCR. They should be reported and details included within the ASTs.

9.2.2.10 Impacts on Private Sector Operators

Impacts on private sector transport providers should be recorded in the TEE analysis. These include changes in investment costs, operating and maintenance costs, operator revenues and grant/subsidy payments. In all instances the cost included should be adjusted for optimism bias (see section 13.3).

Financial costs (and benefits) to the Government should not be included in the TEE assessment. These impacts are covered in Section 12. The cost to Government should be compared with all of the benefits (i.e. across all five STAG Criteria) in order to assess overall value for money rather than the costs and benefits quantified in the TEE analysis.

9.2.2.11 Revenues

Extra revenue should be treated as a benefit to operators. Revenues are related to user charges, as user charges (fares etc) represent money transfers from users to operators which become revenues from the operator's point of view. However, this does not mean that the economic benefit of changes in user charges is the same to the traveller and the operator. In fact, for travellers, the economic benefit of a change in charges is the resultant change in their consumer surplus. For those who do not change their behaviour, the change in consumer surplus is the same as the change in money paid, but for those who do change their behaviour, this is not the case. For operators, however, the economic benefit of a change in charges is simply the change in net revenue received. Therefore, the values for User Charges under User Benefits and the values for Revenues under Private Sector Operator Impacts will usually not be equal in size.

In many cases extra revenues to one operator will to some extent represent a transfer from other operators. For example, a rail investment may lead to modal switch from buses, which represents a loss to bus operators. Where such impacts are likely to be significant, they should be taken into account and the revenue impacts should be disaggregated by mode in order to identify the distributional effects.

9.2.2.12 Investment Costs

These should include all infrastructure costs and vehicle costs incurred by private sector operators which are additional to those incurred in the do-minimum scenario. Fees, design, land acquisition and other preliminary works should be included. Investment costs should always be recorded as a negative entry in the TEE table.

9.2.2.13 Operating and Maintenance Costs

Operating and maintenance costs should include the additional annually recurring costs incurred by the private sector in running and maintaining the facility. Examples of these costs include operating costs for new public transport services, and maintenance costs of vehicles and facilities. Operating and maintenance costs should always be recorded as a negative entry in the TEE table.

9.2.2.14 Grant and Subsidy Payments

In the majority of cases, private sector operator revenues are unlikely to cover the investment and operating costs of an option, and hence some form of grant or subsidy will be required to deliver actions by private sector operators (e.g. First ScotRail, bus operators, etc). Any such grant or subsidy represents a benefit to operators and these should always be recorded as positive amounts in the TEE table.

At the appraisal stage funding agencies are unlikely to be able to give commitments or to be precise about the amounts of support likely to be available. However, the deficit arising from private sector provision without the benefit of grant or subsidy will be indicative of the level of support likely to be required to deliver the strategy or project (although it should be noted that the private sector is likely to require an additional profit margin/return on capital). Consideration should also be given to whether the level of grant or subsidy would be likely to meet the relevant decision criteria published by funding agencies.

There may be a need to disaggregate the market into different operators in order to assess overall subsidy requirements. For example, a rail enhancement may lead to a loss of bus revenue but there will generally be no requirement to compensate the bus operator (although this should still be recorded as a disbenefit to bus operators under "revenues").

In some cases, it may be possible to identify potential developer contributions. In effect, these are 'negative grants', which should be recorded both as a cost to the private sector and a benefit to the public sector (for further guidance please refer to Section 12 Cost to Government). In the TEE table, these appear as negative benefits, while in the Public Accounts table they appear as revenues. Including these contributions in the Public Accounts table clarifies their effect in reducing demands on public funding for schemes, while their inclusion in the TEE table highlights their impact on business.

9.2.2.15 Freight Benefits

The inclusion of freight user benefits should not be used other than those delivered through operating cost and time savings.

Changes to the transport network which impact on freight can affect businesses and the economy in two ways:

- Cost changes – any change to freight operating costs as a result of a transport intervention is transferred to the recipient and eventually the consumer; and
- Production changes – changes in freight provision which allow firms to improve their production results in greater output and therefore consumption within the economy.

When assessing the costs and benefits of any potential transport option, the current STAG methodology already takes account of key factors such as the value of time, vehicle operating costs and network characteristics. Consequently, the first impact is already well accounted for in any transport appraisal assuming the correct data defining actual and projected freight traffic is input into the assessment.

The second impact has traditionally been difficult to capture within appraisals and often ignored. It should be pointed out that this was an issue which related not only to freight, but to all travel which affected businesses' daily operation, such as business travel, etc. This impact is now captured under the Wider Economic Impacts of the Economic Appraisal. As a result Transport Scotland continue to believe that that potential freight impacts are appraised to the same standard as all other impacts within the transport appraisal.

9.3 - Wider economic impacts

The purpose of analysing wider economic impacts is twofold:

- To provide information to decision makers about the nature of outcomes that a project is expected to deliver, and their distribution; and
- To adjust modelled monetised welfare impacts to take account of market failures in non-transport markets.

Both of these objectives relate to impacts that arise in non-transport markets. This guidance is structured around these two objectives.

Section 9.3.1 briefly describes the economic theory that provides the foundations for Wider economic impacts and the implications for appraising transport interventions.

Section 9.3.2 sets out when and how this guidance should be used. It describes the analysis of Wider economic impacts at different phases of the appraisal process, including the analysis that should be undertaken to characterise the baseline situation and economic context.

Section 9.3.3 describes how practitioners should characterise the nature and distribution of impacts that a project is expected to have on Wider economic impacts. This section includes guidance on how to examine impacts in other markets such as the property and labour markets, and how to examine and present the distributional consequences of a transport intervention.

Finally section 9.3.4 sets out the approach to be taken when evaluating impacts on welfare that can arise due to market failures in non-transport markets, such as the impact of agglomeration.

9.3.1 What are Wider economic impacts?

Wider economic impacts are impacts in non-transport markets that are either of importance from a policy or distributional perspective or which affect the net value that society attributes to the outcomes of a transport intervention.

Transport modelling has developed to characterise behavioural responses to changes in transport supply. Alongside this, appraisal techniques have been developed to evaluate society’s willingness to pay to achieve these outcomes. This analysis usually assumes that, outside of the transport market, markets tend to work efficiently under conditions of competition.

An individual’s responses to transport change may include choosing to change where they live or work, or changing the types of activities that they engage in. Simultaneously, changes in transport supply may influence firms to change the way that they operate, or where they locate. These changes could also affect the demand for different products and services and affect the structure of the economy. The first objective of assessing Wider economic impacts is to characterise the likely impacts on the economy in order to help decision makers to understand project outcomes.

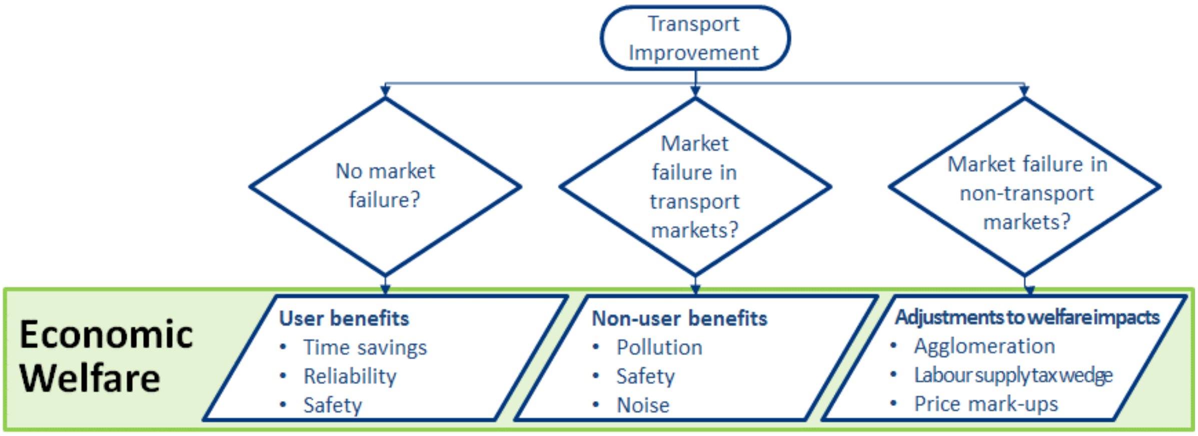
The overall net impact of a transport intervention is derived from a number of different gross impacts, some of which may be positive and others negative. As a result, even quite small options will have impacts which are positive for specific areas or for particular groups, and negative for others. The Scottish Government has Scotland-wide interests and responsibilities and is therefore interested in economic impacts at both the national and local level. The impacts of transport projects are generally highly pervasive and not limited to particular areas. It is therefore necessary to assess Wider economic impacts at both the Scotland level at a more local level. Depending on the context, it may be appropriate to also consider the district level and at the level of smaller towns or communities.

Transport user benefits capture how users of the transport system value the changes in transport supply because of the opportunities that this provides for them. Non-user benefits can also accrue due to other characteristics of the transport market, such as impacts on third parties through pollution or accidents. These forms of market failure are known as externalities. The sum of user and non-user benefits is compared with the project costs to assess Transport Economic Efficiency.

If non-transport markets work efficiently, then these user and non-user benefits accurately capture the total value to society of these outcomes. A faster commuting journey may, for example, enable someone to enjoy more leisure time, or may tip the balance in their choice of where to live. The commuter who decides to enjoy more leisure time will place a value on this which should be captured within appraisal. The commuter who decides to move house to take advantage of a new transport connection will have a complicated new set of circumstances brought about by the move. However, they could have made the move in the absence of the new transport connection and chose not to, so the value for them must be (at most) equal to the change in transport costs that the intervention brought about. Otherwise they would have already made the move. This willingness of 'new users' to pay for the intervention should already be captured in user benefits through the application of the 'rule-of-a-half'. If other markets function efficiently, then the knock on implications of their decision, for example on property markets or local retail activity, simply represent a redistribution of demand from one area to another. They therefore have no net consequences for society's willingness to pay for the intervention or for the monetised benefits.

However, in some case, other markets do not operate efficiently under conditions of competition. This can happen for many reasons and can mean that society's net willingness to pay for a project is not fully captured by the modelled user benefits. **The second objective of assessing Wider economic impacts is to examine how features of non-transport markets could change society's net willingness to pay for the intervention.**

The diagram below shows how the different elements of user benefits, non-user benefits and Wider economic impacts contribute to the overall impact of an intervention on economic welfare.



Practitioners should note that modelled transport impacts and the valuation of user benefits is very closely linked to wider economic impacts. Changes in travel behaviour reflect the fact that people have chosen to change their pattern of activities. The value that they place on changes in journey times reflects the opportunities in the wider economy that now become possible to them due to changes in the transport system. If a project offers the opportunity for very significant changes in behaviour, such as changing commercial driver shift patterns, or enabling business trips within a day that were previously not possible, then this should be reflected in both the characterisation of Wider economic impacts and in the assessment of user benefits where possible.

9.3.2 Wider economic impacts in the appraisal process

Analysis of the wider economy is an important theme which runs through STAG from the Pre-Appraisal phase to monitoring and evaluation in the Post-Appraisal phase. Throughout the appraisal process, practitioners should recognise that transport is not an end in itself. The ultimate goal of transport interventions is to make it easier for people to undertake a wider set of non-transport activities.

Most transport projects will, at least in part, be motivated by a desire to make it easier for people to undertake economic and leisure activities. At each phase in the appraisal process, practitioners should consider how the transport changes reflect other induced changes in the wider economy. These considerations should be integrated into the Pre-Appraisal, Part 1 Appraisal and Post-Appraisal phases. In Part 2 Appraisal, it may be necessary to undertake more formal analysis and quantification of Wider economic impacts which are reported in a separate Wider economic impacts report. This will depend on the objectives of the project and the scale of anticipated impacts.

Pre-Appraisal

The identification of problems and opportunities in the transport and land-use system must form the starting point of a STAG study (STAG Paragraph 2.1.1). This should be based on a full understanding of the study area and the transport system under consideration (STAG Paragraph 2.1.5). STAG guidance is clear that the analysis of problems should look beyond the immediate manifestations of such problems on the transport system (Paragraph 2.1.10). It is necessary therefore to consider the baseline economic conditions within the area affected and identify how other markets and behaviours may be affected by the current performance of the transport system.

For smaller studies, it will be necessary to provide a basic characterisation of the economies affected (such as their sectoral structure) and to comment on how their current use of the transport system is constraining their behaviour or imposing unacceptable costs or risks to economic activity. For larger studies, it will be necessary to further examine how recent economic performance in the areas under consideration, such as trends in prices of labour and property compared to national averages and recent levels of development and employment growth. Faster than average wage growth, coupled with increases in employment indicate that there is unmet demand for labour. Similarly, faster than average growth in property prices, coupled with recent growth in the property stock indicates that there is further pressure for physical development. This analysis should form part of the strategic rationale for a project.

Part 1 Appraisal

Part 1 appraisal is concerned with the development of objectives and transport options and an assessment of what these options could achieve. It begins with the development of Transport Planning Objectives. These provide a way of distilling economic and social objectives into the outputs of the transport system that are considered necessary to deliver these wider objectives. This simplifies the process of analysis and appraisal. However, it risks losing focus on the strategic reasons for intervening in the transport system.

Wider economic impacts should be considered at the beginning and at the end of Part 1 Appraisal. At the beginning, they should inform the selection of Transport Planning Objectives and at the end they should be reconsidered when the outcomes of particular options are described.

In particular, Part 1 Appraisal should:

- Identify the groups and locations that are likely to be most affected by the transport intervention;
- Identify which groups and locations are likely to suffer negative effects and where they are likely to benefit from positive impacts;
- Identify whether there are features of local non-transport markets that provide special reason for believing that a project will impose additional economic costs or benefits; and
- Relate the anticipated Wider economic impacts to the original reasons for intervention.

Wider economic impacts will be scoped qualitatively in the Part 1 Appraisal Summary Tables (AST) in order to establish whether there is a need to undertake a detailed Part 2 Appraisal.

Part 2 appraisal

Part 2 Appraisal involves a more detailed assessment of the outcomes of a shortlist of transport options. Within Part 2 Appraisal it may therefore be necessary to undertake a detailed examination of Wider economic impacts and prepare a Wider economic impacts report.

There are two central elements to the analysis of Wider economic impacts which may need further study within Part 2 Appraisal. First, if the Part 1 Appraisal identifies significant economic impacts on particular markets, groups or locations, then these should be investigated further in Part 2 Appraisal. Practitioners should seek to identify and quantify impacts at the national and local level. Second, if Part 1 Appraisal has identified that non-transport markets could be a source of significant impacts on welfare, then these should be analysed within Part 2 appraisal to provide a more accurate reflection of the net societal valuation of the project. It may be necessary to examine neither of these elements, one of them, or both of them, depending on the intervention being appraised. For example, if an intervention is considered to significantly boost property development in a particular area, then these issues should be examined in more detail within Part 2 Appraisal. The level of depth required in the analysis should be proportional to the size of the option or policy being appraised.

A detailed Part 2 Appraisal of Wider economic impacts is unlikely to be required for small options, except where Wider economic impacts are their principal justification, or where the scoping exercise indicates that there are significant positive or negative impacts on particular areas or groups. The results of detailed investigation should be reported in the Part 2 Appraisal and summarised in the Part 2 AST.

9.3.3 Characterising changes in the economy

Purpose

The purpose of characterising likely changes in the economy is to provide decision makers with a richer picture of the likely consequences of transport investment. This may include its impact on policy measures such as economic activity (GDP or GVA) and/or employment in different areas.

Impacts which it may be necessary to examine include the distribution of impacts on particular markets, groups or locations measured in terms of:

- Economic welfare (including user benefits, non-user benefits and potentially impacts of market failure in non-transport markets such as agglomeration);
- Impacts on economic output (Gross Value Added);
- Impacts on labour market outcomes (employment and/or wages); and/or
- Impacts on property market outcomes (including quantity of development and/or prices).

Approach

Methods of examining economic impacts can be grouped into two classes:

- Structured, partial analysis; and
- Formal transport and economic interaction modelling.

The first method approaches the links between transport and the economy through structured logic chains which describe likely transport and economic responses to changes in transport supply. This method assesses current transport and economic conditions, defines the range of potential responses from different groups to a change in transport supply, and then seeks to provide evidence for which responses are most likely and to what degree. The advantages of this kind of approach is that it can be employed on a case by case basis and the level of analysis can be tailored to the intervention being considered. The disadvantages are that it is selective in what it examines, and it can be difficult to capture feedback mechanisms and second round effects, so it can be difficult to be confident of the net impact of a project across the whole economy.

The second method requires the construction of a formal model which captures interactions between economic agents in a way which is consistent with, and constrained by, principles of economic theory. Modelling of this kind enables unanticipated consequences to emerge from the model. If undertaken robustly, it can reflect the most significant feedback loops in the economy and provide confidence in the level of aggregate effects. However, these models still only capture some of the economic processes and can be complex and costly to implement.

A good example of this second approach is the TELMoS model, which has been commissioned and is maintained by Transport Scotland. This is a land use and transport interaction model which works in conjunction with TMfS to create consistent transport and land use scenarios and model the impacts that transport changes can have on the nature and distribution of economic activity across Scotland. For larger projects it may be appropriate to use TELMoS to support the analysis of Wider economic impacts.

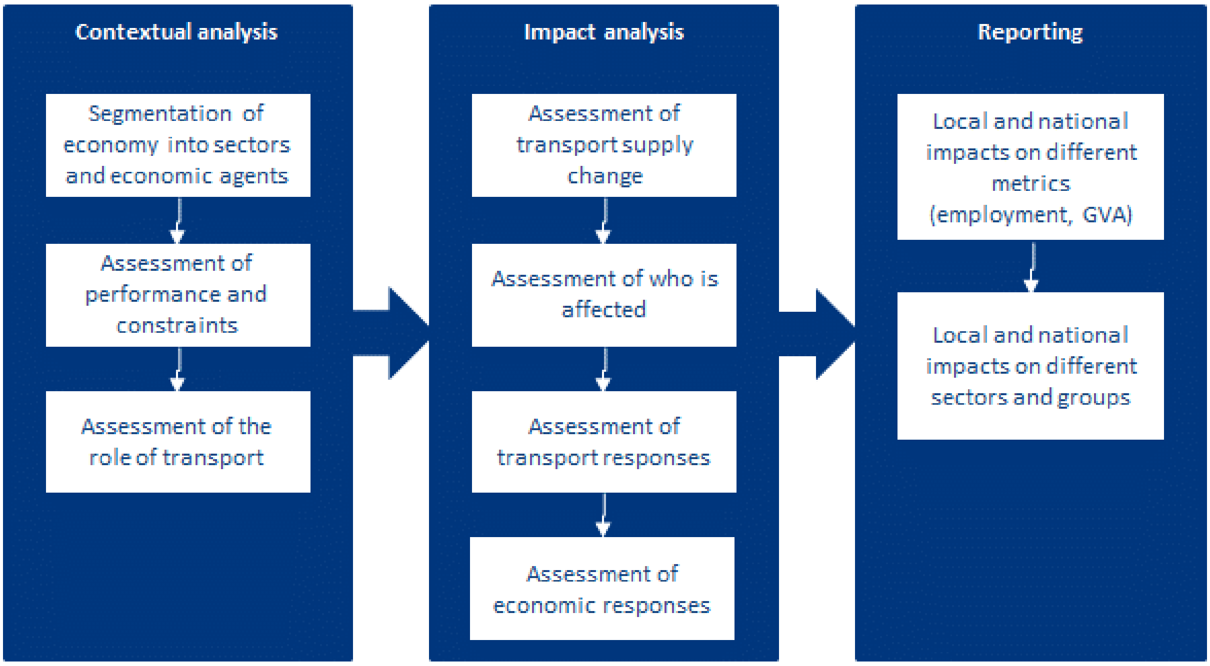
Structured, partial analysis

The approach described here provides a structure for identifying how transport changes affect non-transport markets. It includes guidance on how to capture impacts on economic welfare, economic output and employment at the Scotland level, and locally. This approach can be used when particular Wider economic impacts are considered to be an important part of scheme benefits and when it is not appropriate to use formal transport and economic interaction models, for example for smaller and medium sized transport interventions.

A case by case approach must be tailored to the transport option under consideration and to the appropriate area or spatial level. This forms a partial analysis: it assesses the impacts on different economic actors in the spatial areas directly affected by the transport intervention, but does not formalise feedback effects between them, constrain them, or capture other impacts outside the study area. It is therefore not appropriate to conclude from this analysis that there will be additional net impacts at the Scotland level.

A logic chain approach should begin with a contextual analysis to identify key sectors within the study area and, their performance, and how they are affected by the transport system. It should examine the potential behavioural responses of key economic actors in different sectors such as the manufacturing, business services, tourism or retail sectors. Economic actors include businesses, land and property developers, and individuals in their roles as residents, workers, shoppers, visitors and tourists.

The economic context and role of transport in decision making should be examined for each sector and group of economic actors. For business sectors, this could include for example: current economic performance (such as recent growth trajectory, price pressures, and profitability); constraints on growth (such as physical resources, human resources, management and capital), competitive position; and the role of transport in that sector. For other groups it could include key transport characteristics such as travel to work distances for commuters. The contextual analysis should conclude with an analysis of the potential behavioural responses of key sectors and groups to changes in transport supply. For example, for businesses this could include expansion, contraction, reorganisation or relocation.



The contextual analysis should be followed by an analysis of the impact of the transport intervention under consideration. The impact analysis can be structured around a series of questions, beginning with the transport impacts:

- What will the transport option achieve in terms of transport benefits and costs; for simplicity, focussing on benefits such as time savings, improved accessibility or improved journey quality?
- Which sectors and economic agents will benefit from these impacts, and who, if anyone, will lose? Where are these people and businesses located?
- Given the changes in transport supply, which of the possible transport and behavioural responses are most likely?

The impacts of a transport change will arise through factors such as:

- Direct changes in business cost and risk of doing business arising through changes in business and freight travel costs and reliability (informed by the analysis of business and freight user benefits);
- Labour market impacts through access to a larger pool of labour, which might have efficiency benefits (informed by commuter user benefits);
- Potential changes in demand for local premises and housing as transport changes attract or repel inward investment or the expansion of local businesses; and
- The distribution of the productivity impacts from agglomeration.

The key outcomes of this analysis should be presented by user group, by location and for the different metrics of analysis such as economic welfare, employment and economic output.

Forecast attraction of economic activity to an area must explain, and provide evidence for, why the inward flow of such activity is greater than the outward flow. Improved transport connections enable lower cost access to the local market for competitors from outside the study area or outside Scotland, as well as lower export costs (the so-called 'two way road' effect).

Practitioners should consider how transport benefits propagate themselves through the economy. Under conditions of perfect competition all business cost savings will be passed on to consumers of their products through lower prices, thus increasing standards of living. However, where markets are not perfectly competitive, these benefits could instead be captured by other groups. If a business does not face competitive pressures, then cost changes may not be passed on to consumers and could be captured through higher profits benefitting shareholders. Another example may arise where there are barriers to further property development. In this case, existing property owners could raise rents to capture the benefits of improved connectivity or easier commuting and benefits could become capitalised into property prices.

Data sources to support this analysis could include survey evidence, accessibility analysis, consultation, structured interviews, property and labour recruitment professionals, inward investment agencies or other sources.

Metrics of analysis

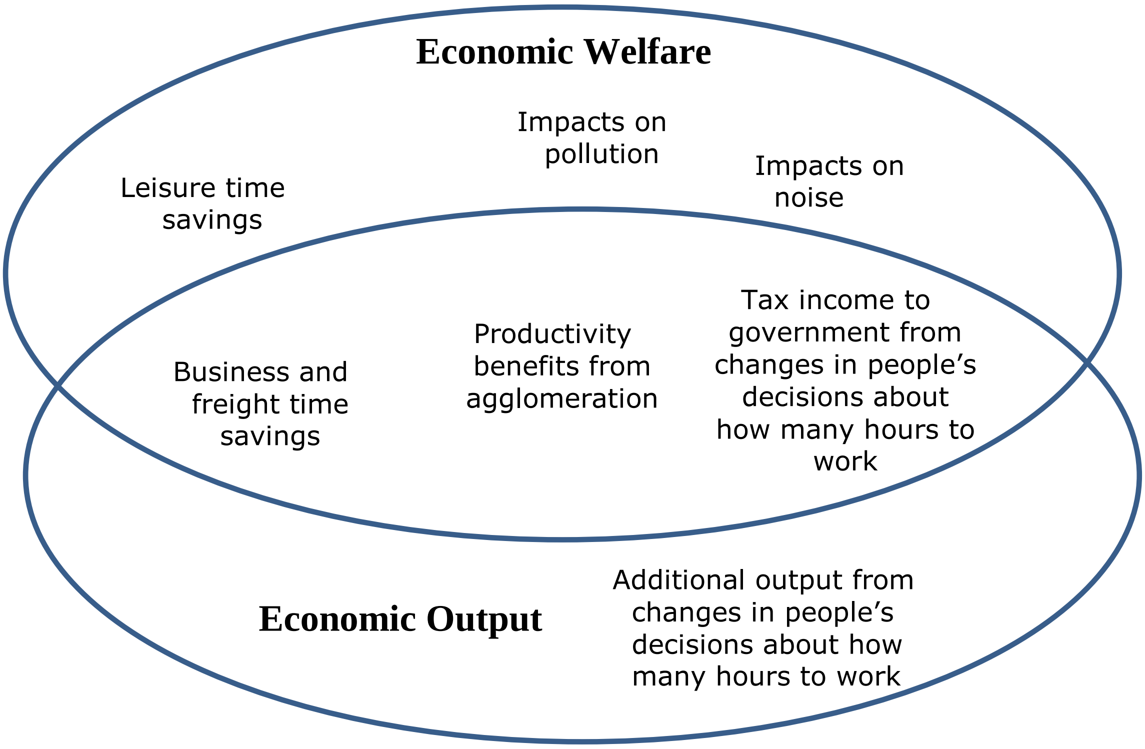
Cost benefit analysis captures the impact of an intervention on economic welfare. This is a measure of how much people would be prepared to sacrifice in order to achieve the project outcomes. However, it can also be helpful to examine the impact of a project on other metrics such as economic activity.

Economic activity is usually measured as Gross Value Added (GVA). This is equal to Gross Domestic Product at basic prices, excluding taxes (less subsidies) on products. The Scottish Government uses the GVA measure in its quarterly series.

The Venn diagram below shows the relationships between different aspects of economic welfare and economic output. Some modelled impacts on economic welfare also reflect impacts on economic output.

Economic welfare

Economic welfare can best be thought of as the amount that people would be prepared to sacrifice in order to gain something. It is measured as a willingness to pay. If people know and understand the outcomes of an intervention then this is equivalent to asking everyone affected how much they would be willing to pay (or how much they would need to be compensated) for those outcomes.



Economic output (Gross Value Added or GVA)

Output is a measure of the value of all of the goods and services produced in the traded economy. It is the measure used to account for economic activity in government economic accounts.

Some activities are not traded (such as DIY where you work on your own home). People value leisure time, although they do not directly pay for it, so changes in available leisure time do not form part of changes in economic output.

Spatial level of analysis

The appropriate level of spatial analysis will be determined by the intervention under consideration. Large schemes or interurban schemes may have extensive effects, while other interventions could have a smaller geographic scope. It may also be necessary to subdivide the study areas where different effects are expected in different parts of it.

Some areas have particular policy significance and are, for example, targeted by Government policies on social inclusion. In these cases, it is helpful to distinguish these areas separately in the analysis of Wider economic impacts[3].

Gross and net impacts

The net impacts of an intervention can mask significant positive and negative gross impacts on different groups and in different places. Economic development arguments for transport investment are frequently made on a distributional basis, typically in order to benefit a particular area or social group. Areas include those which are the focus of other economic policy initiatives, such as remote rural areas, urban housing estates and under-performing/regeneration areas; social groups include the long-term and young unemployed and single parents, many of whom have multiple problems of accessibility to jobs and training. While it is convenient to think in terms of spatial areas, especially where there are regeneration areas, policies are ultimately targeted at people rather than places. Nevertheless, it is important for decision makers to understand where impacts occur so that they can better understand the role of the intervention within the wider policy mix.

Gross and net impacts can be different for different metrics of analysis. It is usually easiest to examine the gross and net impacts and distribution of economic welfare impacts. User benefits are typically available from a transport model spatially and by user group (business traveller, commuter, leisure traveller). Some other non-user benefits can also be located spatially, such as noise impacts where these are calculated and monetised. Monetised impacts arising in non-transport markets (such as agglomeration) can also be examined spatially and by business sector.

Impacts on economic activity and employment will require analysis of potential change and redistribution in response to the transport intervention, either using the logic chain approach or through modelling of transport and the economy.

Where impacts on economic activity are examined using a logic chain approach, these impacts should be reported as gross impacts for particular locations. It should be assumed that any net impacts at the Scotland level only arise from one of two sources:

- Productivity impacts which are captured within the analysis of GVA and are consistent with the modelled user benefits; or
- Attracting mobile economic activity from abroad, including migrants or foreign direct investment.

Similarly, where employment impacts are examined using a logic chain approach, these impacts should be reported as gross impacts for particular locations. Net impacts on employment at the Scotland level can arise for three reasons:

- Easier commuting, consistent with the analysis of monetised welfare impacts due to the labour market tax wedge (see section 9.3.4);
- Attracting mobile economic activity from abroad; or
- Other failures in the labour market which prevent full employment being reached.

[3] The Scottish Index of Multiple Deprivation can be used to help identify local areas of poverty and inequality http://www.gov.scot/Topics/Statistics/SIMD

These other effects could be positive or negative. The default assumption is that these other net effects on employment are zero, i.e. all other changes in employment are either directly abstracted from elsewhere within Scotland or cause changes in the pattern of demand and costs which cause employment in other areas to grow more slowly. This assumption must be adopted unless there are compelling reasons to believe otherwise. Other claims of net changes in employment at the Scotland level must explain:

- who is taking the new jobs; and
- why changes in the demand or supply of labour in the study area are not offset by opposite changes outside the study area.

The net impact of construction jobs is not usually considered as a Wider economic impact of transport interventions. It is assumed that the expenditure would otherwise have been directed towards another project and hence supported construction or other jobs elsewhere. However, it may be that a particular intervention does lead to an increase in demand in the construction sector in a particular area. This may have further local consequences, for example through:

- Backward linkages: as the local construction activity purchases more local inputs through local supply chains; or
- Forward linkages: as those additional local construction workers spend some of their income locally.

If the project had not gone ahead, then additional expenditure elsewhere in the economy would have similar stimulative effects. It will generally not be possible to say what this alternative expenditure would have been[4]. The employment effects of construction should therefore not be considered as a net national benefit because they will displace other economic activity.

Impacts over time

In principle, the analysis of Wider economic impacts could be treated in the same manner as TEE benefits, by creating an estimated flow of impacts which is then discounted to a present value using the discounting assumptions recommended in STAG Unit 9.5. This approach should be taken to the presentation of all monetary impacts.

For employment, the familiar measure is a "job" but for appraisal purposes it is necessary to consider what this means over a period of years. The generally accepted convention is that a job equates to 10 person years of Full Time Equivalent (FTE) employment, discounted at the prevailing rate. Therefore, where an option generates a stream of person years of employment, these need to be discounted and divided by 10 to give a "job".

[4] There are many different alternatives if the project had not gone ahead. For example, taxes could have been lower, boosting net household income and leading to an increase in consumption expenditure and greater demand for consumer products. Another possibility is that government debt could be lower as the government demands less money from the money markets. This will tend to push down interest rates and make some private sector investment projects viable which otherwise would not have gone ahead. In all cases the funding from the project would have been put to different uses which each generate demand in different parts of the economy.

However, the research approach may not provide sufficient information to enable a full time profile for all Wider economic impacts. In this case it may be necessary to provide alternative analysis of the time profile of outcomes. The time frame for assessment should be clearly stated. Where time profiles are presented, practitioners should also refer to the assumptions and caveats relating to forecasting or projecting impacts over future years.

Transport and economic scenarios

Where the objectives of an option are solely or substantially concerned with economic development or regeneration, the reasons for preferring a transport option rather than other economic development measures needs to be clearly articulated. In keeping with guidance on setting objectives and sifting options, it will be necessary to demonstrate that other economic development measures, as well as transport measures, have been properly considered.

In practice, for many transport projects the source of Wider Economic Impacts is an expected release of constraints on land availability. Where a transport investment does enable land that would otherwise be incapable of development to be developed for productive uses, there is potentially a local economic benefit, where the use of the land gives rise to output and employment impacts.

Integrated transport and regeneration projects

In some cases a transport project is part of a coordinated package of investments and activities such as an area masterplan or regeneration plan. Transport Scotland recognises that, in these cases, it is not reasonable to assume that the local development scenario is independent of the transport intervention (or vice versa) and it may be more appropriate to treat the joint transport and regeneration/property investment as a single investment. In this case, practitioners should seek advice from Transport Scotland.

To adequately capture the joint impact of a transport and regeneration programme, it may be necessary to model the following two scenarios:

- Where neither the transport or property developments go ahead (the Reference Case); and
- Where both the transport and property developments go ahead.

Furthermore, to separately identify the impacts of the transport element of the plan, it may be necessary, in addition, to model scenarios in which:

- The transport intervention goes ahead but the other developments do not; and
- The property developments go ahead but the transport intervention does not.

To do this effectively, it may be necessary to model the costs and revenues of property developers or other actors who are part of the joint project in order to fully capture the joint costs of the transport and property intervention. Specialist expertise in property markets and development are likely to be required.

9.3.4 Adjustments to monetised welfare impacts due to market failure in non-transport markets

In some case, non-transport markets do not operate efficiently under conditions of competition. This can happen for many reasons and can mean that society's willingness to pay for a project is not fully captured by the modelled user benefits.

In order to model these impacts and include them within a welfare cost benefit appraisal, they must have three key features:

- There must be a theoretically robust understanding of why they cause social benefits to diverge from user benefits;
- It must be possible to robustly model outcomes in these markets that are brought about by the transport intervention; and
- It must be possible to calculate the net societal value of these outcomes in a way that is consistent with transport appraisal practice and ensure that they are distinct from modelled user benefits.

Three impacts have been identified which meet these criteria. These are:

- Agglomeration economies: The productivity of firms is affected by their connectivity to economic activity. Changes in transport supply can change the levels of this connectivity. Transport change can also influence the spatial distribution of people and jobs and thus change these patterns of connectivity. This effect is distinct from user benefits because it applies to third parties (firms) who are affected independently of transport users.
- Market power and price mark-ups: Firms that are not under competitive pressure can make additional profits from selling their products at prices which are higher than the costs of making them. If firms in this situation price their products as a percentage mark-up over costs, then reductions in their cost base from transport cost changes will be passed on to consumers along with a mark-up. This additional price reduction reflects a net benefit to consumers which is in addition to the transport cost change.
- The tax wedge on wages: The net returns from working are made up of the net wages earned and the costs associated with working (including transport costs). If commuting costs fall, then the net returns from working increase. This could influence some people to change whether or not they choose to work or how much they choose to work. The private benefits to these people are captured in user benefits. However if, except for labour market taxes, the labour market works efficiently, then firms will hire people where their productivity is equal to or greater than the gross cost of employing them. The difference is equal to the taxes on employment. The tax system causes there to be a divergence between individual valuation of a decision and the impact on society, so user benefits do not accurately represent societal benefits when people choose to engage in additional work as a result of a transport change.

Guidance is provided below on how to model these effects and when to include them in appraisal.

Agglomeration economies

Agglomeration economies is a term used to describe a range of different processes and mechanisms which can mean that areas of denser economic activity tend to be more productive than areas of less dense economic activity. These processes can include for example, improved matching of skills to jobs in a deeper labour market, or market size facilitating greater specialisation of firms or of labour. The research evidence suggests that agglomeration economies are not unique to dense areas of economic activity, but can occur anywhere.

The evidence base for agglomeration economies

The approach to quantifying agglomeration economies reflected in this guidance is based on three studies by Imperial College commissioned by the Department for Transport between 2005 and 2009. It should also be noted that some judgements have been made about the most appropriate way of applying the research in the transport appraisal context.

- First, the research approach concentrated on measuring access to workplace jobs, and the impact of this on firm productivity. It is recognised that this approach is only one way to measure connectivity and its impact on productivity. It may be for example that access to labour is equally or more important than access to other businesses. However, in practice it is difficult to disentangle how access to different opportunities affects productivity because places with good access to other businesses also tend to have good access to labour.
- Second, the original research was based on data from company accounts and so only reflected agglomeration impacts in sectors where these accounts were available. It did not, for example, capture the impact of agglomeration on public sector activity. However, it did capture the impact in similar activities in the private sector, such as private health and social care firms and private education providers. This has been used to infer impacts for all sectors of the economy.
- Third the original research was based on a single measure of generalised costs for road trips. It has therefore been necessary to provide guidance on how to construct suitable generalised costs from those typically found within transport models.

The recommended approach reflects the best available research evidence at the time of writing.

The calculation and evaluation of agglomeration is a three stage process. The first stage is to create weighted average measures of generalised costs suitable for use in the calculation of agglomeration. The second stage is to use these generalised costs alongside economic data to construct appropriate measures of connectivity for different areas. Following the Imperial College research, for the purposes of transport appraisal, connectivity is a measure of how well connected zone i is to workplace jobs in all zones. The third and final stage is to use the modelled changes in connectivity to assess impacts on productivity.

Testing has shown that aggregation bias can emerge when larger zones are used in the analysis. The original research was undertaken by calculating connectivity at ward level. Where possible, the size of zones used in the calculation of connectivity should be no larger than ward level in the areas most affected.

The generalised costs used in the calculation of agglomeration should be the weighted sum of generalised costs between i and j across modes, time periods and journey purposes. The weighted average generalised costs should provide the best available representation of all modes of travel which make up more than 10% of trips for each zone pair, including walking and cycling. Where this data is not readily available from transport models (for example in single mode models), then estimates of costs and demand for these modes should be constructed using other available evidence such as the National Travel Survey. Excluding modes, can bias results. All journey purposes of personal travel should be included where possible, including walking and cycling trips. Freight trips should be excluded.

Weighting are based on demand, measured in person trips. Demand changes between the Do Minimum and the Scenario cases can lead to perverse results if applied directly. We therefore recommend that, as a practical approach, the average of Do Minimum and Investment Case (i.e. the Do Something' case) demand is used to provide the weightings.

The appropriate measure of generalised cost is therefore calculated using the following formula:

$$g_{ij}^{X} = \sum\nolimits_{m,t,p} \frac{g_{ij}^{X,m,t,p}}{\left(d_{ij}^{DoMin.m,t,p} + d_{ij}^{Investment\ Case.m,t,p}\right)/2}$$

where g is the generalised cost, X is the scenario (Do Minimum or Investment Case), i is the origin, j is the destination, m is the mode of transport, t is the time period (e.g. am peak), p is the journey purpose and d is demand.

The formula for the connectivity of zone i, as experienced by business sector k, in scenario X (e.g. base, Do-minimum or Investment Case) is given by:

$$C_i^X = \sum\nolimits_j \left\{ \frac{E_j^X}{\left(g_{ij}^X\right)^{\alpha^k}} \right\}$$

where E_j^X is the employment in zone j, g_{ij}^X is the generalised cost of travelling between zone i and j in scenario X, and the parameter α^k represents the rate at which agglomeration economies decay as generalised costs increase within industrial sector k. Note that E_j^X reflects all employment in zone j and not just employment in sector k. This reflects the best available evidence which suggests that access to all employment is a more important driver of agglomeration than access to employment within the same business sector.

Using these connectivity measures, changes in connectivity are used to calculate impacts on economic output in each zone and business sector using the following formula:

$$A_i^k = \left\{ \left(\frac{C_i^{Scenario}}{C_i^{DoMinimum}} \right)^{\rho^k} - 1 \right\} GDP_i^k$$

A_i^k is the agglomeration impact in zone i and sector k, ρ^k is the elasticity of productivity with respect to connectivity in sector k, and GDP_i^k is the level of GDP in zone i in sector

k. Total agglomeration impact is the sum of the impacts for all zones within Scotland, $\sum_i^k A_i^k$.

The recommended parameters for use in the analysis are shown in Table 9.1 below.

Table 9.1: Recommended parameters for use in the calculation of agglomeration

Business sector	Elasticity, ρ^k	Decay parameter, α^k
Manufacturing	0.021	1.097
Construction	0.034	1.562
Consumer services	0.024	1.818
Producer services	0.083	1.746
Health, education and public administration	0.054	1.782

Source: Graham (2009), Transport Scotland interpretation of health, education and public administration parameters.

Parameters for the manufacturing, construction, consumer services and producer services sectors are based on Imperial College's 2009 study [Graham, 2009]. The research evidence is based on the accounts of private firms so comparable analysis is not available for public sector activities. However, work by Imperial College [Graham 2006] shows that private sector businesses in the health and education sectors appear to exhibit strong and statistically significant agglomeration economies. Parameters for health, education, social work and public administration have been based on this. The recommended elasticity and decay parameters for this sector are the average of those found in the producer and consumer services sectors.

The data requirements for the calculation of agglomeration impacts are:

Generalised costs data by mode and journey purpose: To measure connectivity appropriately, a matrix of generalised costs is required which covers a relatively wide area. This must encompass a hinterland which stretches further than the immediate area in which the transport intervention's direct transport effects are felt. If, for example, a transport intervention improves connections between area A and area B, this could contribute to agglomeration impacts in both areas A and B. For area A, connectivity comes from access both to area B and from access to locations in all other directions. The appropriate hinterland of area A may therefore stretch considerably further than the area directly affected by the transport impacts. This is one reason why the data requirements for assessing agglomeration impacts can be challenging. In some cases it may be necessary to construct additional transport costs or use those from a large area-wide model (such as TMfS) to supplement local data;

Demand data by mode and journey purpose: Transport demand data is also required at the same spatial level in order to construct the appropriate weighted average generalised costs;

Employment data by zone; and

GDP data by zone and business sector.

GDP and employment data for future year reference cases are available from Transport Scotland from the TELMoS model[5].

Where transport changes are expected to induce changes in the pattern of economic activity, these can have further impacts on agglomeration. Changes in agglomeration due only to changes in transport generalised costs is known as 'static agglomeration' while the impacts of physical changes in the location of businesses is known as 'dynamic agglomeration'.

To calculate dynamic agglomeration, the same formulae apply as for static agglomeration, except that Reference Case employment is used to calculate Reference Case connectivity and Investment Case employment levels are used to calculate Investment Case connectivity. This will capture the effects of both changes in costs and of changes in the location of employment. Due to uncertainty over the nature and scale of land use changes, it is recommended that dynamic agglomeration is considered as a sensitivity to the main agglomeration analysis.

Market power and price mark-ups

Where there is imperfect competition in a market, the price is normally higher than production costs. Firms and consumers would be jointly better off if firms were to increase production and worse off if they were to reduce it. If changes in transport induce firms to change the level of production, then this can have consequences for economic welfare. Note that this impact is not related to changes in the level of competition, but is a consequence of the existing level of competition in the markets affected.

This impact is calculated on the basis of a factor, V, which is applied to the direct cost savings to firms, i.e. business time savings (BTS) and reliability gains (RG).

Market power impact = (BTS +RG). V

An uplift factor of 10% should be used in almost all cases. However, research commissioned by Transport Scotland has indicated that price cost margins are likely to be higher in very remote rural areas[6]. For schemes in very remote rural areas, an uplift of 20% should be applied. Very remote rural areas are defined as areas with a population of less than 3,000 and over a 60 minute drive time to a settlement with a population of 10,000 or more. For schemes which impact on journeys across different area types, the 20% uplift should be applied only to business journeys which originate or terminate in very remote rural areas. Due to limited evidence for the scale of this impact (data is only available for fuel costs, rather than all business costs), the 20% uplift should only be applied as a sensitivity.

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[5] Note that within TELMoS this data is only available for datazones within Scotland. Cross border agglomeration impacts would not be covered.

[6] Laird J., Review of Economic Assessment in Rural Transport Appraisal, (2009), http://www.gov.scot/Publications/2009/10/29110947/0
This research is based on the Scottish Government's 8-fold Urban Rural Classification – see http://www.gov.scot/Topics/Statistics/About/Methodology/UrbanRuralClassification

Labour supply and the tax wedge

If a transport intervention encourages people into work where they would otherwise have been choosing not to work, then a further welfare impact can arise due to the tax system. The net return from working (the 'effective wage') is made up of the wage payment (net of tax) minus the generalised cost of commuting. By reducing commuting costs, transport interventions can increase the net returns from working and encourage people into work where they otherwise would not.

The welfare consequences for the individual are captured within modelled transport user benefits. However, if labour markets work efficiently apart from the effect of taxes, then people will choose to work based on their net wage but firms will hire them up to the point where their productivity is equal to gross employment costs. The difference between these is the tax wedge. In simple terms, when people choose to work, the government makes a windfall gain due to the income from additional labour market taxes.

The first step is to calculate the effective wage for each zone pair, year and scenario. This is given by:

$$EW_{i,j}^{y,X} = \eta\, \tau\, y_j^y - g_{i,j}^{y,X} - g_{j,i}^{y,X}$$

Where:

$EW_{i,j}^{y,X}$ is the effective wage for a worker who travels from zone i to zone j in year y and scenario X

y_j^y is the average income in area j in year y

$g_{i,j}^{y,X}$ is the generalised costs of the average commuting trip between zone i and zone j

$g_{j,i}^{y,X}$ is the same generalised cost the reverse direction

η is a factor which represents the ratio between the average gross wage paid in zone j (y_j^y) and the wage paid to the marginal worker

τ is the average tax rate on earning required to convert gross earnings into net earnings.

η is assumed to be equal to 0.69. τ is assumed to be 0.30.

This equation simply says that the effective wage in year y and scenario X for someone commuting from zone I to zone j ($EW_{i,j}^{y,X}$) is equal to the marginal wage in that zone after tax in that year minus the round trip generalised cost of commuting from i to j.

Entry into the labour market is calculated using the change in effective wages and an elasticity of entry into the labour market with respect to effective wages. This is calculated using the formula:

$$\Delta W_{i,j}^{y} = \left\{ \left(\frac{EW_{i,j}^{y,Investment\ Case}}{EW_{i,j}^{y,DoMinimum}} \right)^{\varepsilon} - 1 \right\} W_{i,j}^{y}$$

where $\Delta W_{i,j}^{y}$ is the change in workers in zone i commuting to zone j in year y, ε is the elasticity of labour supply with respect to effective density, and $W_{i,j}^{y}$ is the number of workers currently travelling to work from zone i to zone j. ε is assumed to be 0.1.

This change in employment is important in its own right and can form part of the characterisation of Wider economic impacts. The additional gross wage income associated with it is:

$$Wage\ income^{y} = \sum_{i,j} \Delta W_{i,j}^{y}\, \eta y_{j}^{y}$$

However, most of this additional wage income does not reflect an additional welfare impact. The additional element arises from the tax wedge on this additional income. This is given by:

$$Tax\ wedge\ on\ additional\ labour\ supply^{y} = \tau\, Wage\ income^{y}$$

The data to support this calculation includes:

- Generalised cost data for commuting trips which is likely to be available from the transport model;
- Gross wages which is available from the TELMoS model or from Transport Scotland on request; and
- Data on the number of workers travelling from one model zone to another. This can be derived from commuting demand data.

Other potential impacts on economic welfare

By changing the costs of transport between areas, transport can change the level of competition faced by firms. In theory, this can lead to further impacts on economic welfare. However, there is no commonly agreed robust approach to quantifying these impacts. In the light of this, this impact should be treated as neutral.

There are a range of other characteristics of non-transport markets which could give rise to changes in the overall impact of an intervention on economic welfare. However, it is conceptually difficult to identify these, practically difficult to measure them and difficult to ensure that they are distinct from modelled user benefits.

9.3.5 Reporting Wider economic impacts

For larger projects and where further analysis of Wider economic impacts has been undertaken, findings should be reported in a Wider economic impacts report. This should include:

- Baseline analysis to identify the economic characteristics, drivers and challenges of the area under consideration;
- Segmentation and analysis of key business sectors within the study area;
- A description of data sources used, including information about bespoke surveys, consultation or interviews where these have been carried out;
- The approach taken to examining potential economic responses of different groups (including details of economic or land use models and their key characteristics and assumptions if these have been used); and

A detailed assessment of the anticipated economic outcomes including the logic chain that has been used and the evidence which supports the steps in that chain.

Where monetised welfare impacts in non-transport markets are calculated, these should be reported as the net Scottish impact alongside information to help contextualise this. This could include, for example, descriptions or maps of changes in the pattern of connectivity and the impacts in different business sectors and in key locations.

Impacts on spatial distribution, the distribution of effects amongst economic groups and the monetised welfare impacts in non-transport markets should be reported in the Appraisal Summary Table. The relevant section of the AST is shown below.

Economy (Wider economic impacts)			
Sub-objective	Item	Qualitative Information	Quantitative information
Spatial distributional	… of welfare impacts		
	…of population and employment		
	…of physical development		
Impacts on economic groups	Business sectors		
	Local residents		
Monetised welfare impacts in non-transport markets	Agglomeration		
	Labour market tax wedge		
	Price mark-ups		
	Other		

For impacts on spatial distribution and for impacts within different groups, the AST should include a brief qualitative description of the distribution of impacts across key areas, highlighting those most affected and any significant negative effects. Quantitative information on welfare impacts, economic output and employment should be expressed in discounted form where possible. Where this is not possible, or for smaller projects, these outcomes should be expressed as a range and with an indicative time frame, for example over a 3 to 5 year horizon and with some indication of longer term impacts. Depending on the sources of impacts and the scale of the option, GDP impacts should be provided using an appropriate segmentation of economic activity in the in-scope area.

Changes in local employment are of particular interest where the project will benefit people who are unemployed or underemployed, as occurs in regeneration areas, for example. If significant employment effects and expected in these areas, then this should be noted in the qualitative part of the AST, alongside the rationale for these.

Practitioners should ensure that Wider economic impacts are cross-checked against the original analysis of problems or opportunities that was undertaken in the Pre-Appraisal phase to verify that the Wider economic impacts support the original objectives that the intervention was designed to address. This should be summarised in the Strategic Case.

9.4 Appraisal Parameters

9.4.1 Appraisal Period

The appraisal period used for all transport appraisals will be 60 years. The extension to a 60 year appraisal period was prompted by the reduction to the discount rate in the 2003 version of the HM Treasury Green Book.

For some projects, the project life may be determined from the limited life of its component assets. In these cases, the practitioner should set out the evidence, and select an appropriate end year for the appraisal, subject to a maximum of 60 years. Guidance may be sought from the Scottish Government and/or Transport Scotland on the appropriate appraisal period.

9.4.2 Inflation

When forming base cost estimates for transport options, practitioners should apply realistic assumptions about changes in real costs i.e. above the rate of growth in general prices across the economy. For example, the inflation rates relevant to the delivery of many of the current transport schemes in Scotland (all modes) are currently higher than the general rise in prices across the economy. It is not practical to identify general inflation rates that would apply generally to all transport options so practitioners are advised that any assumptions should be based on the best information on current and forecast inflation from industry sources appropriate to their scheme. These assumptions and the sources of evidence should be clearly stated in the appraisal documentation.

9.4.3 Discounting

Discounting is a technique used to compare costs and benefits that occur in different time periods. It is a separate concept from inflation, and is based on the principle that, generally, society prefers to receive goods and services now rather than later, and to defer costs to future generations. This is known as 'social time preference'. The 'social time preference rate' (STPR) is the rate at which society values the present compared to the future.

9.4.4 Discount Rates

HM Treasury recommends a discount rate of 3.5%, which declines over time (i.e. 3.5% for appraisal years 0 to 30 and 3.0% for years 31 to 75 etc. – refer to Table 6.1 of Green Book). Consequently transport appraisals should adopt the standard rate of 3.5% for the period up to 30 years from the year of appraisal and the lower rate of 3.0% for years 31 to 60. Using these discount rates, £1 would be worth roughly the same value in 60 years as it would have been worth in using the previous rates and 30 year appraisal period.

9.4.5 Base Year for Discounting

The base year that all costs and benefits should be discounted to is currently 2010.

9.4.6 Units of Account

The Treasury Green Book recommends the use of market prices as the basis for appraisal. NATA requires the use of a market price base, arguing that this is consistent with the use of 'willingness to pay', as recommended in Sugden's report *Developing a Consistent Cost-Benefit Framework for Multi-Modal Transport*.

The market price unit of account expresses prices in market prices. Market price refers to the price paid by consumers for goods and services in the market and therefore includes all indirect taxation (indirect taxation refers to taxation levied on a product and therefore includes excises, duties and VAT). Prices that do not include taxation (e.g. public transport fares) are still perceived by consumers in the market price unit of account.

The factor cost unit of account expresses prices in resource costs. Resource costs are costs that are net of indirect taxation. The prices paid by Government for goods and services are not subject to indirect taxation as any tax that is paid by Government bodies is recovered by Government and thus may be ignored. Government expenditure is therefore in the factor cost unit of account. Business costs and benefits are also assumed to be in the factor cost unit of account as businesses are free of indirect taxation because they can claim it back. An exception to this is fuel duty, which businesses cannot claim back.

Costs can be converted to (or from) market prices by multiplying (or dividing) by the indirect tax correction factor, (1+t), where t is 19.0% (equivalent to the average rate of indirect taxation in the UK economy).

Perceived costs are those which are actually experienced by users. Perceived costs are different for work and non-work trips because businesses can claim back VAT on purchases. Businesses cannot, however, claim back fuel duty and therefore this is included in their perceived cost. (where certain classes of PSV can claim back fuel duty this should be treated as a subsidy). Note that business users perceive costs in the factor cost unit of account, while consumers perceive costs in the market price unit of account.

Indirect tax revenues should be included in the numerator of the BCR calculation.

The most common indirect tax impact in transport appraisal arises from the differential between road and rail. Put simply, an increase in road activity (and therefore fuel used) will lead to an indirect tax benefit, whereas a shift from road towards rail will typically result in an indirect tax disbenefit, as there is no duty changed on rail fares. It is important to note however that while there is no duty on rail fares, a scheme that results in an increase in rail vehicle kilometres will have an indirect tax impact as rail diesel is subject to fuel duty. Electricity is not subject to fuel duty, therefore battery electric vehicles are exempt from fuel duty.

There are three main sources of indirect tax effects in rail appraisal: (a) when rail revenue changes between the with and without scheme scenarios, expenditure shifts from/to goods or services attracting the average level of indirect taxation to/from rail fares – this has an indirect tax effect as there is no VAT on rail fares; (b) when people switch modes from road to rail (or vice versa), they stop (or start) paying the level of indirect taxation on fuel, which is higher than the average level of indirect taxation. This element of the indirect tax impact for uni-modal model appraisals is generally calculated as one of the elements of Marginal External Costs; (c) if the quantity of rail diesel vehicle kms changes as a result of the scheme, there will be an indirect tax effect as rail diesel is subject to duty.

In rail appraisal, the indirect tax impact of shifts from/to car use should be estimated with the indirect tax element of the marginal external costs. For public transport schemes, this should be complemented with the indirect tax impact from increased/reduced spending on public transport fares (on which VAT is not applied) and from changes in fuel use relating to public transport provision (when indirect tax is paid on that fuel).

9.4.7 Price Base Year

The price base year should be the standard base year of 2010. All current/nominal prices in the appraisal should be adjusted for inflation and converted to 2010 prices using the GDP deflator and not CPI or RPI. The GDP deflator is produced by HM Treasury and is used by the Department for Transport to adjust for inflation. It is considered more appropriate for deflating public expenditure series than consumer price indices such as CPI and RPI, due to its coverage of a broader range of annual price changes within the economy. The latest GDP deflator index (1990 – 2100) can be obtained via the WebTAG databook.

9.4.8 Model Base Year

The model base year will depend on the currency of the dataset used to develop the model. On the assumption that significant new datasets will be collected, the model base year is likely to be the current year (the year in which the surveys will be conducted).

9.4.9 Forecasts

In the case of a single intervention, forecasts are ideally required for the year of opening (see below) and a second 'forecast' year, some years after opening. In the case of a strategy or plan, forecasts are ideally required for at least the year of opening of each of the main elements of the option and for the future 'forecast year'. However, it may not always be practical to conduct forecasts for the opening years of every one of the main elements of an option. In such cases an appropriate common year should be chosen so that streams of costs and benefits can reasonably be inferred from a variety of different starting points.

9.4.10 Opening Year

In order to establish streams of costs and benefits for use in the CBA, it is necessary to assume an option opening year. This will be the year in which operating and maintenance costs begin to be incurred and typically the year in which the users begin to gain positive benefits from the option. Where elements of an option have different opening years, a reasonable approach to estimating cost and benefit streams without making an excessive number of model runs will be required. This will typically involve extrapolation and interpolation of the costs and benefits back from a common year for which the model is run.

9.4.11 Forecast Year

The 'forecast year' is the future year - typically 10 to 15 years after the opening year - for which the model is also run to generate single-year costs and benefits from which the streams of costs and benefits may be inferred. The forecast year may vary, depending on:

- The timing at which problems are thought likely to become critical and in need of solution;
- The kinds of solution considered appropriate and the time likely to be required for implementation; and
- The availability of model input data on future trends, economic growth, and so on.

Thus, a study which is concerned with problems which are in need of urgent resolution in the next few years and for which traffic management solutions, for example, are considered appropriate, may use a forecast year only a few years away from the model base year. On the other hand, a study in which problems are thought likely to persist over a longer timeframe may use a forecast year 20 to 30 years away from the model base year.

A study may involve preparing forecasts and conducting analyses and appraisals for more than one forecast year. For example, if a strategy involves phased implementation of the options or if there is expected to be significant change in the rate of growth in user benefits over the appraisal period, then it is recommended that the model be run to generate forecasts for a set of time points which will enable the whole benefit and cost stream to be calculated.

9.4.12 Values of Time

The tables below provide the latest recommended values of time for application in most standard transport appraisals (all expressed in average 2010 values and prices). The data presented is taken from Table A 1.3.1 of the WebTAG data book.

An Economy Spreadsheet which supports Section 9 – Economy of the STAG Technical Database has now been published. This spreadsheet provides tables 9.2 to 9.20 in Excel format for ease of use. This can be found in the Section 17.1 or the Downloads and Worksheets section.

The use of mode specific values could potentially increase the risk of not accounting for people who switch between modes. Where the number of people switching modes is high relative to the number of existing users it may be inappropriate to use the values below. Under these circumstances the practitioner should contact Transport Scotland for advice.

Table 9.2: Values of Working (Employers' Business)Time by mode (£ per hour, 2010 prices) (Source: WebTAG data book Table A1.3.1)

Mode	Factor Cost	Perceived Cost	Market Price
Car driver	14.86	14.86	17.69
Car passenger	14.86	14.86	17.69
LGV (driver or passenger)	10.24	10.24	12.18
OGV (driver or passenger)	12.06	12.06	14.35
PSV driver	12.32	12.32	14.66
PSV passenger	8.42	8.42	10.02
Taxi driver	10.89	10.89	12.96
Taxi/minicab passenger	14.86	14.86	17.69
Rail passenger	24.52	24.52	29.18
Underground passenger	8.42	8.42	10.02
Walker	8.42	8.42	10.02
Cyclist	8.42	8.42	10.02
Motorcyclist	14.86	14.86	17.69
Average of all working persons	16.19	16.19	19.27

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

The values of time presented here are based on the results of primary research undertaken for DfT in 2015. One of the key conclusions from that research was that Employers' Business values vary according to a number of factors (e.g. trip, time, trip cost, trip distance). The researchers concluded that a reasonable proportion of variation in the values of time can be explained by trip distance. Based on the recommendations of this research, the value of time for Employers' Business trips recommended for use in appraisals vary with distance.

The recommended method for generating distance-related values of time for Employers' Business trips by rail or car is to use the continuous function described below. This is seen as the most robust approach because it provides the most precise relationship between trip distance and the value of time:-

Formula for employers' business value of time by mode (car and rail only) (£ per hour, 2010 prices, 2010 values)
$$VTTS = \frac{U}{\left(1 + e^{\frac{x_{mid} - D}{k}}\right)}$$

Parameter definitions for employers' business value of time by mode	
Parameter	**Descrition**
D	distance (km)
VTS	value of time
U	upper limit (asymptote) of function
Xmid	distance at the inflexion point of the curve (where VTTS =U/2)
k	scale parameter (inversely proportional to the steepness of the curve)
e	Euler's number. A mathematical constant approximately equal to 2.71828

Parameter values for employers' business value of time by mode		
Parameter	**Car**	**Rail**
U (factor cost)	£24.80	£36.47
U (perceived cost)	£24.80	£36.47
U (market price)	£29.52	£43.40
Xmid	66.53	107.04
k	67.02	63.95
VTTS where *D=0* (factor cost)	£6.71	£5.76
VTTS where *D=0* (perceived cost)	£6.71	£5.76
VTTS where *D=0* (market price)	£7.98	£6.85

In the event that the application of the continuous function is not proportionate, the practitioner may use the following table which present values of time varying by distance band. The approach should be agreed in advance with Transport Scotland or the relevant overseeing organisation.

Values of Working (Employers' Business) Time by mode per person (distance banded)			
Mode	**Resource Cost**	**Perceived Cost**	**Market Price**
Car (driver or passenger) 0-50km	8.42	8.42	10.02
Car (driver or passenger) 50-100km	13.62	13.62	16.21
Car (driver or passenger) 100-200km	18.49	18.49	22.00
Car (driver or passenger) 200km+	23.77	23.77	28.28
Rail passenger 0-50km	8.42	8.42	10.02
Rail passenger 50-100km	13.62	13.62	16.21
Rail passenger 100-200km	23.72	23.72	28.23
Rail passenger 200km+	34.22	34.22	40.72

If practitioners are using TUBA v.1.9.8 onwards, this will capture the variation in travel time by trip length provided that the full length of the trip is being considered in the model.

However, not all models, and not all software fully model the full length of a trip. In these circumstances, practitioners must be cautious if using TUBA as this is likely to undervalue the benefits and disbenefits of any travel time savings and gains respectively. In these circumstances and when using other economic evaluation software or evaluation methods, one option would be to use values of Working (Employers' Business) Time which is averaged across all distances. This does not preclude other approaches although these should be agreed in advance with Transport Scotland or the relevant overseeing organisation.

Table A1.3.1. of the WebTAG data book provides an 'all distance' value of Working (Employers' Business) Time, based on trip lengths taken from National Travel Survey data. Scotland is not represented in the National Travel Survey, so this value should ideally be replaced using local data. The methodology for determining an 'all distance' value of Working (Employers' Business) Time should be agreed in advance with Transport Scotland or the relevant overseeing organisation.

Table 9.3: Values of Non-Working Time by Trip Purpose (£ per hour, 2010 prices) (Source: WebTAG data book Table A1.3.1)

Vehicle Occupant	Resource Cost	Perceived Cost	Market Price
Commuting	8.36	9.95	9.95
Other	3.82	4.54	4.54

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

Practitioners should note that the values for non-working time (commuting and other) spent waiting for public transport is two times the values presented in Table 9.3.

9.4.13 Forecast Growth in Values of Time

The recommended forecast values of time are presented in Table 9.4 in the Economy Spreadsheet which supports this section of the STAG Technical Database. The data presented in Table 9.9 has been taken from the Department for Transport's WebTAG data book Table A1.3.2)

9.4.14 Vehicle Occupancies

Car occupancy data extracted from the 1999-2001 National Travel Survey are shown in Table 9.5**.** This presents the sum of driver occupancy (always 1) and passenger occupancy.

Table 9.5: Car Occupancies (2000)

Journey Purpose	Weekday					Weekend Average	All Week Average
	7am – 10am	10am – 4pm	4pm – 7pm	7pm – 7am	Weekday Average		
	Occupancy Per Vehicle Kilometre Travelled						
Work	1.23	1.19	1.17	1.18	1.20	1.28	1.20
Commuting	1.16	1.15	1.13	1.13	1.14	1.14	1.14
Other	1.71	1.78	1.82	1.77	1.78	1.97	1.85
Average Car	1.37	1.59	1.45	1.47	1.48	1.88	1.58
	Occupancy Per Trip						
Work	1.26	1.19	1.20	1.21	1.21	1.30	1.22
Commuting	1.16	1.14	1.14	1.13	1.15	1.13	1.14
Other	1.72	1.70	1.76	1.71	1.72	1.96	1.79
Average Car	1.46	1.59	1.53	1.54	1.54	1.88	1.63

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

Occupancies for all other vehicles are illustrated in Table 9.6**.** Different occupancy figures for LGVs are available for a weekday and weekend. Only all week average occupancy figures are available for all other vehicles and these should be applied for all time periods.

Table 9.6: Other Vehicle Occupancies (2000)

Vehicle Type and Journey Purpose	**Occupancy per vehicle Kilometre Travelled**		
	Weekday Average	**Weekend Average**	**All week Average**
LGV			
Work (freight)	1.20	1.26	1.20
Non Work (commuting and other)	1.46	2.03	1.59
Average LGV	1.23	1.35	1.25
OGV1 Work Only	1.00	1.00	1.00
OGV2 Work Only	1.00	1.00	1.00
PSV			
Driver	1.00	1.00	1.00
Passenger	12.20	12.20	12.20

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

The forecast decline in car passenger occupancies (annual percentage change) to 2036 is shown in Table 9.7, below. After 2036 car passengers are assumed to remain constant. The occupancy rates for all other vehicles should be assumed to remain unchanged over time.

Table 9.7: Annual Percentage Change in Car Passenger Occupancy to 2036 (% per annum)

Journey Purpose	**Weekday**					**Weekend Average**	**All Week Average**
	7am – 10am	**10am – 4pm**	**4pm – 7pm**	**7pm – 7am**	**Weekday Average**		
Work	-0.48	-0.40	-0.62	-0.50	-0.44	-0.48	-0.45
Non-Work (commuting and other)	-0.67	-0.65	-0.53	-0.47	-0.59	-0.52	-0.56

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

9.4.15 Journey Purpose Splits

National Travel Survey (1999-2001) data is also used to produce journey purpose splits for work and non-work travel, based on distance travelled and the number of trips made. This allows the calculation of values of time per vehicle for the average vehicle. These journey purpose splits are assumed constant over time.

The Proportions of Travel / Trips in Work and Non-Work Time are presented in Table 9.8 and 9.9 in the Economy Spreadsheet which supports this section of the STAG Technical Database. The data presented in Table 9.8 and 9. has been taken from the Department for Transport's WebTAG data book A1.3.4). Due to the small sample sizes involved these data should be treated with caution.

9.4.16 Values of Time Per Vehicle

The market price values of time per vehicle are presented in Table 9.10 in the Economy Spreadsheet which supports this section of the STAG Technical Database. The data presented in Table 9.10 has been taken from the Department for Transport's WebTAG data book A1.3.5).

These values are based on distance travelled and are calculated by multiplying the relevant data from Tables 9.2, 9.3, 9.5 and 9.6. Using national average vehicle proportions for 2010, the market price value of an average vehicle is £13.91 per hour, 2010 prices and values.

9.4.17 Vehicle Operating Costs (VOC)

The use of the road network by private cars and lorries generate operating costs for the user. Vehicle operating costs are defined as costs that vary with vehicle usage and are based on vehicle-miles travelled. These costs include fuel, tyres, oil, maintenance, repairs, and mileage-dependent depreciation. Clearly transport projects or policies can generate changes in vehicle operating costs by affecting the volume of car traffic, either through mode switching or induced traffic, and the speed and distance travelled through route changes.

9.4.18 Vehicle Operating Costs (Fuel and electricity)

Fuel consumption is estimated using a function of the form:

$$L = (a + bv + cv^2 + dv^3) / v$$

Where:
$L =$ consumption, expressed in litres per kilometre;
$v =$ average speed in kilometres per hour; and
$a,\ b,\ c,\ d$ are parameters defined for each vehicle category.

Evidence of the energy consumption of electric cars is currently limited. At present, it should be assumed that energy consumption is proportional to distance by independent of speed (i.e. equivalent to a "b" parameter in the fuel consumption formula with the a, c and d parameters all zero). The appraisal of electric cars is a developing area and it is expected that speed related curves will be developed in the future.

The parameters needed to calculate the fuel/energy consumption element of VOCs are presented in Table 9.11. The fuel consumption parameter values are based on a 2010 vehicle fleet, whilst the electrical energy consumption values are based on 2011 values.

Table 9.16: Fuel/Energy Consumption Formulae Parameter Values (Source: WebTAG data book Table A1.3.8)

	Parameters			
Vehicle Category	**a**	**b**	**c**	**d**
Fuel Consumption Parameter Values (litre per km, 2010)				
Petrol Car	1.11932	0.04400	-0.00008	0.000002
Diesel Car	0.49215	0.06218	-0.00059	0.000005
Petrol LGV	1.95083	0.03453	0.00007	0.000004
Diesel LGV	1.39688	0.03348	-0.00023	0.000008
OGV1	1.43145	0.25802	-0.00391	0.000034
OGV2	2.67011	0.55716	-0.00798	0.000060

PSV	5.98005	0.24528	-0.00306	0.000031
Energy Consumption Parameter Value (kWh per km, 2011)				
All electric vehicles	0.12564			

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

Table 9.11 no longer provides consumption values for an 'average car', as units for electric cars (kWh) differ from the units for petrol and diesel cars (litres). However, it is possible to convert the consumption values into costs and estimate the fuel/energy per kilometre for an average car. Examples of this are given in Table 9.12 (which gives 2010 values, excluding electric cars) and Table 9.13 (which gives 2011 values, including electric cars and a combined average for petrol, diesel and electric cars).

Table 9.12: Fuel/Energy VOC Formulae Parameter values (2010 values and prices)

	Parameters			
Vehicle Category	**a**	**b**	**c**	**d**
Values excluding VAT (for vehicles in course of work)				
Petrol Car	111.378	4.379	-0.008	0.0002
Diesel Car	49.825	6.295	-0.060	0.0005
Average Car	86.309	5.159	-0.029	0.0003
Petrol LGV	194.117	3.436	0.007	0.0004
Diesel LGV	141.422	3.389	-0.023	0.0008
Average LGV	144.511	3.392	-0.022	0.0008
OGV1 (diesel)	144.921	26.122	-0.396	0.0034
OGV2 (diesel)	270.325	56.407	-0.808	0.0061
PSV (diesel)	605.427	24.832	-0.310	0.0031
Values including VAT (for vehicles in course of other purposes)				
Petrol Car	130.869	5.145	-0.010	0.0003
Diesel Car	58.545	7.397	-0.070	0.0006
Average Car	101.413	6.062	-0.034	0.0004
Petrol LGV	228.088	4.037	0.008	0.0004
Diesel LGV	166.171	3.982	-0.027	0.0009
Average LGV	169.800	3.986	-0.025	0.0009

Note: In 2010 it is assumed there are no electric cars, so the 'Average Car' is an average over petrol and diesel.

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

Table 9.13: Fuel/Energy VOC Formulae Parameter values (2011 values and prices)

	Parameters			
Vehicle Category	**a**	**b**	**c**	**d**
Values excluding VAT (for vehicles in course of work)				
Petrol Car	121.962	4.795	-0.009	0.0003
Diesel Car	55.457	7.007	-0.067	0.0005
Electric Car	0.000	1.551	-0.00000	0.000000
Average Car	93.354	5.744	-0.034	0.0004
Petrol LGV	216.258	3.828	0.008	0.0004
Diesel LGV	156.626	3.754	-0.026	0.0009
Average LGV	159.856	3.758	-0.024	0.0008
OGV1 (diesel)	164.977	29.738	-0.450	0.0039
OGV2 (diesel)	307.736	64.213	-0.919	0.0069
PSV (diesel)	689.214	28.269	-0.353	0.0035
Values including VAT (for vehicles in course of other purposes)				
Petrol Car	146.354	5.754	-0.011	0.0003
Diesel Car	66.549	8.408	-0.080	0.0006
Electric Car	0.000	1.628	0.00000	0.000000
Average Car	112.025	6.893	-0.040	0.0005
Petrol LGV	259.509	4.593	0.009	0.0005
Diesel LGV	187.951	4.504	-0.031	0.0010
Average LGV	191.828	4.509	-0.029	0.0010

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

Fuel Costs, Fuel Duty and VAT rates are shown in Table 9.14, which is provided in the Economy Spreadsheet which supports this section of the STAG Technical Database. The data presented in Table 9.14 has been taken from the Department for Transport's WebTAG data book A1.3.7).

Table 9.15 now removed. Refer to table 9.14 for costs from 2031.

The resource cost of fuel VOCs is net of indirect taxation. The market price is gross of indirect taxation and is therefore the sum of the resource cost and fuel duty, plus VAT (market price= [resource cost + fuel duty] x [1+VAT]). In work time the perceived cost of fuel VOCs is the cost perceived by businesses. Businesses are generally viewed as perceiving costs in the factor cost unit of account as most business costs are free of indirect taxation because they can claim it back. However, businesses cannot reclaim fuel duty and therefore the perceived cost of fuel VOCs in work time is equal to the resource cost plus fuel duty. In non-work time, the perceived cost of fuel VOCs is the cost as perceived by the individual consumer. Consumers perceive costs in the market price unit of account and therefore the perceived value of fuel VOCs in non-working time is equal to the market price.

Values for fuel duty and VAT in Table 9.19 take account of all changes announced in the 2012 Budget Report (HMT March 2012). These are:

- A 3.02p per litre increase in fuel duty from 57.95p per litre to 60.97p per litre on 1 August 2012
- Increases in line with RPI on 1 April each year from 2013 onwards.

The actual price of a unit of electricity may vary according to the type of electricity used (domestic, commercial or industrial) which in itself will depend on where electric cars are recharged. We would expect much of the electricity for electric cars to be charged at the domestic rate. At the same time, the rail industry pays a much lower price for electricity than domestic users.

Beyond 2030, the electricity prices for both car and rail are assumed to vary according to the change in carbon cost only. For petrol and diesel beyond 2030, both the resource and duty prices are forecast to grow at a rate of 0.195% per year.

Information on the rates of fuel duty to be applied in the calculation of rail fuel operating costs can be found in Section 9.5.22 Rail Operating Costs.

Table 9.16 shows the forecast proportion of the car and LGV fleet using petrol, diesel or mains electricity used to calculate average car and LGV values. Values for years between 2005 and 2029 that are not shown in the table should be estimated using linear interpolation between the two closest years. Values for 2031 onwards should be assumed to be held at 2030 levels. With electric cars still in the early stages of development, and uncertainty over the rate of progression in battery technology (a key barrier to progress) there is necessarily a large margin of error around any forecast take up of electric vehicles. As such this projection should be seen as one of a range of potential development pathways and any particular sensitivity to the pathway given out here noted in the analysis.

Table 9.16: Proportion of cars and LGV vehicle kms using petrol, diesel or electricity (%) (Source: WebTAG data book Table A1.3.9)

Year	Cars			LGVs		OGV1		OGV2		PSV	
	Petrol	Diesel	Electric	Petrol	Diesel	Diesel	Electric	Diesel	Electric	Diesel	Electric
2004	73.28	26.72	0.00	11.07	88.93	100.00	0.00	100.00	0.00	100.00	0.00
2010	59.27	40.73	0.00	5.86	94.14						
2015	47.97	51.87	0.16	3.64	96.36						
2020	43.70	55.33	0.96	1.89	98.11						
2025	44.41	53.05	2.54	1.04	98.96						
2030	44.46	50.23	5.31	0.79	99.21						

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

9.4.19 Rates of Change in Fuel VOCs

There are two causes of changes in fuel VOC over time: improvements in vehicle efficiency and changes in the cost of fuel. For cars, changes in fuel VOCs also reflect changes in the proportion of traffic using either petrol, diesel or mains electricity.

Vehicle efficiency assumptions are illustrated in Table 9.17. These figures show changes in fuel consumption and therefore negative figures indicate an improvement in vehicle efficiency.

Table 9.17: Forecast Assumed Vehicle Fuel Efficiency Improvements (Source: WebTAG data book Table A1.3.10)

Year	Change in Vehicle Efficiency (% pa)							
	Petrol Car	**Diesel Car**	**Electric Car**	**Petrol LGV**	**Diesel LGV**	**OGV1**	**OGV2**	**PSV**
2006 - 2007	-0.42 (actual)	-0.49 (actual)		-0.01 (actual)	0.00 (actual)	-1.23 (actual)	-1.23 (actual)	0.00 (actual)
2007 - 2008	-1.05 (actual)	-1.07 (actual)		-0.01 (actual)	0.00 (actual)	-1.23 (actual)	-1.23 (actual)	0.00 (actual)
2008 - 2009	-1.78 (actual)	-0.92 (actual)		-1.35 (actual)	-1.23 (actual)	-1.23 (actual)	-1.23 (actual)	0.00 (actual)
2009 - 2010	-1.43 (actual)	-1.63 (actual)		-0.34 (actual)	-1.80 (actual)	-1.23 (actual)	-1.23 (actual)	0.00 (actual)
2010 - 2015	-1.81	-2.23	0.10	-0.11	-2.71	0.00	0.00	0.00
2015 - 2020	-3.32	-2.22	-0.02	-2.35	-2.35	0.00	0.00	0.00
2020 - 2025	-3.16	-2.02	-0.12	-2.85	-1.65	0.00	0.00	0.00
2025 - 2030	-1.56	-1.19	0.00	-2.40	-0.74	0.00	0.00	0.00
2030 - 2035	-0.57	-0.52	0.08	-0.54	-0.22	0.00	0.00	0.00

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database. The spreadsheet also contains Table 9.17a: Cumulative Change in Assumed Vehicle Fuel Efficiency Improvements.

As with consumption values noted earlier, values for an average car are no longer provided as petrol, diesel and electric cars do not have common units. Table 9.18 shows how the parameters to calculate fuel/energy cost per kilometre changes through time for an average car and an average LGV.

Table 9.18: Average Vehicle Fuel/Energy Cost Formulae Parameter Values (2010 prices) (Source: WebTAG data book Tables A1.3.12 and A1.3.13)

	Parameters			
Vehicle Category	**a**	**b**	**c**	**d**
Average Car, excluding VAT (for travel in course of work)				
2010	86.309	5.159	-0.029	0.0003
2015	61.554	4.163	-0.027	0.0003
2020	56.169	4.063	-0.028	0.0003
2025	56.307	4.121	-0.028	0.0003
2030	52.301	3.851	-0.026	0.0003
Average LGV, excluding VAT (for travel in course of work)				
2010	144.511	3.392	-0.022	0.0008
2015	108.851	2.571	-0.017	0.0006
2020	105.886	2.519	-0.017	0.0006
2025	112.989	2.697	-0.018	0.0006
2030	110.531	2.642	-0.018	0.0006
Average Car, including VAT (for travel in course of other purposes)				
2010	101.413	6.062	-0.034	0.0004
2015	73.865	4.995	-0.032	0.0003
2020	67.403	4.873	-0.033	0.0003
2025	67.568	4.937	-0.034	0.0003
2030	62.761	4.604	-0.031	0.0003
Average LGV, including VAT (for travel in course of other purposes)				
2010	169.800	3.986	-0.025	0.0009
2015	130.622	3.085	-0.020	0.0007
2020	127.064	3.022	-0.020	0.0007
2025	135.587	3.237	-0.022	0.0007
2030	132.637	3.170	-0.022	0.0007

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

9.4.20 Vehicle Operating Costs (Non-Fuel)

Non-fuel-related costs include the costs of oil, tires, maintenance and repairs, depreciation and capital saving for vehicles in working time.

Non-fuel VOCs are calculated using the following formula;

$$C = a1 + \frac{b1}{V},$$

Where;
C = cost in pence per kilometre travelled,
V = average link speed in kilometres per hour,
a1 = a parameter for distance related costs defined for each vehicle category,
b1 = a parameter for vehicle capital saving defined for each vehicle category (only relevant to working vehicles).

Currently parameter a1 takes the same value for petrol and diesel vehicles. For electric vehicles, the evidence is very weak, but suggests that the costs are lower because there are fewer moving parts that are likely to wear out with mileage. There is currently no evidence to confirm whether the a1 parameter differs by trip purpose for electric cars. There is also no evidence regarding the b1 parameter for electric cars in-work. For the present it will be assumed that the vehicle capital saving for electric cars will be the same as for petrol/diesel cars.

Table 9.19 presents the required parameters to calculate the non-fuel vehicle operating costs.

Table 9.19: Non-Fuel Resource VOCs, 2010 (2010 prices and values) (Source WebTAG data book Table A1.3.14)

Vehicle Category		Parameter Values	
		a1 p / km	b1 p / hr
Car	Work Petrol	4.966	135.946
	Work Diesel	4.966	135.946
	Work Electric	1.157	135.946
	Non-Work Petrol	3.846	0.000
	Non-Work Diesel	3.846	0.000
	Non-Work Electric	1.157	0.000
LGV	Work	7.213	47.113
	Non-Work	7.213	0.000
	Average	7.213	41.458
OGV1	Work	6.714	263.817
OGV2	Work	13.061	508.525
PSV	Work	30.461	694.547

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

Non-fuel VOCs are assumed to remain constant in real terms over the forecast period; however parameters for an average car vary through time (owing to changes in the proportion of electric vehicles) and are given in Table 9.20.

Table 9.20: Forecast Non-Fuel Resource VOCs (2010 prices) (Source WebTAG data book Table A1.3.15)

Year	Work Car		Non-Work Car		Average Car	
	a1 pence/km	b1 pence/hr	a1 pence/km	b1 pence/hr	a1 pence/km	b1 pence/hr
2010	4.966	135.946	3.846	0.000	3.992	17.809
2015	4.960	135.946	3.842	0.000	3.988	17.809
2020	4.929	135.946	3.820	0.000	3.965	17.809
2025	4.869	135.946	3.778	0.000	3.921	17.809
2030	4.764	135.946	3.703	0.000	3.842	17.809

This table is also provided in the Economy Spreadsheet which supports this section of the STAG Technical Database.

9.4.21 Bus Operating Costs

In a standard appraisal of a road scheme buses should be treated as part of the traffic flow, and the operating cost formulae (described above) are applied, using the appropriate parameter values for PSVs. In a multi-modal study, however, different options may result not only in faster or slower running times for existing bus services, but in the need for more or different levels and patterns of bus service provision. In these cases, the impact of options on the costs of bus service provision have to be considered in more detail.

9.4.22 Rail Operating Costs

Information on rail operating costs can be obtained through discussion with Transport Scotland.

9.4.23 Rail Appraisal – Road Network Effects

Transport Scotland recommend that impacts on the wider transport network are assessed with a multi-modal transport model. However, it recognises that in some cases the cost of developing such a model cannot be justified as being in keeping with the principle of proportionality in STAG appraisal. In such cases suitable approximations of the impact on the road network should be applied and identified separately in the TEE table.

In many cases, approximate values can be obtained through taking skims of existing road network models for the local area. The Department for Transport has also provided estimates for the impact of marginal changes to car flows on the road network based on data from the NTM. Practitioners should make use of the methods and values set out in Unit A5.4 of WebTAG where local models of the road network are unavailable.

It should be noted that, consistent with STAG guidance under the Environment Criterion, monetised values for journey ambience, local air pollution, or noise should not be included in the AST.

9.5 Reporting

It is important that practitioners provide clear and concise details of the impacts which are calculated during Part 2 Appraisal under the Economy Criterion in the STAG Report. For the TEE analysis, a statement of key appraisal parameters should be made and the key components of the present value of benefits should be presented and described – Travel time, User charges, Vehicle Operating Costs and Quality/Reliability benefits (where appropriate). This should be complemented by the presentation and discussion of the distribution of journey time (dis-) benefits by size, the product of the analysis outlined in section 9.2.2.1.

A tabular presentation of results is expected in the Part 2 AST with supporting information provided to outline the basis for the quantitative impacts calculated. Calculated WEIs should be presented clearly in the same Part 2 AST supplemented by spatial analysis of the impacts of the scheme where possible (most likely, using GIS. Where no WEIs impacts are expected this should be stated clearly.

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