TAG UNIT A1.1

Cost-Benefit Analysis

May 2018

Department for Transport

Transport Analysis Guidance (TAG)

https://www.gov.uk/transport-analysis-guidance-webtag

This TAG Unit is guidance for the **APPRAISAL PRACTITIONER**

This TAG Unit is part of the family **A1 – COST BENEFIT ANALYSIS**

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1 Introduction

1.1 What is Cost-Benefit Analysis?

1.1.1 The Green Book [HMT, 2003] sets out best practice guidance on assessing and evaluating policies, programmes and projects and recommends that options should be appraised using cost-benefit analysis (CBA). The Green Book defines CBA as 'analysis which quantifies in monetary terms as many of the costs and benefits of a proposal as feasible, including items for which the market does not provide a satisfactory measure of economic value.'

1.1.2 Therefore CBA entails presenting as many of the impacts of a scheme or option as possible in monetary terms, so that they can be compared in a common unit of measurement. Some valuations can be made using prices paid in markets and predictions of future prices, e.g. fuel prices. The valuation of some other impacts, for which markets do not provide prices, is derived from research, e.g. stated preference studies to derive values of time that are used to convert time saved into a monetary value.

1.1.3 It is currently infeasible or impractical to derive monetary values for some impacts. While these impacts will not form part of a monetised CBA, the Green Book recognises their importance and recommends that supplementary techniques should be used to weigh up non-monetised impacts – it does NOT recommend that consideration should be restricted to those impacts that can be valued in monetary terms. The Green Book notes that the most common technique used where there are unvalued costs and benefits is weighting and scoring, or multi-criteria analysis. In particular, multi-criteria analysis can handle circumstances where there are several different kinds of impacts that cannot readily be valued.

1.1.4 TAG Unit Families A2, A3 and A4 on Economic, Environmental and Social Impact Appraisal, provide guidance on qualitative and quantitative analysis of a range of impacts that can not be monetised but should be included in the Appraisal Summary Table (AST). Therefore, while CBA forms an important part of the transport appraisal, it is only one element of what is effectively a multi-criteria analysis. TAG Unit Family A5 on Uni-Modal Appraisal provides additional guidance on how the principles described here should be applied in specific contexts.

1.1.5 The benefits or disbenefits to transport users will usually be derived from a transport model. They should include all significant user costs and benefits, taking account of all significant traveller responses. Further guidance on modelling is given in the TAG Units in Unit Families M1-M5, while the derivation of monetised benefits/disbenefits is discussed in TAG Unit A1.3 – User and Provider Impacts.

1.2 The scope of this Unit

1.2.1 Section 2 of this TAG unit sets out the general principles of CBA that should be applied to all monetised costs and benefits. Guidance on how to estimate and value specific impacts is given in the TAG Manuals for Appraisal Practitioners listed above.

1.2.2 Table 1 lists all of the impacts included in the AST, categorised by impacts that:

- are typically monetised and reported in the Transport Economic Efficiency (TEE), Public Accounts (PA) and Analysis of Monetised Costs and Benefits (AMCB) tables;

- can be monetised but their monetary values are not reported in the AST as the underlying evidence base is considered less robust; and

- it is currently infeasible to monetise so qualitative or quantitative analysis should be reported in the AST.

Table 1 - Appraisal Summary Table Impacts			
Category of impact	Impacts that are typically monetised	Impacts that can be monetised but are not reported in the AMCB table	Impacts that it is currently not feasible or practical to monetise
Economy	Business users and private sector providers (including revenues)	Reliability impact on business users Wider Economic Impacts	
Environment	Noise Air quality Greenhouse gases	Landscape	Townscape Historic Environment Biodiversity Water environment
Social	Commuting and other users Accidents Physical activity Journey quality	Reliability impact on commuting and other users Option and non-use values	Security Access to services Affordability Severance
Public Accounts	Cost to broad transport budget Indirect tax revenues		

2 Principles of Cost-Benefit Analysis

2.1 Introduction

2.1.1 This section provides guidance on principles that should be applied to all costs and benefits that are monetised in CBA. These principles can be summarised as:

- the impacts of a scheme should be based on the difference between forecasts of the **without-scheme and with-scheme cases**;

- impacts should be assessed over a defined **appraisal periods**, capturing the planned period of scheme development and implementation and typically ending 60 years after scheme opening;

- the magnitude of impacts should be **interpolated and extrapolated over the appraisal period** drawing on forecasts for at least two future years;

- values placed on impacts should be in the **perceived costs, factor costs and market prices** unit of account, converted as appropriate from factor costs using the indirect tax correction factor;

- values should be in **real prices**, in the Department's base year, accounting for the effects of inflation;

- streams of costs and benefits should be in **present values**, discounted to the Department's base year;

- results should be presented in the appropriate **cost-benefit analysis metrics**, normally a Benefit-Cost Ratio (BCR); and

- **Sensitivity testing** should be undertaken to reflect uncertainty.

2.1.2   Section 3 provides guidance on reporting cost-benefit analysis results in the Department's standard Transport Economic Efficiency (TEE) table, Public Accounts (PA) table; Analysis of Monetised Costs and Benefits (AMCB) table; and Appraisal Summary Table (AST).

2.1.3   CBA aims to take account of all the impacts of a project and there are essentially two ways of describing the impacts: as a calculus of willingness-to-pay (WTP); or as a calculus of social costs and benefits (SCB). If properly applied, both methods will result in the same valuation of the net benefit to society but will present the impacts in a different way. For transport appraisal the WTP calculus should be used as it allows different impacts on different groups to be identified. More detail on the differences between WTP and SCM calculus is given in Appendix A.

2.2   The without-scheme and with-scheme cases

2.2.1   To estimate the impacts of a transport scheme for CBA it is necessary to forecast two future versions of the world, one with the scheme and one without. CBA then focuses on the differences between the two. TAG Unit M4 – Forecasting and Uncertainty provides guidance on how the 'without-scheme' and 'with-scheme' forecasts should be constructed but there are a number of factors that are particularly important for CBA.

2.2.2   Both the without- and with-scheme cases should include 'near certain' and 'more than likely' land-use changes (e.g. new housing or employment developments) and improvements to the transport network, other than that being assessed. In all cases there should be no difference in land-use between the without- and with-scheme cases. When a development is dependent on a transport scheme going ahead, the analyst should refer to TAG Unit A2.2 - Induced Investment Impacts for specific guidance on dependent developments.

2.2.3   In most cases there should also be no difference in the transport network, other than the scheme being assessed, between the without- and with-scheme cases. However, there may be circumstances where it is clear that transport conditions without the scheme are such that further improvements are likely. Where that is the case, these improvements, and their associated costs, should be included in the without-scheme case but not in the with-scheme case. TAG Unit M4 provides more guidance on this issue.

2.3   Appraisal periods

2.3.1   The costs and benefits of a transport project or policy will typically occur over a long time period. For example, the initial capital expenditure of a transport investment may occur in the first couple of years but ongoing maintenance costs and impacts on factors like travel time or greenhouse gas emissions will last much longer. Therefore, to compare the costs and benefits of a scheme, the appraisal period, the period over which streams of costs and benefits are estimated, should 'cover the period of usefulness of the assets encompassed by the options under consideration'[1].

2.3.2   For many transport investments, including most road, rail and airports infrastructure, it is expected that maintenance and renewal will take place when required. This effectively means that the asset life will be indefinite, or at least as long as maintenance and renewal activity is continued.

2.3.3   For these projects the appraisal period should end 60 years after the scheme opens and the CBA should include the costs of ongoing maintenance and renewal (more detail is given in TAG Unit A1.2 – Scheme Costs). Assessing scheme impacts over a standard 60 year period allows better comparison between options and schemes.

2.3.4   Some projects may involve assets that have a limited life; have special circumstances, such as franchises; or be addressing a transport problem with a short time horizon, so that a shorter appraisal period is more appropriate. In these cases with finite lives, an appraisal period of fewer

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[1] Green Book paragraph 5.10

than 60 years can be used. The analyst should set out the evidence justifying the chosen appraisal period, including where a project is deemed to have an indefinite life and a 60 year period is used.

Residual values

2.3.5 The appraisal period should cover the period of use of an asset but assets may still have some value at the end of the appraisal period. Residual asset values should be included in CBA of projects with finite lives of fewer than 60 years. Residual values should be based on the resale or scrap value of assets, including land and buildings; include any related clean-up costs; and account for 'residual value risk', the uncertainty around the future resale or scrap value. The Green Book provides guidance on valuing land and guidance should be sought from DfT or external risk experts on risk adjustments.

2.3.6 Residual values should **not** be included for projects with indefinite lives with an appraisal period ending 60 years after scheme opening. Where a special circumstance, such as a franchise, limits a project's life, the residual value should be estimated by:

- estimating the 'unconstrained project benefits', the benefits disregarding the special circumstances, over the appropriate appraisal period (i.e. either the asset life or 60 years for an asset with an indefinite life); and

- subtracting the benefits from the project life dictated by the special circumstance from the unconstrained project benefits to give the residual value.

2.4 Interpolation and extrapolation over the appraisal period

2.4.1 The impacts of transport schemes are typically estimated with transport models but it would not be practical to run a model for every year of an appraisal period, particularly for projects with indefinite lives. TAG Unit M4 – Forecasting and Uncertainty provides guidance on selecting forecast years and this section describes how impacts should be interpolated and extrapolated to cover the whole appraisal period.

2.4.2 Interpolation between modelled years should take account of both the change in the magnitude of impacts (for example, the amount of time saved) and the value attributed to them (for example, the real increase in the value of time savings). The TAG Data Book provides the growth rates that should be applied to values. For example, the growth rates for values of time can be found in:

TAG Data Book: Annual parameters

2.4.3 Beyond the last modelled year, benefits should be estimated by extrapolation. As with interpolation, this should account for both the change in the magnitude and value of impacts. However, determining the change in the magnitude of impacts requires more care.

2.4.4 Results from modelled years, particularly where intermediate years have been modelled, will be useful in determining what it is appropriate to assume. It will be reasonable to assume that growth in the magnitude of impacts after the last modelled year is not greater than that implied by modelling results up to the last modelled year.

2.4.5 It is useful to recognise that the magnitude of impacts is usually the product of usage (e.g. trips or vehicle kms) and the impact per unit of use (e.g. time saved per trip). Increasing usage is likely to cause an increase in the magnitude of impacts but will generally lead to congestion or overcrowding, which would reduce the impact per unit of use. Therefore, it may not be credible to assume that the magnitude of impacts will continue to grow indefinitely after the last modelled year.

2.4.6 Analysts should consider:

- whether the magnitude of impacts will continue to grow after the last modelled year and, if so, at what rate;

- whether the magnitude of impacts will decline in the future and, if so, at what rate and from when; and

- how and when the transition from growth to decline will occur.

As an example, Unit A5.3 sets out an approach where the magnitude of impacts is extrapolated on the basis of the ONS national population projections[2], if certain conditions are satisfied.

2.4.7   These factors will be scheme specific and analysts should set out clearly what has been assumed, the evidence supporting those assumptions and sensitivity tests around those assumptions. In case of programme appraisals or funding rounds, other specific approaches may be used and advice from DfT may be required

2.4.8   TUBA is the Department's appraisal software used to calculate benefits to transport users and providers. The default assumption in TUBA is that there is no growth in the magnitude of impacts after the last modelled year. Where the extrapolation of benefits is used, it is expected that the default assumption of zero growth is included as a sensitivity test. In cases where the final modelled year is more than 20 to 25 years after the **scheme appraisal year**, a sensitivity test must be carried out in which zero growth is assumed 20 years after the scheme appraisal year. These tests will demonstrate the impact that assumptions on long-term demand growth (whether forecast or extrapolated) have on the benefits of the scheme.

2.4.9   TUBA also applies the growth in the value of impacts as set out in the TAG Data Book.

2.5   Perceived costs, factor costs and market prices

2.5.1   Transport models use 'perceived costs', those experienced by users, to forecast travel behaviour. However, indirect taxation, like VAT, means that different users perceive costs differently. For example the price of petrol is different for businesses, which can reclaim VAT, and personal travellers, who can't. Different users are perceiving costs in different units of account. Individual consumers perceive 'market prices', including indirect taxation, while businesses and government perceive costs in the 'factor (or resource) cost' unit of account, net of indirect taxation. More detail is given in Appendix B.

2.5.2   CBA could be based on either the factor-cost or market-price unit of account. Which is used will not affect the overall results of a CBA[3] but it is essential that all impacts are expressed consistently. Many of the values used in transport CBA are derived from estimates of people's willingness-to-pay, which are expressed in market prices, so it is natural to use the market price unit of account.

2.5.3   The indirect tax correction factor, (1+t), should be used to convert all values estimated in factor costs to market prices. The current value for t (the average rate of indirect taxation in the economy) is given in the TAG Data Book:

A1.3.1: Value of time per person

2.5.4   Impacts on businesses and government should typically be estimated in factor costs so values that normally require adjustment to market prices include:

- business user travel time savings and reliability impacts (the tables A1.2.1 and A1.2.2 of the TAG Data Book provides values in the market price unit of account);

- business user vehicle operating costs (although they do not pay VAT, business users do pay fuel duty so the correction factor should be applied to the price including duty);

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[2] Extrapolation in line with population projections assumes that the magnitude of impacts per capita remains constant after the final modelled year. This includes travel per capita (trip rates), distance per capita and, crucially benefits per capita. It is a pragmatic approach, particularly where model assumptions, parameters and responses are less reliable into the future, provided that it can be demonstrated that capacity constraints do not curtail benefits growth.
[3] The choice of unit of account will affect the scale of all impacts, all costs and benefits will be (1+t) higher in market price units, but would not affect the Benefit Cost Ratio or make a positive Net Present Value become negative (or vice versa).

- public transport provider revenues and operating costs;

- costs to the broad transport budget; and

- changes in indirect taxation.

2.6 Real prices and accounting for inflation

2.6.1 Inflation is the general increase in prices and incomes over time which reduces what a given amount of money can buy. For example, £1 today can buy much less than £1 twenty years ago and much more than £1 will be able to buy in sixty years' time. Therefore, when applying monetary values to impacts over a long appraisal period in CBA, it is very important to take the effects of inflation in to account. Failing to do so would distort the results by placing too much weight on future impacts, where values would be higher simply because of inflation.

2.6.2 When inflation is not taken in to account, values are said to be in 'nominal' prices and when values are adjusted to account for inflation they are said to be in 'real' prices. For CBA purposes all values should be expressed in real prices to stop the effects of inflation distorting the results. To convert nominal prices to real prices, a price base year and an inflation index need to be selected. The real price in any given year is then the nominal price deflated by the change in the inflation index between that year and the base year.

2.6.3 The Department uses HMT's GDP deflator, which is a much broader price index than consumer price indices (like CPI, RPI or RPIX) as it reflects the prices of all domestically produced goods and services in the economy. Therefore the following formula should be used to convert nominal prices in year *y* to real prices in the Department's price base year, *base,* which is currently 2010:

Real price$_y$ = Nominal price$_y$ * GDP deflator$_{base}$ / GDP deflator$_y$

2.6.4 The monetary values in the TAG Data Book are provided by default in the Department's price base year. Many of the values will increase over time with real increases in income. TAG Units dealing with valuation of specific impacts will include guidance on how those values are expected to change with income. The relevant growth rates, including forecast increases in GDP per capita and per household, are given in:

TAG Data Book: Annual parameters

2.6.5 The growth rates for GDP per capita and per household are in real terms; they reflect forecast growth in income accounting for future inflation. The tables also provide indices of real GDP growth per capita and per household. These indices can be used to calculate a real value, in the Department's price base, for a future year *y*, using the following formula:

Real value$_y$ = Real value$_{base}$ * GDP index$_y$ / GDP index$_{base}$

2.6.6 A similar approach should be taken when considering real cost inflation (i.e. the increase in construction or operating costs over and above the general inflation rate), which is discussed in TAG Unit A1.2.

2.7 Present values and discounting

2.7.1 There is significant evidence to show that people prefer to consume goods and services now, rather than in the future. In general, even after adjusting for inflation, people would prefer to have £1 now, rather than £1 in 60 years' time. As the impacts included in CBA are presented in monetary terms, all monetised costs and benefits arising in the future need to be adjusted to take account of this phenomenon, known as 'social time preference'.

2.7.2 The technique used to perform this adjustment is known as 'discounting'. This process is separate from that used to adjust for inflation. Adjustments for inflation are made to account for the reduction in what £1 can purchase over time, while discounting is performed to reflect people's preferences for

current consumption over future consumption. As discounting is a separate process from accounting for inflation, it should be performed once values are already in real prices. A 'discount rate', which represents the extent to which people prefer current over future consumption, is applied to convert future costs and benefits in to their 'present value', the equivalent value of a cost or benefit in the future occurring today.

2.7.3　The present value of a stream of monetary values can be calculated by discounting the values in which they occur and then summing the stream of discounted values. Formally, this can be shown by the following formula:

$$PV = \sum_{y=0}^{n} \frac{B_y}{\prod_{i=base}^{y}(1+r_i)}$$

2.7.4　Where PV is the present value; B_y is a monetary value (in real prices) received in year y; and $\Pi(1+r_i)$ is the product of 1 plus the discount rate for each year from the *base year* to the year y, when the value is received. The Green Book provides the discount rates which should be applied over different periods and these are given in the TAG Data Book:

A1.1.1: Green Book Discount Rates

2.7.5　These rates should be applied from the current year, i.e. the year when the appraisal is undertaken, and not the scheme opening year. The discount rate is assumed to fall over very long periods because of uncertainty about the future.

2.7.6　As with adjusting for inflation, it is necessary to have a base year for discounting and the Department's current base year is 2010. All streams of costs and benefits, interpolated and extrapolated over the whole appraisal period, presented in real prices and in the market-price unit of account, should be discounted back to this base year. A discount rate of 3.5% should be applied for years between the current year (the year the appraisal is taking place) and the base year.

Present Value of Benefits

2.7.7　Summing the stream of discounted benefits over the appraisal period results in the 'present value of benefits' (PVB), the value of a benefit in the base year equivalent to the stream of estimated benefits. The PVB in the Department's base year *by*, for a scheme with opening year *oy* and a 60 year appraisal period, is given by:

$$PVB_{by} = \frac{B_{oy}}{\prod_{i=by}^{oy}(1+r_i)} + ... + \frac{B_{oy+59}}{\prod_{i=by}^{oy+59}(1+r_i)}$$

where $\Pi(1+r_i)$ applies the Green Book schedule of discount rates in the TAG Data Book to the benefits in each year, B_y.

Present Value of Costs

2.7.8　The 'present value of costs' (PVC) is calculated using a similar formula. The majority of investment costs are likely to occur before the scheme opening year but should be treated in the same way. Appendix C gives a worked example of how to calculate present values.

2.8　Cost-Benefit Analysis metrics

2.8.1　The PVB and PVC allow comparison of the costs and benefits of a scheme or option. This can be done using a number of metrics and the metric chosen can affect how impacts are classified as

costs or benefits. The two most commonly used metrics are the 'benefit-cost ratio' (BCR) and the 'net present value' (NPV).

Benefit-cost ratio

2.8.2   The benefit-cost ratio (BCR) is given by PVB / PVC and so indicates how much benefit is obtained for each unit of cost, with a BCR greater than 1 indicating that the benefits outweigh the costs.

2.8.3   Whether an impact is included as a negative cost or a positive benefit (or vice versa) will impact on the BCR. Therefore, the BCR requires a clear definition of what constitutes a cost or a benefit. It might appear attractive to classify all positive impacts as benefits and negative impacts as costs. However, this would lead to inconsistencies as a given impact could be negative for some schemes or options and positive for others, leading to changes in the BCR definition between schemes.

2.8.4   For example, consider an appraisal comprising three elements: investment costs, time savings and greenhouse gas emissions; and comparing two options, both with investment costs of £10m. Option A generates time saving benefits of £50m and greenhouse gas benefits of £10m while Option B yields greater time savings of £100m but increases greenhouse emissions with a £10m disbenefit. Both options cost the same and the total net benefit (the NPV, see below) of Option B is £80m compared with £50m for Option A, suggesting that Option B should be preferred.

2.8.5   However, if the PVC is defined to include all negative impacts, Option A has a BCR of 6 ((50+10)/10) while Option B has a BCR of 5 (100/(10+10)). This definition of the PVC moves the greenhouse gas impact between the PVB and PVC for the two options and distorts the BCR, reducing its usefulness in comparing schemes or options.

2.8.6   As the BCR is used to inform value for money assessments of transport schemes, the PVC should reflect the public budget available to fund transport schemes, referred to as the 'Broad Transport Budget'. The PVC should only comprise Public Accounts impacts (i.e. costs borne by public bodies) that directly affect the budget available for transport.

2.8.7   Public Accounts impacts that do not directly affect the transport budget, such as Indirect Tax Revenues which accrue to the Treasury, and impacts on transport users and providers that might commonly be referred to as costs, such as fuel costs or public transport operating costs, should be included in the PVB. Where a scheme leads to changes in public sector revenues (for example tolling options) careful consideration should be given to whether they will accrue to the Broad Transport Budget and all assumptions, and their justifications, should be clearly reported.

2.8.8   In the example given above, this definition generates a BCR of 6 for Option A and 9 for Option B, resulting in a ranking that is more consistent with the options' NPVs and costs.

Net present value

2.8.9   The net present value (NPV) is simply calculated as the sum of future discounted benefits minus the sum of future discounted costs: PVB – PVC. A positive NPV means that discounted benefits outweigh discounted costs and, in a world with no budgetary constraints there would be a case for taking forward all projects with a positive NPV (providing the net monetised benefit outweighed any net negative non-monetised factors).

2.8.10   As the NPV is a simple summation it makes no difference whether impacts are classified as benefits or costs, as long as they have the correct sign. For example, increased tax revenue could be considered either as a negative cost (since it offsets investment costs) or a positive benefit (since it would facilitate provision of public services or reductions in other taxation) and it would make no difference to the NPV.

2.8.11   The NPV is a useful metric where schemes or options do not impact on the 'Broad Transport Budget' or where they generate significant revenues that accrue to the 'Broad Transport Budget', offsetting investment and operating costs in the PVC. This can lead to a negative cost estimate and,

therefore, a negative BCR, which can be difficult to interpret and makes comparison of schemes or options difficult. However, the major drawback of the NPV is that it does not represent the relativity of benefits and costs and, therefore, its use is limited when making value for money judgements within a constrained budget.

NPV/k (NPV/capital cost)

2.8.12 For schemes that require initial capital expenditure but generate significant revenues that accrue to the 'Broad Transport Budget' the NPV/k metric, where k represents the discounted capital (or investment) costs, may be more useful than the simple NPV. As the NPV is a measure of the net benefit of the scheme, a positive value means that benefits outweigh costs. The advantage of the NPV/k metric over the NPV is that it represents the total benefit per pound of capital expenditure and so provides more information of the relative benefits of different options.

2.9 Uncertainty and sensitivity testing

2.9.1 TAG Unit M4 – Forecasting and Uncertainty provides guidance on alternative scenarios that should be modelled as sensitivity tests to reflect uncertainty in local factors and national demand growth. The principles described above are equally applicable to alternative scenarios as they are to the core scenario.

2.9.2 However, there will be additional sources of uncertainty around some elements of CBA, such as the values that should be applied to an impact. Therefore the more detailed guidance on how to assess specific impacts given in TAG Units for the Appraisal Practitioner may require additional sensitivity tests.

3 Reporting Cost-Benefit Analysis results

3.1 General principles of reporting

3.1.1 As discussed in this Unit, all costs and benefits should be reported as real, present values, in the market prices unit of account.

3.1.2 The primary metric used in reporting the cost-benefit analysis results in most circumstances is the benefit-cost ratio (BCR), which requires a clear definition of what constitutes the Present Value of Benefits (PVB) and Present Value of Costs (PVC). The general principle is that the PVC should only include impacts on the 'Broad Transport Budget', that is costs and revenues which directly affect the public budget available for transport. All other impacts, including operating costs and revenues for private sector transport providers and impacts on wider government finances, should be included in the PVB.

3.1.3 The rest of this section provides guidance on how the various impacts of a transport scheme should be reported in the Department's standard tables: the Public Accounts (PA) table, the Transport Economic Efficiency (TEE) table, the Analysis of Monetised Costs and Benefits (AMCB) table and the Appraisal Summary Table (AST).

3.2 Reporting scheme costs in the Public Accounts and Transport Economic Efficiency tables

3.2.1 TAG Unit A1.2 – Scheme Costs provides guidance on estimating scheme investment and operating costs, including on applying adjustments for risk and optimism bias. This section describes how the outputs from that guidance should be reported in the Department's standard tables.

Public sector provider impacts

3.2.2   Investment and operating costs incurred by a public sector provider[4] should be recorded as positive values in the appropriate rows of the PA table. The cost of 'land gift' by a Local Authority should be included in the 'Investment Costs' row under 'Local Government Funding'.

Private sector provider impacts

3.2.3   Investment and operating costs incurred by private sector providers[5] should always be recorded as negative values in the appropriate row of the 'Private sector provider impacts' section of the TEE table.

3.2.4   The disaggregation in the column headings is quite broad, meaning they include service operators' infrastructure providers. Following the decision to reclassify Network Rail as a Central Government Body[6], Network Rail spending and revenues should be considered to impact directly on the Broad Transport Budget. For rail this means that additional operating costs need to account for track access charge payments and allocation of costs between the track authorities (e.g. Network Rail) and service operators (e.g. TOCs). So, an increase in Network Rail operating costs should be recorded as a positive number in the 'Operating costs' row of the Central Government section of the PA table; related increases in track access charges should be recorded as a negative number in the 'Operating costs' row of the Private Sector Provider section of the TEE table and in the 'Revenue' row of the Central Government section of the PA table. Unless there is evidence of a net negative or positive private sector impact, in the central case, subsidy payments should be set so as to ensure that sub-total 3 in the TEE table is equal to zero.

Transfers between public and private sector bodies

3.2.5   It is important that all costs are correctly allocated and the PA and TEE tables allow for accounting of transfers between public and private sector providers.

3.2.6   The value of 'land gift' by a private sector provider and hypothecated developer contributions should be included in the investment costs recorded under the public sector provider in the PA table. The value of the 'land gift' or contribution should also be recorded as a negative value in both the 'Developer and Other Contributions' row of the PA table (to offset the cost recorded to the public sector provider) and the 'Developer contributions' row of the TEE table (to register the cost to the private sector provider/developer).

3.2.7   Similarly, if private sector costs are met, in part or in full, by a grant or subsidy from the public sector, the full cost to the private sector provider should be recorded as a negative value in the TEE table and the value of the grant or subsidy should be included as a positive value in the appropriate rows of both the TEE and PA tables. Grants from European Restructuring and Development Funds (ERDF) or other public sector sources should be treated in the same way.

3.3   Reporting user and provider impacts in the Public Accounts and Transport Economic Efficiency tables

3.3.1   TAG Unit A1.3 – User and Provider Impacts provides guidance on estimating impacts on transport users and private sector providers. The resulting monetised impacts on these groups are summarised in the TEE table. Benefits should be reported as positive values and disbenefits (or costs) as negative values.

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[4] Costs to public sector providers might typically include provision and maintenance of roads and car parks; highway maintenance costs arising from bus schemes; the costs of providing, maintaining and enforcing bus priority measures, stops and shelters that fall to the highway authority or PTE; and costs of investing in rail track and signals.
[5] Private sector provider costs might typically include investment in bus fleets or ticketing and information systems; investment in rail rolling stock or passenger facilities; and the costs of operating bus and rail services.
[6] http://www.ons.gov.uk/ons/dcp171766_345415.pdf

3.3.2   User travel time, vehicle operating cost and user charge impacts should be included in the TEE table, as should user impacts during construction and maintenance (which should include both travel time and vehicle operating cost impacts). Monetised reliability impacts should not be included in the TEE table.

3.3.3   The 'Private sector provider impacts' section of the TEE table should include estimates of changes in revenues, as well as costs (see paragraph 3.2.3). As discussed above, any changes in grants or subsidies should also be recorded in the appropriate row of both the PA and TEE tables. For example, if a scheme is forecast to increase public transport revenues, which will reduce subsidy payments, the reduction in subsidy should be recorded as a negative value in the 'Grant/subsidy' row of both the PA and TEE tables. More detail on the treatment of revenues and subsidy payments in the context of rail franchises is given in TAG Unit A5.3 – Rail Appraisal.

3.3.4   Impacts should be attributed to the mode and source of change as described in TAG Unit A1.3 (note that the totals for 'User charges', calculated with the 'rule of a half', and private sector provider 'Revenues', calculated from changes in fares and demand, should not be expected to match) and should be reported separately for business (including freight), commuting and other trips. The sub-totals for business, commuting and other indicate the distribution of gains (and, potentially, losses) from the option.

3.3.5   Changes in indirect tax revenue should be reported in the 'Indirect tax revenues' row of the PA table, with increases in indirect tax revenue reported as negative values.

3.3.6   Where not explicitly quantified in the modelling approach, the impacts on pedestrians, cyclists and others should be assessed using the method set out in TAG Unit A5.5 –Highway Appraisal.

3.4   The Analysis of Monetised Costs and Benefits and Appraisal Summary Tables

The Analysis of Monetised Costs and Benefits (AMCB) Table

3.4.1   The AMCB table summarises all of the monetised impacts of a scheme that are considered sufficiently robust for inclusion in the scheme or option's Net Present Value (NPV = PVB- PVC) and Benefit-Cost Ratio (BCR = PVB / PVC). This combines information from the TEE and PA tables with monetised estimates of other impacts (such as accidents and greenhouse gases). Key cells in the TEE, PA and AMCB tables are labelled to indicate how information should be carried from the TEE and PA tables to the AMCB table.

3.4.2   (1a), (1b) and (5) from the TEE table, the net impacts on commuting users, other users and businesses, respectively, should be entered in the corresponding rows of the AMCB table.

3.4.3   Indirect tax revenues, labelled 'Wider public finances' (11) in the PA table, should be entered in the corresponding row of the AMCB table. Analysts should note that indirect tax revenues are included in the calculation of the Present Value of Benefits (PVB). Therefore, the sign of the value in the PA table should be reversed in the AMCB table because the PA table presents costs as positive values.

3.4.4   The impact on the 'Broad transport budget', labelled (10) in the PA table, should be entered in the corresponding row of the AMCB table. This cost to the broad government transport budget forms the Present Value of Costs (PVC) so it is not necessary to change the sign when transferring the value from the PA table to the AMCB table.

3.4.5   The final AMCB table should include monetised estimates of noise, air quality, greenhouse gas, journey quality, physical activity and accident impacts, where appropriate, based on guidance in TAG Unit A3 – Environmental Impact Appraisal and TAG Unit A4.1 – Social Impact Appraisal. Monetised estimates of other impacts, such as reliability or Wider Impacts, should not be included in the AMCB table.

3.4.6   The AMCB table includes costs and benefits for which the evidence on monetary values is considered most robust. There may also be other significant costs and benefits, some of which cannot be presented in monetised form or where the evidence on monetisation is less well developed. Where this is the case, the analysis presented in the AMCB table does not provide a full measure of value for money and should not be used as the sole basis for decisions.

The Appraisal Summary Table (AST)

3.4.7   The Appraisal Summary Table (AST) (see Guidance for the Technical Project Manager) provides a more complete summary of a scheme or option's impacts. Estimates of costs and benefits to transport users and providers from the AMCB table should be included in the AST.

3.4.8   The net impacts on 'Business users and transport providers', (5), and 'Commuting and other users', (1a)+(1b), should be reported in the 'Monetary £(NPV)' column of the corresponding rows in the AST. In addition, the value of journey time changes, including disaggregation by time saving band (following the approach in TAG Unit A1.3), should be separately reported in the 'Quantitative' column.

3.4.9   The 'Summary of key impacts' column should identify the main sources of the benefits, for example, total vehicle hours saved, which should be included for all schemes or options that impact on road congestion. Where analysis of non-motorised modes finds a significant impact, the conclusions of that analysis (i.e. using the 7-point scale) should also be reported here.

3.4.10   The impacts on the 'Broad transport budget', (10), and 'Wider public finances', (11), should be reported in the 'Monetary £(NPV)' column of the 'Public Accounts' section of the AST. Costs should be reported as negative values so that an increase in indirect tax revenue would have a positive value (as in the AMCB).

3.4.11   The 'Summary of key impacts' column in the 'Cost to broad transport budget' row should include any special considerations and simplifications adopted in the analysis and a breakdown of the main components of costs to the broad transport budget, such as the split between local and central government funding and details of funding from other sources, like developer contributions or European grants.

3.4.12   Monetised, quantitative and qualitative information for other categories of impact should be included in the relevant rows and columns of the AST. TAG Unit Families A2, A3 and A4 provide more detailed guidance on what information should be reported.

4   References

HMT (2003) Appraisal and Evaluation in Central Government [http://www.hm-treasury.gov.uk/data_greenbook_index.htm]

DfT (April 2009), NATA Refresh: Appraisal for a Sustainable Transport System

Department of the Environment, Transport and the Regions. Design Manual for Roads and Bridges, Volume 12. [http://www.dft.gov.uk/ha/standards/dmrb/vol12/index.htm]

DfT, Transport Users Benefit Appraisal User Manual, TUBA User Guidance with accompanying TUBA software [https://www.gov.uk/government/publications/tuba-downloads-and-user-manuals]

Sugden (1999) Review of cost/benefit analysis of transport projects

5   Document Provenance

This TAG Unit forms part of the restructured WebTAG guidance, taking previous TAG Unit 3.5.4 – Cost Benefit Analysis as its basis. That Unit was based on Appendix F of Guidance on the Methodology for Multi-Modal Studies Volume 2 (DETR, 2000), with inputs from GOMMMS

Supplement 3, and was updated following the NATA Refresh, in 2009, and the introduction of a 2010 base year in August 2012.

This TAG Unit also covers elements of guidance previously included in TAG Units 2.5 – Appraisal, 2.7 – Transport Appraisal and the Treasury Green Book, and 3.2 – Appraisal (particularly relating to reporting in the Appraisal Summary Table).

In November 2014 this TAG Unit was updated to provide guidance on how Network Rail costs should be treated and reported in appraisal following the decision to reclassify Network Rail as a Central Government body.

Appendix A Cost-Benefit Analysis calculus

A.1.1   Cost-Benefit Analysis aims to take account of all the ways in which a project affects people, irrespective of whether those effects are registered in conventional financial accounts. It can be described in two different ways - as a **calculus of willingness-to-pay (WTP)** or as a **calculus of social costs and benefits (SCB)**. These lead to two different ways of presenting the cost-benefit accounts, but (if properly carried out) both lead to the same valuation of net social benefit.

A.1.2   The SCB calculus focuses on the total resources used, and benefits generated, by a project without accounting for transfers between different groups. The WTP calculus takes account of such transfers, providing more information on how different groups are affected.

A.1.3   The principal advantage of the WTP calculus is this ability to present how a project impacts on different groups (e.g. car users, public transport users, taxpayers), rather than hiding distributional impacts in the aggregation of resource costs and benefits. Similarly, financial and non-financial impacts can be readily distinguished from one another. The latter kind of disaggregation is particularly important when projects are sponsored or co-sponsored by private sector firms, or by public sector agencies which are expected to act in a quasi-commercial way (i.e. to have regard to their own financial balance sheets). For a traditional highway project, where all costs are borne by a government agency and the services of the road are provided to users free of charge, the distinction between financial costs and non-financial benefits is straightforward; in such an application, the calculus of social costs and benefits may be acceptable. But almost all public transport, and some roads, are now supplied by private firms. A common CBA methodology for the transport sector needs to lead to the kind of balance sheet that is generated by the WTP calculus.

A.1.4   The principles of the WTP and SCB calculus are summarised in the extracts from Sugden's report in Box 1. Figure 1 shows graphically how the two approaches result in the same overall measure of net benefits and how the WTP calculus provides more detail on how different groups are affected.

Box 1 The Willingness to Pay Calculus

The basic strategy of the willingness-to-pay (WTP) calculus is to arrive at a money measure of the net welfare change for each individual that is brought about by the project under consideration, and then to sum these. The welfare change for any individual is measured by the **compensating variation,** i.e. the individual's WTP for benefits or the negative of his/her willingness to accept compensation for disbenefits. The principle behind this calculus is the Kaldor-Hicks **compensation test:** a move from one state of affairs to another passes this test if, in principle, those who benefit from the move could fully compensate those who lose (without themselves becoming losers). When the cost-benefit accounts are presented in this way, there often are items which appear as benefits for one person and equally-valued costs for someone else: such items are **transfer payments or pecuniary externalities.** Items which do not cancel out in this way are **social** *costs* or benefits (sometimes called **resource or real resource** costs or benefits). The word 'social' is used to signify that these are costs or benefits which fall on 'society as a whole', understood as the aggregate of all individuals.

The calculus of social costs and benefits seeks to measure the value of the 'resources' used by, and the benefits created by, a project. This approach distinguishes between social costs/benefits and transfer payments at the outset, and takes account only of the former. For example, consider a straightforward market transaction: a person buys and consumes a can of beer. In the calculation of social costs and benefits, the marginal cost of producing the beer is a social cost, while the consumer's enjoyment of the beer is a social benefit; the actual payment made for the beer is a transfer payment, and is ignored. (In contrast, the calculus of WTP would record a benefit to the consumer equal to the consumer's surplus on the beer, i.e. the excess of WTP over the price paid, and it would record a benefit to the producer of the beer equal to the producer's surplus, i.e. the excess of price received over marginal cost). Because the calculus of social costs and benefits nets out transfer payments, this approach does not allow the net social benefit of a project to be disaggregated into impacts on different economic interest groups.

Clearly, the two methods are equivalent. It is important to realise that the difference between the two methods is simply a difference in presentation. It is **not** a difference between wider and narrower ways of defining the class of effects that ultimately count in CBA.
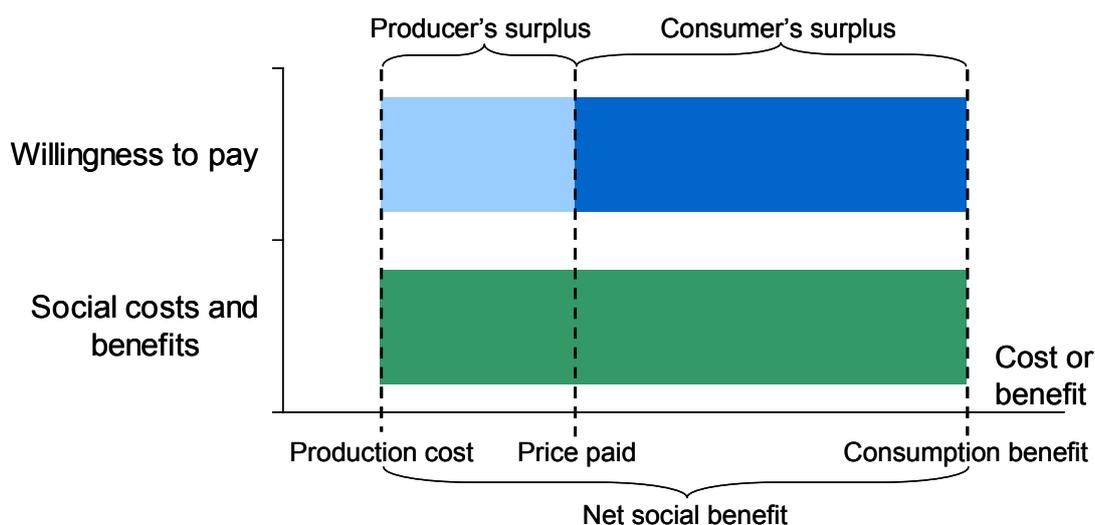

Figure 1 – Willingness to Pay and Social Costs and Benefits calculus

Appendix B Perceived costs, factor costs and market prices

B.1.1   Section 2.5 introduced the idea that indirect taxation creates two possible units of account for CBA: **market prices** (gross of indirect tax) and **factor costs** (net of indirect tax). Businesses and government, which do not pay indirect tax, perceive costs in the factor cost unit of account while consumers perceive market prices. What's important for CBA is not which is used but ensuring all impacts are presented in consistent units. The **indirect tax correction factor** is the conversion between the two units. Transport CBA uses the market prices unit so a correction factor has to be applied to costs or benefits that have been measured net of tax. The principles of the market price base are summarised in the extracts from Sugden's report in Box 2.

Box 2 Principles of the Market Price Base

Denote the average rate of indirect tax on final consumption by t. Thus, goods which are valued at £1 net of tax are valued at £(1 + t) gross of tax; of each £1 of consumer spending, £1/(1 + t) goes to producers in wages, rents and profits and £t/(l + t) goes to the government. Assume that the government balances its budget. Now suppose the government increases its spending by £1, and wishes to finance this through direct taxation. To do this, it must raise direct taxes by **more than £1**, since the increase in direct taxation will imply a reduction in disposable income and hence a fall in indirect tax revenue. In fact, direct taxation must be increased by £(1 + t). Disposable income will then fall by £(1 + t). Since the proportion t/(1 + t) of all consumer spending goes to the government direct tax revenue, indirect tax revenue will fall by £(1 + t) x t/(1 + t), i.e. by £t. Thus the net effect on government tax revenue is £(1 + t) - £t = £1. The implication of this example is that each extra £1 spent by the government is equivalent to a £(1 + t) loss of disposable income by households.

This conclusion should not be interpreted as saying that resources have a different value when they are in the hands of the government than when they are in the hands of private consumers. The point is simply that we are using two different units of account. When we say the government spends £1, we mean that it spends £1 in terms of the factor-cost unit of account. The cost to households in terms of disposable income is £(1 + t), but this is in terms of the market-price unit of account. Each factor-cost unit converts into (1 + t) market-price units: this conversion rate (or its reciprocal, depending on which unit we treat as basic) is the indirect tax correction factor.

Nor should it be thought that this argument applies only to goods which are traded on markets. For example, suppose the government spends £1 million (in factor-cost terms) on a road improvement whose only benefits are savings in leisure time. Suppose these time savings have a value of x when measured in terms of individuals' WTP, as expressed in stated preference surveys. How great must x be in order for the road improvement to be worthwhile? The answer is £(1 + t) million. In other words, if we are carrying out a CBA and are using the factor-cost unit of account, the WTP measure of benefit must be deflated by the tax correction factor. Why? Because stated preference surveys use the market-price unit of account. When a person says that she would be willing to pay up to (say) £1 to save one extra hour of travelling time, she is saying that, in order to save that hour, she would be willing to forgo consumption goods which are worth £1 **at market prices**. The same information could equally well be expressed by saying that she would be willing to forgo consumption goods which are worth £1/(1 + t) at factor cost. It is simply an accounting convention of stated-preference surveys (when addressed to private individuals or households) that answers are expressed in the market-price unit of account.

Appendix C Calculating present values worked example

C.1.1 Section 2.7 included the equation for applying discount rates and calculating present values in the Department's base year, *by*; for a scheme with opening year *oy*; and a 60 year appraisal period, where *Π(1+r_i)* applies the Green Book schedule of discount rates:

$$PVB_{by} = \frac{B_{oy}}{\prod\limits_{i=by}^{oy}(1+r_i)} + ... + \frac{B_{oy+59}}{\prod\limits_{i=by}^{oy+59}(1+r_i)}$$

C.1.2 Table C1 provides an example of applying this formula to a stream of benefits from a scheme with a 2010 Present Value base year, 2013 appraisal year and 2016 opening year.

Table C1 Example of applying discounting and calculating present values									
Year	Discount rate	Discount factor	Benefits £m (2010 prices)	Present Value Benefits	Year	Discount rate	Discount factor	Benefits £m (2010 prices)	Present Value Benefits
2010		1.000		0.00	2043	3.5%	3.112	4.00	1.29
2011	3.5%	1.035		0.00	2044	3.0%	3.205	4.00	1.25
2012	3.5%	1.071		0.00	2045	3.0%	3.301	4.00	1.21
2013	3.5%	1.109		0.00	2046	3.0%	3.401	4.00	1.18
2014	3.5%	1.148		0.00	2047	3.0%	3.503	4.00	1.14
2015	3.5%	1.188		0.00	2048	3.0%	3.608	4.00	1.11
2016	3.5%	1.229	8.00	6.51	2049	3.0%	3.716	4.00	1.08
2017	3.5%	1.272	7.73	6.08	2050	3.0%	3.827	4.00	1.05
2018	3.5%	1.317	7.47	5.67	2051	3.0%	3.942	4.00	1.01
2019	3.5%	1.363	7.20	5.28	2052	3.0%	4.060	4.00	0.99
2020	3.5%	1.411	6.93	4.92	2053	3.0%	4.182	4.00	0.96
2021	3.5%	1.460	6.67	4.57	2054	3.0%	4.308	4.00	0.93
2022	3.5%	1.511	6.40	4.24	2055	3.0%	4.437	4.00	0.90
2023	3.5%	1.564	6.13	3.92	2056	3.0%	4.570	4.00	0.88
2024	3.5%	1.619	5.87	3.62	2057	3.0%	4.707	4.00	0.85
2025	3.5%	1.675	5.60	3.34	2058	3.0%	4.848	4.00	0.83
2026	3.5%	1.734	5.33	3.08	2059	3.0%	4.994	4.00	0.80
2027	3.5%	1.795	5.07	2.82	2060	3.0%	5.144	4.00	0.78
2028	3.5%	1.857	4.80	2.58	2061	3.0%	5.298	4.00	0.76
2029	3.5%	1.923	4.53	2.36	2062	3.0%	5.457	4.00	0.73
2030	3.5%	1.990	4.27	2.14	2063	3.0%	5.621	4.00	0.71
2031	3.5%	2.059	4.00	1.94	2064	3.0%	5.789	4.00	0.69
2032	3.5%	2.132	4.00	1.88	2065	3.0%	5.963	4.00	0.67
2033	3.5%	2.206	4.00	1.81	2066	3.0%	6.142	4.00	0.65
2034	3.5%	2.283	4.00	1.75	2067	3.0%	6.326	4.00	0.63
2035	3.5%	2.363	4.00	1.69	2068	3.0%	6.516	4.00	0.61
2036	3.5%	2.446	4.00	1.64	2069	3.0%	6.711	4.00	0.60
2037	3.5%	2.532	4.00	1.58	2070	3.0%	6.913	4.00	0.58
2038	3.5%	2.620	4.00	1.53	2071	3.0%	7.120	4.00	0.56
2039	3.5%	2.712	4.00	1.47	2072	3.0%	7.333	4.00	0.55
2040	3.5%	2.807	4.00	1.43	2073	3.0%	7.554	4.00	0.53
2041	3.5%	2.905	4.00	1.38	2074	3.0%	7.780	4.00	0.51
2042	3.5%	3.007	4.00	1.33	2075	3.0%	8.014	4.00	0.50
					Total			272.0	108.0

C.1.3   The scheme opening year is 2016 so the appraisal period extends to 2075 to include 60 years of benefits.

C.1.4   The Green Book schedule of discount rates is applied from the year of the appraisal, 2013, so a 3.5% discount rate applies until 2043, with 3% applied until the end of the appraisal period in 2075. The 3.5% rate also applies in years between the appraisal year, 2013, and the Department's Present Value base year, 2010. The discount factor for a given year is the product of (1+discount rate) for each year between the base year and that year.

C.1.5   The stream of benefits, in real 2010 prices and the market prices unit of account, has been interpolated and extrapolated across the appraisal period and the benefit in each year is divided by the discount factor for that year giving the present value for the benefit in each year. For example, the £4m benefit in 2030 is divided by a discount factor of approximately 2, resulting in a present value of the benefit a little over £2m. The same £4m benefit in 2075 is divided by a discount factor of around 8, resulting in a present value of £0.5m. This means that the same £4m benefit (in 2010 prices) is valued around 4 times higher in 2030 than in 2075, because of the individuals' preference for more immediate consumption.

C.1.6   The final stage of the process is to sum the discounted value of the benefit in each year to give a Present Value of Benefits (PVB). In the example above, the PVB is £108m, meaning that the stream of benefits over the 60-year period is equivalent to a one-off benefit of £108m occurring in 2010.

C.1.7   Calculating the Present Value of Costs is very similar. A stream of future operating, maintenance and renewal costs should be estimated over the same appraisal period as the benefits and discounted in the same way. The main difference for most scheme appraisals will be that a significant proportion of investment costs will occur between the appraisal year and the scheme opening year and these costs should be discounted in the same way.