Business Case Development Manual

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EVERY JOURNEY MATTERS

Preface

This manual explains the steps and methods used to make a Business Case. A Business Case must be made for any proposal for change. But how do such proposals arise? Transport for London is charged with ensuring that best use is made of the limited funds available. There is a continuous process of review, intended to identify valuable opportunities for change. The checklist below sets out the possible grounds for change. Most proposals are based on a combination of these, but an understanding of the prime motivator for a proposal may help the appraiser to identify and quantify the appropriate items when making a Business Case.

Why Spend? - Checklist

1. Compulsion
   - Meet statutory requirements
2. Cost effectiveness
   - Avoid age related costs
   - Introduce new, cheaper to run alternative
3. Risk avoidance
   - Reduce potential service disruption/worsening
   - Reduce safety/accident risk
4. Enhancement of primary services
   - Benefit customers, staff or stakeholders
   - Generate added demand and revenue
5. Generation of secondary income
   - Generate revenue from vending, advertising etc.

As we demonstrate in the manual, it is not enough to show simply that a proposal can be justified by making a case for it against any one of these headings. It is also necessary to estimate the size of the net benefit by assessing the total impact on areas 2 to 5, and to investigate options to show that none of the possible alternatives gives better overall value than the one proposed.

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1. Introduction

1.1 Purpose of the Manual

The aim of the Business Case Development Manual is to provide a uniform framework for the evaluation and presentation of business cases across Transport for London (TfL). This will enable authorising bodies within Transport for London and its subsidiaries, and the Department for Transport (DfT), to make informed decisions on whether to approve proposals for change. Business case appraisal is an essential part of all stages of expenditure planning throughout TfL and all its subsidiaries.

All business cases involving capital expenditure, changes in day to day operating expenditure, and the setting and revision of engineering and other standards should be prepared according to the requirements of this manual.

However, major strategic changes (such as railway extensions and intermediate mode schemes) will require more sophisticated demand modelling than is described in this manual. In addition, major projects which have a potentially wider network effect such as line extensions or large-scale interchange schemes are likely to require the more extensive Five Case format business cases and follow the DfT's requirements as set out in WebTAG.

The Public Service (Social Value) Act 2012 requires a contracting public authority to consider how a proposed procurement might improve the social, economic and environmental well-being of its area. Following the processes and procedures set out in this manual will ensure that the business case is compliant with this Act.

1.2 How to use the Manual

Section 2: 'Concepts and Principles of Appraisal' is intended to help managers determine the framework for the appraisal of their projects.

Section 3 onwards describes various financial effects that need to be considered in appraisal. These sections largely deal with what goes on the bottom of a benefit to cost ratio. From section 10 onwards different aspects of social benefits are dealt with. As well as the quantified approaches feeding into the top of a benefit to cost ratio, wider approaches such as multi-criteria analysis and management of value are summarised.

Data has now been removed into online spreadsheets in the same way that WebTAG uses a data book. These can be found on the Business Case Working at TfL Page: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

2. Concepts and Principles of Appraisal

2.1 Appraisal in Context

Appraisals in a business case should evaluate the possible options and identify the best course of action. Analysis however is only part of the decision making process, and if other factors override analysis, then this should be documented and the reasons outlined in the business case document.

The diagram below shows the decision making process in an organisation such as TfL. All should be described in a business case to demonstrate why TfL is following a course of action.

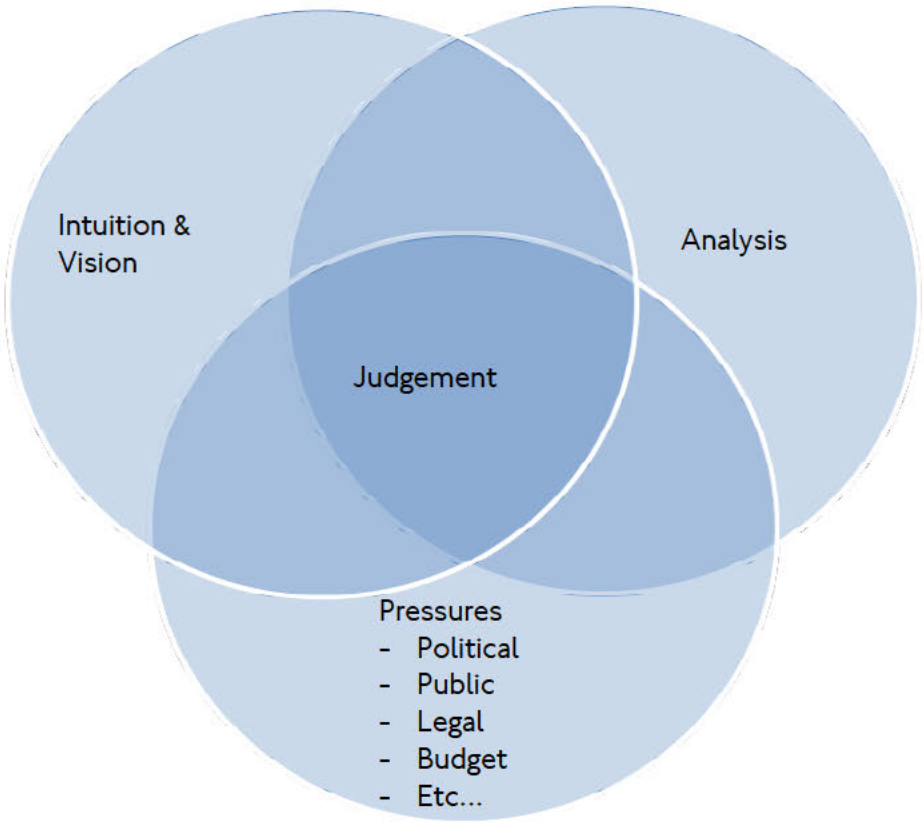


Figure 2-1: Decision Making (Source: Mackie P.J., Worsley T and Eliasson J.E. (2014) Transport Appraisal Revisited, Research on Transport Economics (RETREC), Elsevier.)

Business cases are much more than the benefit to cost ratio. They should include:

- Strategic narrative that provides the compelling story of why a particular course of action is required
- Multi-criteria analysis, which is a framework for evaluating strategies (see section 2.8: Measures of success)
- Formal cost benefit analysis (the benefit to cost ratio)

The first two bullet points can be supported by any relevant quantified or qualitative analysis. In addition the first bullet point can also be supported by relevant diagrams, maps or photographs that help make the case (in an appendix where extensive or peripheral).

2.2 The Purpose of Appraisals

The purpose of an appraisal is to identify the effect that a course of action will have both on the finances of TfL and on "securing efficiency, economy and safety of operation in ... transport services" [Greater London Authority Act 1999]. The achievement of efficiency is interpreted here as the following business objective:

To maximise net social benefit within available funds

The objectives of a project must be stated as precisely as possible, referring to specific outputs against which the project can subsequently be monitored. Where appropriate, these objectives should be related to those of the relevant part of the business, those of TfL overall, and those set by the Government. For example, TfL is under a statutory obligation under Health & Safety legislation to reduce safety risks to a level which is 'As Low As Reasonably Practicable' (the ALARP principle). Another example (from DfT's appraisal guidance) is that, wherever appropriate, the intended level of accessibility for people with mobility handicaps should be indicated.

The substantive provisions of the Social Value Act 2012 require that TfL considers:

- How what is being procured might improve the economic, social and environmental well-being of its area (addressed by producing a TfL business case)
- How that improvement might be secured (the business case and benefit realisation strategy should be robust)
- Whether TfL needs to consult on the potential improvements themselves or how they might be secured (See Sponsorship Handbook and Stakeholder Engagement Plan)

Note that producing a TfL-compliant Business Case satisfies the first two requirements.

Project development must ensure that an appropriate range of options is considered so as to enable TfL to meet its statutory responsibilities with due regard to efficiency, economy and safety. One of these options will be a base case which might be to continue to operate as now or to minimise the potential consequences of asset deterioration, and the other options will be to implement a change which will benefit TfL by ensuring that total benefits exceed costs. Where the project has an impact on safety, the appraisal needs to identify whether the base case can be demonstrated to be ALARP, or if not which option would be required to satisfy this principle (see Section 15: Safety).

Appraisals should be used not only to select the best projects, but also to identify the best operating procedure (for example trading off maintenance levels against failure rates and service availability). For proposals in both categories, those with the best benefit:cost ratios should normally be selected for implementation, until all available funds are exhausted. (Benefit/Cost Ratios are described in Section 2.7.7). If there are material impacts that are not included in the benefit to cost ratio, multi-criteria assessment and judgement will also need to be applied. Where the investment prioritisation process excludes projects which have been identified as necessary to ensure that safety risks are ALARP, priority should be given to such projects unless a case can be made for programming implementation at a later stage.

The appraisal process requires the following steps:

- define objectives, and outputs against which project can be monitored
- define a base case
- develop options
- identify all costs and benefits
- quantify costs and benefits at base year prices
- carry out appraisal

The resources committed to an appraisal should at all times be commensurate with the cost of a project and potential usefulness of the results of the appraisal. In the case of minor projects, the cost and/or time of carrying out a formal appraisal may not be warranted, but the principle would be that benefits clearly outweigh the costs and therefore a business case could be demonstrated if necessary. In the case of large projects where the costs, benefits, and indeed the scope of a project may be very unclear at the outset, it would not be appropriate to commit substantial resources to an appraisal which could only yield estimates within a wide range. (Nevertheless, using more modest resources, it is important to obtain a reasonable estimate of the maximum cost and order of magnitude of benefits at an early stage, as an aid to investment planning.)

Expenditure thresholds for requiring formal business cases to accompany submissions for inclusion in the Business Plan, or for implementation, may vary from time to time, and similarly the procedures adopted for approval may vary, but the points at which business cases are likely to be needed are generally as follows:

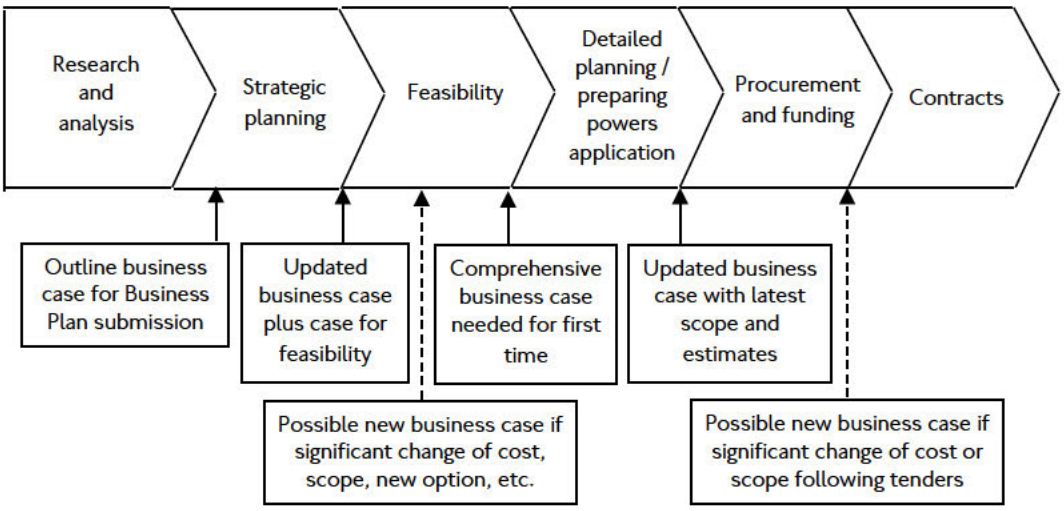


Figure 2-2: Business Case Submissions within the Project Lifecycle

Note that the Feasibility stage might be carried out over a long period, and although there may not be a formal requirement to obtain new authorisation, if a significant change occurs from the project as defined at the previous authorisation, it will be important to update the business case accordingly.

Business Case Development: Ryan Taylor, [redacted]

2.3 Definition of a Base Case

In appraising a project, the effects of doing it must be compared with the effects of not doing it. Often this involves literally comparing the results of the project options with the results of doing nothing or continuing as now (e.g. maintaining an old asset). However, in some cases doing nothing may not be the most sensible base (for example if a decision needs to be taken on the closure of a station or a line). In such cases an alternative base case may be appropriate such as:

- replacing like for like (if still available)
- replacing with a modern equivalent
- delay replacement by one year (if the only question is when to replace)
- closing a facility down

Essentially the requirement is to define the minimum realistic alternative to the proposed course of action. If this is not "do nothing" an explanation will be needed. The definition of the base scenario may take account of:

- LUL Development Plans affecting the assets (where these have already established a business case for a certain level of spend)
- the achievement of required standards (again, where a business case for a certain level of spend has already been established)
- legislative requirements

2.4 Development of Options

2.4.1 Generation of options

In order to give decision makers confidence that a particular project is the best way to achieve an objective, a range of alternative options with similar objectives needs to be defined and appraised in a consistent way. To give real confidence these options must be realistic practical ways of achieving the objective; they must cover all the reasonable alternatives available, whilst at the same time being limited to a manageable number. Options must also take account of any commitments, which may have been expressed in Environmental Reviews of the investment programme, to consider specific environmental issues.

Options may represent either an enhancement or a downgrading compared to the base, or they may involve a re-scheduling of the base programme.

Other factors which should be considered when assembling options include the following:

- timing: deferring or bringing forward implementation dates
- scope: cutting back on full implementation
- standards: enhancing or reducing specification
- synergy: in combination with other projects some options may score particularly well or, alternatively, simultaneous implementation at a site could create problems; business plans can help identify the opportunities for synergy
- corporate image and the value of company-wide or corporation-wide consistency

2.4.2 Treatment of options

For many appraisals an incremental approach to option selection is essential. Thus in appraising a proposal to provide new lifts at a station it is important to consider the incremental costs and benefits of providing one, two, three or four lifts. The four lift option appraisal as a total project may have a satisfactory benefit/cost ratio, but the incremental investment in the fourth lift compared with the third may have a low ratio. In this way the appraisal can identify the optimum level of investment in new facilities.

Where there are a large number of options, a matrix showing the 'score' of each option against a variety of criteria could be useful in eliminating and shortlisting. The following factors should be considered when using this approach.

If the scores are to be aggregated, try to arrange the 'levels' (e.g. low, high, poor, good, etc.) of each criterion in such a way that a given score for one criterion indicates the same order of importance as the same score for another. An alternative approach is to use different weightings for the criteria. Such assessments are inevitably subjective, and the robustness of the assessment system will be improved if several people (with the relevant specialist knowledge) contribute to the process. To the extent that a number of independent judgements about the suitable levels/weightings are reasonably consistent, the assessment system will have improved credibility. Similarly, when the system is actually used to compare options, it will make the case for choosing the preferred option(s) stronger if a number of independent assessments tend to coincide.

- Try to avoid overlaps, i.e. where one criterion duplicates part of another.
- Sometimes a high aggregate score for an option would be misleading, if perhaps a zero for one criterion rules it out completely. It might be helpful to highlight those items where a zero score would virtually rule out the option.
- It should be emphasised that such a matrix, whilst being useful for sifting through options and for providing background information to go with the business case, is NOT a substitute for a business case; in assessing the advantages and disadvantages of a short list of options, the usual costs and benefits must be calculated.

2.4.3 Options with enhanced standards of urban design

Options exhibiting high quality urban designs should be carefully considered.

Contributions to improved urban design should be considered in the Strategic Assessment Framework, (see Section 2.9 below). An indication of the townscape appearance both before and after the proposed scheme should be provided, and the strength of public support for the design should be verified.

Some aspects of Urban Realm can be monetised into the benefit to cost ratio, see ambience values in the Ambience Benefit Calculator spreadsheet. Further guidance on the Urban Realm and other tools such as the Valuing Urban Realm Toolkit can be found in 16.4.

2.5 Identifying Costs and Benefits

2.5.1 Financial Costs

For projects, costs must be calculated for the whole life of the assets involved in the project. For operating changes, a single year may be adequate if there are no "up-front" costs. Costs should include:

- One-off costs e.g. construction costs, purchase cost etc.
- Part life costs e.g. main overhauls, renewals etc.
- On-going costs e.g. annual maintenance, fuel, staff, energy, overheads etc.
- Reductions in fares revenue (including during construction)
- Reductions in other revenue (e.g. advertising, vending machines)
- Cost increases in other TfL areas
- Compensation to landowners etc.
- Redundancy payments
- Professional services – design, legal, management etc.
- TfL support costs – IT, HR, Property and Facilities (see Section 9.2 for the Support Services Rate Card).

2.5.2 Financial Savings

As a result of business plan or Spending Review pressures, TfL is always looking to secure significant cost savings. Consideration should be given to whether the project will generate any savings.

All of the following should be included in a business case if applicable, however only those that are cashable (i.e. the net financial cost to the business is reduced, freeing up funding to use elsewhere) should be included in formal Savings and Efficiency reporting.

Savings and other financial benefits must also cover the whole life of the assets and should include:

- Avoidance of one-off costs e.g. savings in redundancy costs
- Avoidance of part life costs
- On-going savings in operating costs
- Cost savings in other TfL areas
- Delivering the same services with less resource or delivering more or better services with the same resource through:
    - Securing / negotiating lower prices for goods and services
    - Changing working methods

Other important, but more difficult to quantify, financial savings include organisational benefits such as:

- Better management information
- Improved corporate image.

Financial savings can be calculated using the same methodology as calculating costs. This should include assumptions for optimism bias and inflation. Where insufficient information is available, the TfL Benchmarking team may be able to provide further information to aid calculation.

2.5.3 Other Financial Impacts

Other financial impacts must also cover the whole life of the asset and should include:

- Changes in fares revenue to public transport as a whole
- Changes in other revenues (e.g. advertising, vending machines)
- External contributions e.g. by developer
- Residual value of assets at end of project life

2.5.4 Benefits/disbenefits

Monetised social benefits include

- changes in time for all components of passengers' journeys:
    - travelling time
    - waiting time
    - access times
    - interchange times
- "ambience" benefits/disbenefits:
    - appearance
    - ride
    - noise
    - perceived security
- pollution – greenhouse gases CO2, and local air quality NoX and PM10
- health benefits from physical activity
- safety benefits/disbenefits

2.5.5 Wider Impacts

Wider economic, social or external impacts, for example:

- regeneration benefits
- social inclusion benefits

should also be quantified or described if the effects are significant. See Section 19: Economy for further information on impacts on the economy such as uplift to Gross Domestic Product (GDP) otherwise known as Gross Value Added (GVA)..

Any social benefits and disbenefits during implementation shall be quantified, including any specific external effects (e.g. effects on local traffic and businesses).

2.6 Quantifying Costs and Benefits at Current Prices

For all options, costs and benefits shall be calculated in comparison with the base option at constant prices. Costs and benefit streams over the life of the project shall then be discounted to give present values in the base financial year over the whole appraisal period.

Methods of calculating costs and benefits are given from Section 3.

2.7 Carrying Out an Appraisal

2.7.1 Appraisal period

For projects where assets are procured, appraisals must cover the whole life of the proposed assets (including disbenefits during construction). This is to ensure that all the attendant costs of assets e.g. half life overhauls, and annual maintenance costs etc. are included, and that incorrect evaluations do not result from different phasing of these costs between the alternative options. All options must be evaluated over the same appraisal period, and accordingly, a longer rather than a shorter appraisal period shall be used. A list of selected asset lives is given in Table 2-1 below.

The nature of the discounting process (described below) means that the contribution to present values decreases for the later years, so the importance of using very detailed forecasts decreases for the later years of the appraisal period. However, these forecasts must still be made and recorded in the appraisal. The likely increase in annual maintenance costs as an asset gets older must be reflected in the costs and then compared with the option of earlier replacement with new assets.

It is not always possible to pre-determine the economic life of an asset. That may depend upon the later costs of continuing to maintain the asset in comparison with savings arising from replacement – see section 6 on Lifecycle Costing. The following asset lives are therefore offered only as guidance in deciding an appropriate appraisal period. When in doubt, make the period longer rather than shorter. It should be noted that extending the appraisal period does not affect the "life" of the asset.

Asset Type	Sub-Group	Useful Life
Rail Cars		35 - 40 years
Buses		3 (RMs) - 10
Bus shelters		10
Bus electrical	e.g. ticket machines, depot readers, security systems etc.	7
Underground electricity supply equipment		25 - 40
Escalators	(Underground stations)	40
	(Bus stations)	20
Lifts	(Underground stations)	40
	(Bus stations)	20
Plant, Machinery and equipment		10 - 30
Computers	- Hardware	3 - 10
	- Software	5
Radio, TV, and office equipment		10
Road vehicles		3 - 10

Table 2-1: Useful Life of Assets

In some projects there may be options with economic lives of different lengths. For these appraisals it may be appropriate to use an equivalent annual cost methodology or other Lifecycle cost approaches (see section 6).

For some schemes with staggered options or where different items of scope last for different time periods there are other approaches to ensuring a fair appraisal. Benefit streams can be truncated to reflect the life of the asset in advance of the benefit stream for the main asset, which is the preferred approach as it reduces the potential for error. It is also possible to use repeated re-investment cycles and a continued benefit stream. It is also possible to use residual values.

2.7.2 Constant prices

All costs, revenues and benefits used in the evaluations must be computed at constant prices for the base price year. This is normally taken as the year in which the appraisal is undertaken. All costs, revenues, and benefits must then be computed at that year's prices to remove any effects due to price inflation. Note that where unit costs and benefits are likely to rise at a different rate than the general level of inflation (for example staff costs), then any real increases shall be reflected in the costs and benefits over the appraisal period. Only the effect of general price rises as measured by the GDP Deflator shall be removed from the calculations. This approach is coded into the standard Business Case Model spreadsheet.

2.7.3 Discounting costs and benefits

The purpose of discounting costs and benefits to a base financial year (see below) is to bring all options to a common basis regardless of the timing of their costs and benefits. It reflects the social time preference for money as defined by HM Treasury and TfL and the public sector is not at liberty to vary this assumption. To do this the real cost of capital as expressed by the discount rate must be used. At a discount rate of 3.5% then £100 which is not spent this year will be worth £103.50 next year. Similarly, if we need to spend £100 in a year's time then that is equivalent to an expenditure of just £96.62 now i.e. 100/(1+3.5/100). Thus the present value (PV) of an expenditure of £100 in one year's time at a discount rate of 3.5% is £96.62. Similarly, the PV of an expenditure of £100 in three years time at a discount rate of 3.5% is £90.19 $(100/(1+3.5/100)^3)$. This calculation is separate to any assumptions about inflation.

All costs and benefits over the appraisal period must be calculated in present value terms for the base financial year. When this has been done it is possible to compare options which have different timings of costs and benefits. This is known as discounting all costs and benefits back to their present value in the base financial year. In financial calculations the discount rate reflects the real (net of inflation) cost of capital. As all investment in TfL projects is underwritten by the Government, all appraisals use the Treasury discount rate.

The discount rate currently used is 3.5% and can be found in the Business Case Model Spreadsheet on the Business Case Intranet page. Discounting will automatically take place in this spreadsheet.

The base financial year is normally taken as the first year in which cash flows will be affected by any of the options under evaluation. All costs incurred or benefits which accrue in future years should be discounted to their present value in the base financial year (year 0).

2.7.4 The effects on revenue

Many projects will alter the demand for TfL services, and hence the revenue received. Improvements to station lighting, for example, can make the service more attractive to passengers

and hence increase the revenue generated. The effects of proposals on passenger demand and revenues need to be calculated using consistent assumptions, which are discussed in Section 7: 'Revenue' below.

2.7.5 Financial effects

Having calculated the present value of all cash flows, the financial effects of the proposal can now be calculated.

The Net Financial Effect is the sum of the present values of the cash flows (positive and negative). That is, PV of cost savings plus revenues less PV of implementation and other cost increase.

If the Net Financial Effect is positive (i.e. there is a positive financial return) and there are no net social disbenefits (see Section 2.7.6 below) then the option passes the value for money test on financial grounds alone and the NFE and payback period should be presented for decision making. However, any passenger benefits, if present, should still be quantified so that the contribution to the TfL objectives can be calculated. This is particularly important where there are winners and losers in the appraisal and the breakdown between different parties should be shown. The number of years after which the project remains financially positive shall be stated.

If the Net Financial Effect is negative, the benefit:cost ratio (see Section 2.7.7 below) shall be used to judge whether the social benefit justifies the net cost. If there are negative social benefits and a negative Net Financial Effect, then the scheme does not show good value for money using monetised cost benefit analysis and the reason for pursuing the project should be expressed. A breakdown of the winners and losers should be shown.

2.7.6 Passenger Benefits

In addition to financial cash flows, TfL also considers the benefits or disbenefits which the options will give to customers – benefits which are not necessarily recovered from fares. If the Net Financial Effect as calculated in Section 2.7.5 above is negative (i.e. there is a net cost), the value of these benefits shall be compared with the net financial costs of the options in a cost benefit appraisal.

Such benefits include benefits to passengers such as time savings, improvements to trip quality, and improved safety and security. Any passenger disbenefits during implementation shall be taken into account.

As well as user benefits / disbenefits, it is also possible that the following impacts could be added if significant:

- Disbenefits to existing users from increased congestion (many models already take this into account). This must be included if the scheme has a impact on strategic movements rather than just local movements.
- Benefits to new users (via the rule of a half).
- Benefits to non-users (e.g. reduced road congestion for pedestrians).

Advice should be sought if at all unsure as to whether all significant impacts have been captured.

2.7.7 Benefit to cost ratios

The present value of costs, revenues and benefits for all options in comparison to the base option should now be presented to decision makers along with a recommendation on the proposed course of action.

Decision makers will then have to determine the priority of each project's claim to the scarce resources available in the light of other competing projects. To do this they will need to know the benefit to cost ratio of each of the options. This is calculated by dividing the Net Present Value of passenger benefits by the Net Financial Effect.

In order to choose between competing projects decision makers need to know the benefit:cost ratio of each project. This shall be calculated as follows:

$$\textit{Benefit to Cost ratio} = \frac{\textit{Present Value of Net Social Benefit}}{\textit{PV of Costs - PV of revenues}}$$

Note that it is important that all revenue effects are included as negative costs in the denominator of the expression and not as benefits in the numerator.

Authorising bodies will normally expect the benefit to cost ratio to be greater than one and usually greater than the benchmark for good value for money of 1.5:1.

A higher target may sometimes be set to avoid frequent changes in plans; e.g. in bus service planning, higher ratios have been used to ensure that service levels are not increased and then decreased with short-term fluctuations in demand. On the other hand, lower targets may also be appropriate if a project provides wider benefits that are not fully captured in the ratio.

The Business Case Spreadsheet: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx calculates these statistics automatically. A guide to interpretation of the Net Financial Effect (NFE) and Benefit to Cost Ratio (BCR) is tabulated below.

Top of BCR (Social Benefit)	Bottom of BCR (Financial Effect)	Decision making criteria
Positive	Negative	Classic benefit to cost ratio. VfM if BCR >1.5:1
Positive	Positive	Positive NFE and payback period. VfM – always try to do if cash flow allows. Check winners and losers in social benefits.
Negative	Positive	Disbenefit to cost savings ratio. Do if ratio is less than 1:1, the smaller the better.
Negative	Negative	Negative NFE. Not VfM. Try not to do unless forced (legislation etc.) Check why value not being expressed

2.7.8 Sensitivity Tests

Any factors which put the achievement of the project's value at risk must be listed and included as sensitivity tests as part of the appraisal documentation.

The required components are:

- identify the key uncertainties (e.g. costs, demand, benefits, timescales for implementation), where possible estimating the probability and impact

- identify the worst cases to give the maximum and minimum values they may take based on a realistic analysis of the possible risks, taking account of possible combinations of risks, where they are likely to occur together

- input the results into sensitivity tests (see below) and re-calculate the benefit:cost ratio

- "switching values" - identify any notable point at which the recommendation would change, e.g. "benefit:cost ratio remains below 1.5:1 until costs are reduced by 26%". This kind of test is very effective if the chances of the scenario are known or very obviously low, but if not, it is of limited value unless the risk of it happening can be quantified.

The standard business case spreadsheet automatically calculates a number of sensitivity tests and has the functionality to have user defined tests specified.

The choice of sensitivity test should be defined using the judgement of the appraiser and be specific to each proposal and not based on pre-determined +/- X % variations. This will illustrate the risks and ranges appropriate for the project in question.

2.7.9 Volatility of Benefit to Cost Ratio

TfL's ratio is sometimes 'volatile', i.e. under certain circumstances it can react disproportionately to changes in benefits or costs. When the Net Financial Effect is negative and small (i.e. near the break-even point) the benefit:cost ratio is likely to be very high.

Consider this example:

	£000s NPV
Costs	-570
Revenue derived from elasticity (0.28 times increase in Passenger Benefits)	560
Net Financial Effect	-10
Increase in Passenger Benefits	2000
Benefit:Cost Ratio	200:1

It is possible that only half the anticipated benefits will occur. This is quite plausible if the project is innovative / new, where there is no previous data to inform the estimate. The case then becomes:

	£000s NPV
Costs	-570
Revenue derived from elasticity (0.28 times increase in Passenger Benefits	280
Net Financial Effect	-290
Increase in Passenger Benefits	1000
Benefit:Cost Ratio	3:1

and the benefit:cost ratio has plummeted from 200:1 to 3:1.

Fortunately, the benefit:cost ratio is not liable to such disproportionate effects when the ratio is smaller. However, when larger ratios are involved, e.g. in the prioritisation of projects, it should be remembered that relatively small percentage changes can make a big difference. If a project with a 25:1 ratio has its benefits reduced by 20%, for example, then typically the ratio will reduce to about 9:1.

This does not reduce the validity of prioritisation, but it does emphasise that differences may be more marginal than they appear.

2.7.10 Incremental benefit:cost ratio

An incremental benefit:cost ratio should be used to assess the extra benefit achieved by the extra cost of implementing a more expensive option (or a more expensive project, where different projects are being compared). The assessment is carried out in the same way as described in the previous section, i.e. dividing the increase in benefits by the increase in Net Financial Effect (both expressed in terms of Present Value). At one extreme a low incremental ratio could illustrate an increment in scope which is not justified, even though the project with this extra scope included has a satisfactory benefit:cost ratio. At the other extreme a high incremental ratio could justify the increment in scope, even though the project without this extra scope added would have a higher benefit:cost ratio –the justification consists in the increment itself potentially having better value than many other projects in TfL's programme. However, note that the overall benefit:cost ratio of the preferred option against the base option will be the one that represents the project's value.

2.8 Measures of success

2.8.1 Characteristics of Measures of Success

This manual describes the quantification of benefits using standard methodologies. However, it is also important for a business case to identify measures of success specific to that project, so that the outcome of implementation can be evaluated. When reviewing the success of a project it is sometimes difficult to separate the project's impact from that of others completed during the same era and wider external changes. In these circumstances project-specific measures can be used to establish whether or not the intended effects have been achieved. Characteristics of useful measures of success would include:

- wide coverage of the areas of benefit which have been claimed, for example in a train refurbishment (see 2.8.2 below) the effect on door delays would cover only one aspect - additional measures would be needed here to give a fuller picture of the outcome
- not being influenced by factors other than the project
- being as close to formal business indicators as possible, e.g. MSS scores where applicable, otherwise being simple / inexpensive to provide
- statistics measured over a sufficiently long period to mitigate the effects of random variation

2.8.2 Examples of Measures of Success

Some examples of measures of success (there would usually be more than one measure per project) which a business case could plan for, to confirm that the claimed benefits are being achieved after implementation, are shown below.

Train refurbishment:	Measured over year following project, door-related delays reduce from (current) 50 per period to average of 35 per period
New computer system:	When system has been running for six months, average response time to standard query is less than 15 seconds (where performance of local network is not a significant factor)
Station congestion relief:	Average time from leaving train to reaching UTS gates reduces by 45 seconds -use median of 100 trips between 8.30 and 9.30 am. distributed over 5 different days
Staff training scheme:	MSS score for "Staff willingness to help" increases by 15 points at stations where staff have participated in the training

Table 2-2: Examples of Measures of Success

2.8.3 Feasibility studies

Measures of success are particularly relevant when developing proposals for feasibility studies. Often, the benefits and costs of eventual implementation are only very broad estimates at this stage. One of the measures of success (or "deliverables", in this context) of the feasibility study itself could be a detailed business case. Others could include:

- review of options, looking at incremental approaches, phasing, etc. and eliminating any options where further investigation is likely to be fruitless
- establishing realistic demand scenarios
- quantifying safety risk
- quantifying risk of project overspend

In each case, the deliverable should be as specific as possible, e.g. instead of "investigation of demand scenarios", the deliverable could be "provision of demand forecasts to 2016 with/without Crossrail 1 and with/without Thameslink 2000".

2.9 Business Cases and Project and Programme Lifecycle

The table below summarises the various business case names, with lifecycle stages and Pathway stages.

Pathway Lifecycle Stage		Five-Case Name
1	Outcome Definition	Strategic Outline Case
2	Feasibility	Outline Business Case
3	Concept Design	
4	Detailed Design	Full Business Case
5	Delivery	Outturn Business Case
6	Project Close	
No stage	Business As Usual	

The level of detail depends on the lifecycle stage. There are four main stages of a business case:

- **Strategic Outline Case** – confirms the strategic context and makes a case for change (without committing to a preferred option). Maps onto gates: OGC 1, Pathway 1.

- **Outline Business Case** – The purpose is to identify a preferred option, a robust single option selection should be demonstrated. Maps onto gates: OGC 2, Pathway 2.

- **Full Business Case** – Outline Business Case is updated following procurement negotiations, demonstrating an affordable solution that optimises value for money with the recommended supplier. Maps onto gates: OGC 3, Pathway 4. Note that this is a development of the Outline Business Case above but focusing on the preferred option with revised costs and benefits following any changes during procurement or from detailed design.

- **Outturn Business Case** – updated post delivery with actual costs and any known changes to likely or actual benefits using indicative statistics as identified in the Benefits Management Process or that has arisen through design changes. Maps onto gates Pathway 6 and beyond. A benefit realisation exercise should be taken after benefits have had time to bed in (currently ungated in Pathway). This could be two years after practical completion, be an update of the outturn business case and focus on the Benefits Management Plan. The importance of this is that it feeds back lessons learnt to future business cases and it demonstrates the actual benefits of projects as delivered rather than being based on prediction.

Business cases should be locked down and version controlled as they develop and the version at each key stage identified. Business cases should be updated as revised information becomes apparent, perhaps from more detailed modelling of benefits or more robust cost estimates and be presented in advance of the appropriate Gate.

The expectations at the different gateways are set out below:

- Pathway 1 – Feasibility. An outline (TfL terminology) case is made, with a likely or range of benefit to cost ratios presented and the strategic reasons for intervention. The range of options should not be unduly restricted.
- Pathway 2 – Single Option Selection. The options are narrowed down to a shortlist and the case for each assessed to show the preferred single option recommended to be taken forward. A Quantified Risk Assessment (QRA) should have been undertaken to help give confidence to the cost estimates. Measures of success should be identified but not yet baselined. This is the most important business case as it is upon this that the decision to implement is made and a robust case for the preferred option should be presented.
- Pathway 3 – Begin Procurement. The single option business case should be developed to focus on the preferred option and the preferred case should be updated with any revisions to costs and benefits as a result of detailed design or other developments.
- Pathway 4 – Delivery. The business case should be updated with costs as expected or agreed as a result of procurement. Benefits should be updated with any agreed scope changes. Benefits should have baseline measures of success.
- Pathway 5 – Practical Completion. Updated with expected outturn costs.
- Pathway 6 – Financial Close. Updated with final outturn costs and any expected changes in benefits.
- Ungated – Benefit Realisation. The business case should be updated with realised benefits by factoring any original modelled results with the outturned position. Analysis should describe the changes over the project lifecycle and measures of success should be

compared to prediction. Other benefits should be described and where possible quantified. Business Case lessons learnt and conclusions should be drawn. This should provide feedback to future business case development and provide evidence to make the case for future investment.

A change log should be maintained throughout, so that if staff changes occur, knowledge will not be lost on the changes that have been made.

2.10 Delivery Portfolio Business Cases

Business cases for Delivery Portfolios that are aiming to **maintain a group of assets** with a stable condition profile (and hence no new or lost passenger benefits), existing narrative from asset strategies or plans (such as Annual Asset Maintenance Plans (AAMP)) can be used so long as it includes the following:

- An explanation of the ideal lifecycle replacement – why is 18 years (for example) an optimal replacement cycle?
- An explanation of the overall estate asset condition profile (including what the impact would be if the funding was increased or decreased) – show the asset condition profile and set out the impact on this with investment levels that vary around the preferred option. Business planning scenarios should have already been required for this or they will be needed.
- An explanation of the prioritisation process – what determines the particular work bank composition? What factors are important? What prioritisation model has been used and have any manual overrides been used (such as to for efficient delivery of nearby assets at the same time)? Does this work bank align to the funding required?
- An explanation of why that replacement process offers optimal value for money (consider other technologies, other replacement cycles, other efficiencies and dependencies).

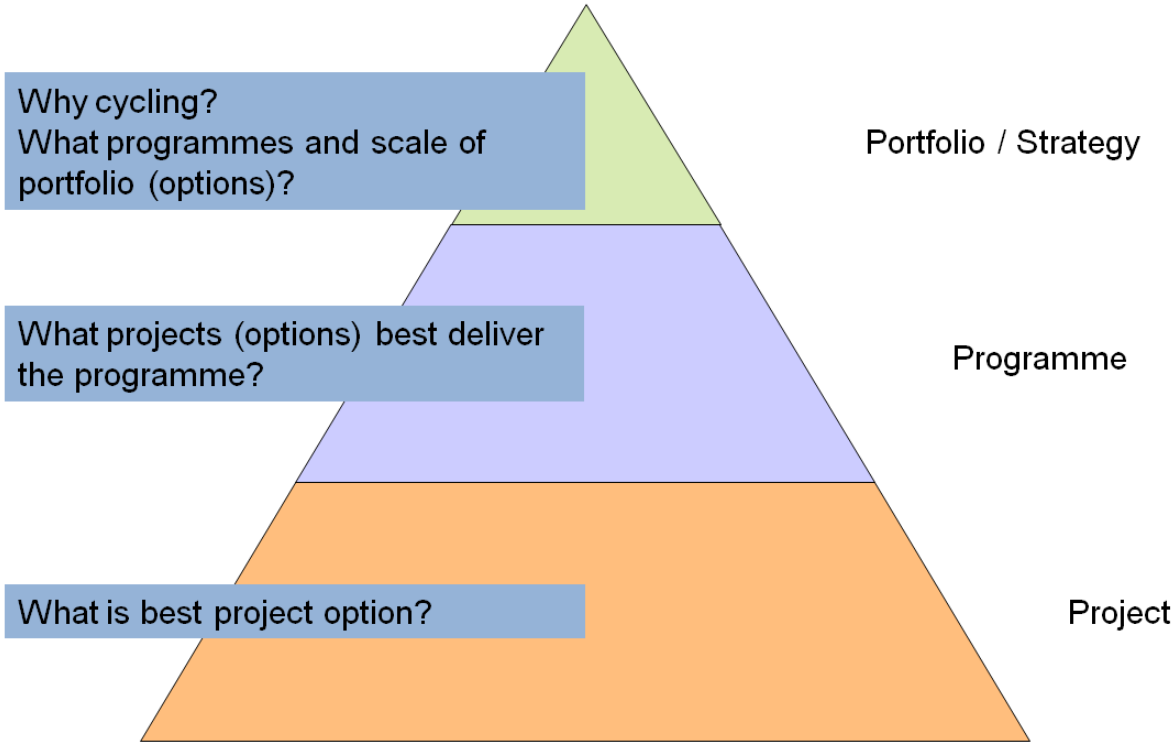
This should be provided in a single existing document such as an AMP Justification that is used to justify the size and composition of the portfolio rather than using the standard Business Case template. Different templates for this currently exist around the business and these should continue to be used but with a check that they contain the information listed above. If this information does not exist then an addendum note should be produced.

For Delivery Portfolios where the replacement rate **improves or declines the overall estate asset condition profile** (results in new or lost customer benefits) then a standard business case should be produced with a benefit to cost ratio.

For Delivery Portfolios that are **collections of projects grouped together for managerial convenience**, an overarching summary business case should be produced but justification for each individual project should also be obtained at an appropriate level. The standard business case template should be used following guidance within the template on appropriate scaling.

2.11 Hierarchy of Business Cases

It is worth considering and planning how the business case should be written before starting to ensure that the most efficient approach is used. This will save time and resources and make the information provided more clearly linked to the decision to be made. This is graphically represented in the diagram below.



The premise is that the business case should be aimed at the right decision. It is not necessary for each project business case to justify investment in that overall asset or strategy area. Take cycling for example. At the top level a Strategy or Portfolio document should justify why we should invest in Cycling. It should justify the size of the investment fund and the overall objective and outcomes of the investment. Other options would include an analysis of the different types of markets in which the outcomes are expected and an assessment of the different programmes that could best fulfil the expected outcomes.

Business cases for each programme, such as Cycle Superhighways then does not need to justify the existence of the programme compared to any other, but is should compare the best way of delivering that programme through the optimal mix and priority of individual projects.

A project business case could then more efficiently set out the case for the preferred route and start and end points. The strategic case may be shared across several projects with a relatively light section referring to the overall strategic case in the Programme and Portfolio business cases.

3. Financial Effects Overview

3.1 Introduction

As described in section 2.7.7 the benefit to cost ratio in the public sector should more accurately be described as a social benefit to financial impact ratio. This section is concerned with the financial effects that form the denominator (the bottom) of the benefit to cost ratio.

If there are no social benefits in an appraisal then just a net financial effect (NFE) will be returned. A benefit to cost ratio is not appropriate in this situation and the NFE should be presented along with the payback period. The higher the NFE and the shorter the payback period the better, however other considerations need to be taken into account such as the affordability. No matter how big the payback, the upfront capital costs may not be affordable.

Where there are social benefits as well as a positive financial effect, an NFE and payback period is still an appropriate justification for value for money. The impact on social benefits should still be set out however as there may be distributional concerns over the various winners and losers and the magnitude of social benefits is still an important factor. Incremental benefit to cost ratios can be used to illustrate the change in social benefits compared to the NFE. For example, an option with a slightly worse NFE may have much higher social benefits and be the better value solution.

3.2 Financial Effects: Key Principles

- All cash flows (costs, cost savings, revenues and revenue losses) must be estimated for the whole appraisal period (i.e. for the life of the main assets involved).
- They must all be at constant prices, preferably in the base price year and they must all be discounted to give present values in the base financial year.
- For operating costs, if it can be assumed that this is a constant impact only one year's effects on costs and savings is needed if there are no "up-front" costs (such as redundancy payments). The number of years to determine a payback can illustrate value for money.
- Where costs or revenues are likely to change in real terms over the life of the project, i.e. differently from the GDP deflator standard measure of inflation, specific indices must be used to estimate this effect. Staff costs are a good example. Historically, earnings have risen at a higher rate than standard inflation. This needs to be reflected in the calculation of future costs by using the likely real growth of earnings.
- Cost estimates are expected to mature over the lifecycle of the project. In the early stages they are less robust than in later stages.
- Project budgeted Expected Final Cost (EFC) is not the same as appraisal costs because:
    - Project costs are only for the up-front delivery of an asset, and are not likely to include ongoing impact on operating costs, revenues, savings and mid-life refurbishments that represent the lifecycle financial impact of an asset.
    - Project costs are in outturn prices (exactly what cash is expected to be spent), appraisal costs are in real base-year prices - i.e. real inflation over and above standard inflation is included and the appraisal is in 2015 (for example) prices.
    - Appraisal figures are discounted for the time preference of money. EFCs are not.

4. Project Costs

4.1 Overview

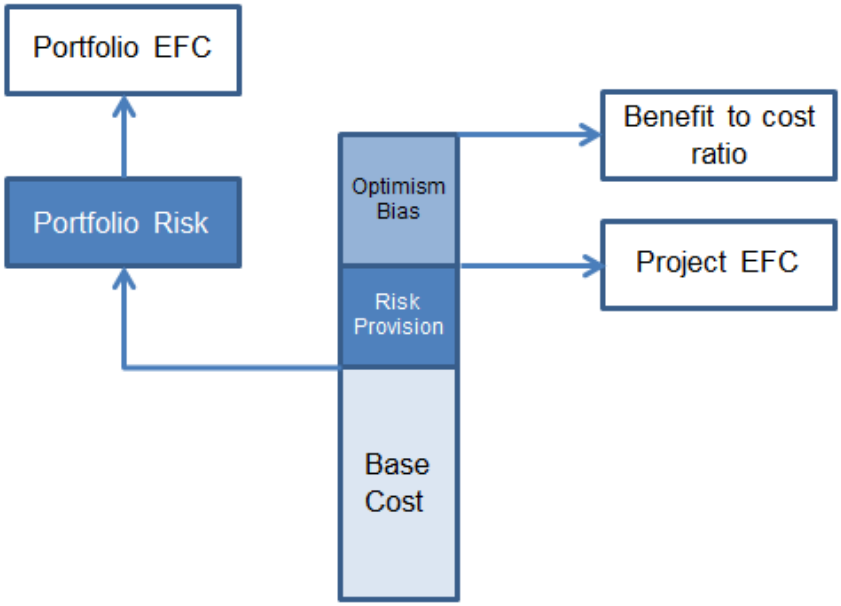
This section applies to all capital Projects, including Programmes and Delivery Portfolios. The key components of project cost are described in the table below and in more detail in the sections that follow.

Base Costs	The most likely expenditure required to deliver the requirements of a project, programme or delivery portfolio, excluding risk, contingency and optimism Bias.
Risk Allowance	A provision within the total project budget or forecast that is to be used (in accordance with operating business procedures) to deal with anticipated events of uncertain outcome. This provision is calculated by a Quantified Risk Analysis of identified risks or a percentage uplift in the early stages. This is the only category of risk to be used for project authorisation and is controlled via risk draw down.
Uncertainty	The amount applied to a base estimate's EFC to account for uncertainty in scope and delivering a defined set of user requirements. This includes provisional sums, percentage uplift, three point estimate range and uncertain assumptions. This needs to be included for planning and budgeting purposes
Portfolio Risk	A specific set of risks defined by TfL to be excluded from project risk exposure calculations and analysed and managed centrally.
Management Contingency	A provision controlled by senior management for the uncertainty inherent in the estimation of costs and risks. This may include programme or portfolio risk provision not held at project level or sums to cover unforeseen cost increases.
Optimism Bias	A quantity to be added to costs and risks in the business case appraisal to take account of systematic cost estimation bias shown by past projects in the transport and other sectors.

The estimated final cost (EFC) of a Project is the sum of the base cost estimate plus the risk provision in outturn (budget) prices. Risk provision can be calculated from a QRA (Released as project Authority) or as uncertainty (not released as Project Authority but used for planning and budgeting purposes).

When carrying out a business case appraisal, an appropriate optimism bias uplift should be added to the EFC to take account of systematic cost estimation bias. Note that optimism bias should be included in the appraisal but not the project budget.

The diagram below graphically illustrates the composition of project costs and the difference between budgeting and the business case (benefit to cost ratio) requirements. Portfolio Risk is estimated from project base costs and together with all the project EFCs forms the Portfolio EFC.



The latest EFC forecast (including risk) should be fed back into the business case as it is updated through the project lifecycle.

The Green Book Supplement on valuing infrastructure spend (2013), gives a good overview of costs, risk, optimism bias and contingency (https://www.gov.uk/government/publications/green-book-supplementary-guidance-valuing-infrastructure-spend/early-financial-cost-estimates-of-infrastructure-programmes-and-projects-and-the-treatment-of-uncertainty-and-risk) and says that the Treasury would like;

- to move towards a systematic and application-specific approach to building base costs and contingency estimates
- to ensure that the financial risk exposure of the project / programme / portfolio is rigorously justified and developed with more detailed cost and risk analysis as soon as possible
- that cursory application of Optimism Bias provisions is not used as a substitute for accurate estimating at any stage

It should be noted that the cost estimates used in business case appraisals (unlike project budgets) strip out GDP deflation, so include only 'real terms' inflation increases. The latest GDP Deflator series can be obtained from this link: https://www.gov.uk/government/collections/gdp-deflators-at-market-prices-and-money-gdp. However, a consistent series used across the business for business cases is included in the Business Case Model: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

Further information on Project Costs can be found at DfT WebTAG Unit A1-2 Scheme Cost Guidance:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275128/webtag-tag-unit-a1-2-scheme-costs.pdf

4.2 Risk

4.2.1 Overview

The approach to risk is defined by the level of maturity of the products feeding into the cost estimates, such as the maturity of business case and benefit estimates, requirements and scope.

To ensure appropriate financial provisions are made for projects, a thorough assessment of potential risks is essential throughout the project lifecycle, to account for cost consequences of:

- the development and refinement of the design
- The greater understanding of the solution's interfaces with its physical environment
- legitimate changes in requirement scope
- a reducing provision for other areas of uncertainty which are not addressed by the above as provided for by optimism bias in earlier high level assessments)
- specific risks (e.g. changes in key personnel during the project, pending legislative changes) which would impact on the project

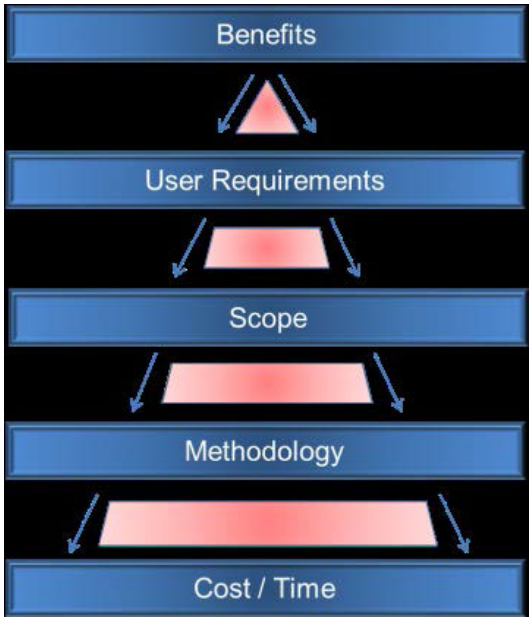
Risks should be evaluated as accurately as possible, with evidence from similar previous projects sought where available. The risk analysis should cover the full scope of the project, regardless of which stages have project authority or funding, and regardless of the funding sources.

The risk value used in business case appraisals should be based on the most likely level of costs. Worst case costs should be used only for a sensitivity test, not for the main appraisal. The latter should always, where appropriate including specific overspend outcomes multiplied by their estimated probabilities

Project risks should be regularly updated throughout the project lifecycle using QRA, including Monte Carlo simulations where appropriate.

4.2.2 Cost Maturity

Cost estimates mature through the project lifecycle based on the certainty of key elements.



A cost estimate can be considered mature when:

- The project design, including its interfaces with the physical environment are sufficiently understood that the base cost is broadly complete (although still subject to refinement, as the design is further developed).
- A risk analysis has been undertaken at a level sufficient to recognise all significant risks and allow them to be assessed using Quantified Risk Analysis (QRA) techniques.
- The risk allowance relates to project specific risk items, with no unallocated risk exposure and therefore contingency (that is contingency accounting for indefinable / undefined uncertainty).

4.2.3 Approach to Risk

Based on the maturity of the requirements and scope, one of three risk assessment techniques will be used to calculate the EFC. Only figures calculated from a Quantitative Cost Risk Assessment (QCRA) will be categorised as "risk". All others (such as a percentage uplift of range estimate) will be termed "uncertainty".

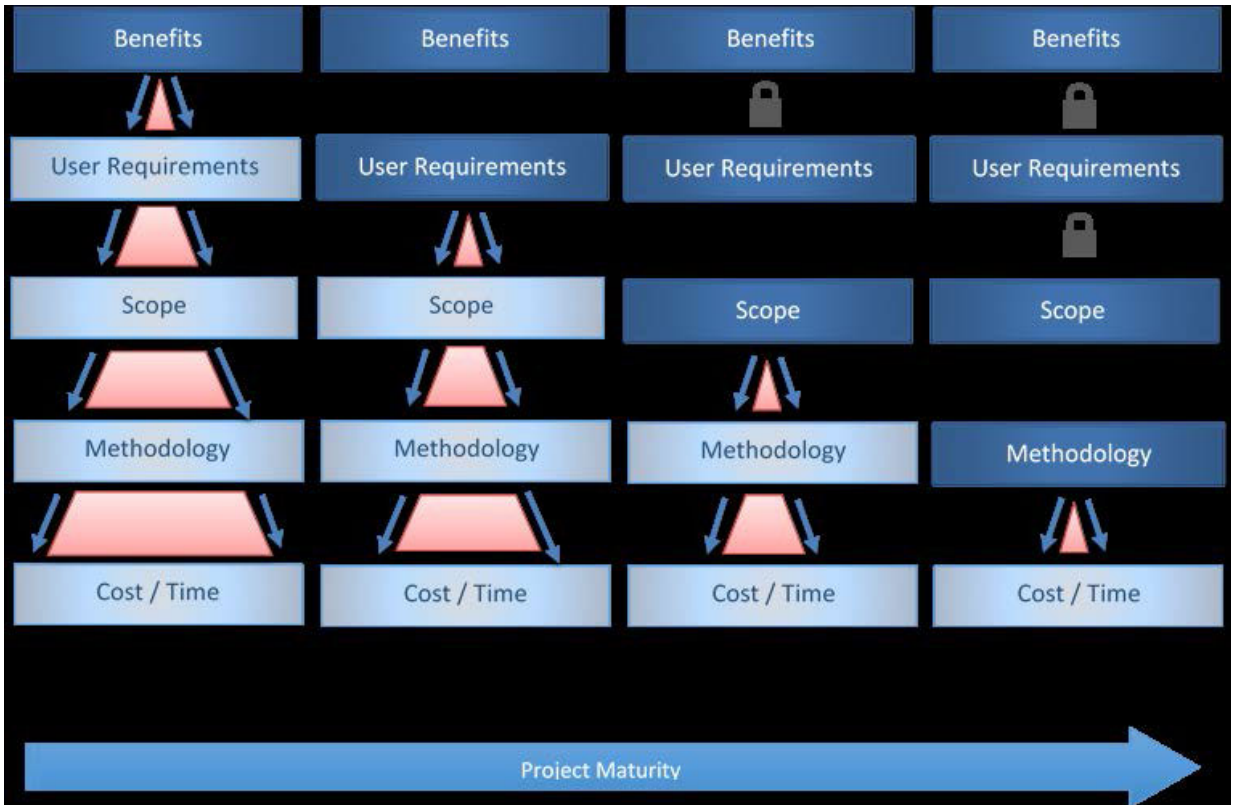
Technique	Exposure Category	Suitable For
Range Estimate	Uncertainty	Business Planning
% Uplift		Financial Authority (planning assumption)
QRA	Risk	Project Authority (funded risk)

A Portfolio Risk Structure is to be created that will be expected to manage higher level risks not within the control of the project. Examples include:

- Inflation
- Foreign Exchange
- Catastrophic Events

In the early stages of a project, the EFC will include uncertainty and be used for budgeting to set Financial Authority. In the delivery phase of a project, the only form of risk that is released in project authority is that estimated through a QRA. Any residual uncertainty will be kept outside the project and procurement authority.

A graphical representation is given below showing how the approach to risk varies by the level of cost maturity.



Terminology

Risk:

- Is the calculated P50 value from a Quantitative Risk Analysis (QRA) lined to specific risks affecting the delivery of a defined scope.
- Is the only category to be used for project authority.
- Includes examples such as ground conditions, weather, access, productivity etc.
- This exposure is best managed by the project delivery team as it covers specific on site challenges.
- Controlled via risk drawdown process.

Uncertainty:

- The amount applied to a base cost estimate's EFC to account for uncertainty in the scope of delivering a defined set of user requirements. Used for planning and budgeting.
- Uncertainty cannot be committed for expenditure without a paper seeking project authority.
- Includes examples such as provisional sums, percentage uplifts, three point estimate range, uncertain assumptions in the business case.
- This exposure is to be managed by the body responsible for the overall business case.

Portfolio Risk

- A specific set of risks defined by TfL to be excluded from project risk exposure calculations and managed centrally.

- E.g. political influences, inflation fluctuation, foreign exchange fluctuation, catastrophic events, delivery confidence above P50 (currently management contingency).
- Analysis and mitigation of these risks is the responsibility of the Portfolio Risk Board.

Enhanced Control Over Pathway Lifecycle Gates

Project Authority on scope is only set once a bottom up risk analysis has been completed. A QRA is only used to calculate full EFC from the end of Concept Design or Detailed Design depending on the procurement strategy.

The table below indicates typical estimation techniques by lifecycle stage.

Pathway Stage	Outcome Definition	Feasibility	Concept Design	Detailed Design	Delivery
Technique	Range Estimate	% Uplift	QRA	QRA	QRA
Predominant Category	Uncertainty	Uncertainty	Uncertainty / Risk	Risk	Risk
Used For	Business Plan	Financial Authority	Project Authority (Design & Build)	Project Authority (Traditional)	Project Authority
Assurance	Gate Review	Gate Review	Gate Review	Gate Review	Drawdown template & reporting

At each gateway between stages a full EFC will be reforecast to set Financial Authority (budget provision) and set Project Authority (released to project team) for the known scope required to complete the next stage.

For example, a major project will require significant project authority to complete design stages while still using a percentage uplift to calculate the full EFC.

This is shown diagrammatically below:

Advice on the management of risk can also be found in the Risk Management Handbook:
Pathway Risk Management Handbook

4.2.4 Assessing Project Risk

The cost impact of a possible risk event estimated using a QRA should be specified as a range of figures, rather than a point estimate. In other words, although the lowest cost impact of a risk event is zero, because that event may not actually happen, if it does happen the cost could be specified in terms of Minimum, Most Likely, and Maximum.

For business case appraisal, the risk provision should be set at P_{50}, or the expected (P_{Mean}) value. The key risks and their values should be summarised in the Business Case Narrative (Note: the risk provision for individual risk events should be expressed as P_{Mean} rather than P_{50}, which can give a misleading representation of an individual risk).

Where risk mitigation is planned, the likely post-mitigation probability and impact should be used as the basis for calculating the risk provision. However, not all mitigating actions will be completely successful and as such there is generally a spectrum of likely outcomes between zero or low mitigation effect and full or high mitigation effect.

If the project is at an early stage and a QRA has not yet been undertaken then a best estimate of the risk provision should be used. This would generally be expected to be between 20% and 40% of base cost but will depend upon the individual circumstances of each project. Where applicable, and in the absence of a QRA, risk values should be informed by previous similar projects.

4.2.5 Phasing of Risk Provision

Generally, phasing of risk and uncertainty should be pro-rata to the amount of future base cost spend forecast to occur by the end of each project stage.

For example if 80% of expenditure occurs in the implementation phase of a project then 80% of the risk provision should be forecast in the implementation stage and the remaining 20% forecast in earlier stages.

If in the view of the sponsor / project manager this places excessive risk provision in the early stages then it is permissible to pro-rata risk provision over the period of implementation only.

For risk support contact:

Ibar Murphy, [redacted]

4.3 Base Costs

The base cost estimate is made up of known project costs such as:

- Capital Items
- Resourcing (e.g. staff costs or consultants' fees)
- Accommodation
- Consumables (e.g. power or IT supplies)
- Expenses (e.g. travel and subsistence)

Costs have four possible attributes;

- **Direct costs** are exclusive to the project, programme or portfolio; they include resources directly involved in delivering and managing the work.
- **Indirect costs** include overheads and other charges that may be shared out across multiple activities or different departments.
- **Fixed costs** remain the same regardless of how much output is achieved, such as the purchase of an item of plant or machinery.
- **Variable costs**, such as salaries, fluctuate depending on how much resource is used.

4.3.1 Estimating

Costs should be obtained in a particular price base (e.g. 2014 prices or 2016 prices) usually for the year in which the estimates are being made. These should be entered into the business case spreadsheet without inflation added but then an inflation series should be selected for which the cost estimating specialist expects those costs to go up by.

For instance, we would expect costs for an item to be £2m in current (2016) prices but then rise with the standard LU TPI inflation series (see below). The cost estimating specialist should state the appropriate inflation series, and be made aware of the standard categories below, but should have the opportunity to say that a more specific assumption is more appropriate for that cost estimate.

There is the ability to enter outturn costs into the business case model spreadsheet, but this is mainly expected to be used for outturn business cases post delivery as part of benefit realisation analysis. It is not appropriate to enter outturn costs into the business case spreadsheet for a predictive business case in the early stages of development as this will result in inconsistency should the official inflation series forecasts change.

It is important that the inflation assumptions are made clear in the business case spreadsheet so that there is consistency across the portfolio and the ability to test investment portfolio exposure to different inflation assumptions.

Cost estimates are usually subject to some uncertainty, especially at the early stages of a Project but should always be based on the most likely level of costs. Worst case costs should be used only for a sensitivity test, not for the main appraisal.

Although it is common practice is to provide 'point estimates' for base cost elements with base cost uncertainty included as a project risk, a more comprehensive estimate is provided by specifying a range of estimates for each significantly large cost element. Various distributions could be applied to a cost element, but an obvious simple range of estimates is; Minimum, Most Likely and Maximum. The base cost used in the business case appraisals would then be the total P50 (or the ‘expected’ value know as PMean) from this analysis of the individual cost elements.

4.3.2 Inflation

In order to ensure that projects produce robust estimates of their outturn cost, the following guidance is given on the forecast tender price inflation that projects should use up to contract award (NB. Inflation post-contract award is dealt with separately and guidance should be sought from Procurement). These values should be used where projects are procured in an open-tendering environment only. Adjustment may be required in other circumstances such as negotiated.

If project costs are made up of significant non-tendered costs such as staff time, or agreed rates from framework agreements with built in cost escalators, then these items should be inflated at the appropriate rate (for example business planning assumptions or the framework procurement business partner).

Tender Price Inflation (TPI) Indices

Short Term (0-5 Years)

TfL TPI's are available at three levels:

1) TfL "All-in" TPI
2) TPIs by Programme Area
3) TPIs by work Group Area

These are shown in the table below:

Index Level 1: TfL	**Index Level 2:** By Programme Area	**Index Level 3:** By Work Groups
TfL	**Underground**	Civils
		Power
		Track
		Signalling & Telecoms
	Rail	Buildings & Stations
		Buildings & Stations (excl. M&E)
		Buildings & Stations: Telecoms
		Buildings & Stations: Lifts & Escalators
		Buildings & Stations: Mechanical & Electrical
	Surface Transport	Structures & Tunnels
		Highways & Cycling
	Information Management	People
		Sub-Contract
		Equipment

These are available in the Business Case Model Spreadsheet http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx and the series are extended for the medium and long term advice given in the sections below. They are also available on the Commercial Estimating site (with other sector specific inflation series): http://onelink.tfl.gov.uk/sites/cmrcl/toolkit/Commercial-Systems/CostPlanEst/Pages/BCIS-Indices.aspx

Tender Price Indices represent the average expected change in tender prices over the forthcoming years. This tendering climate can vary depending on the activity of work, sector, etc. therefore it is appropriate to use the most detailed TfL indices where estimate granularity permits.

Medium Term (5-10 Years)

For those projects / programmes that exceed the 5-year forecast period, the extrapolation of the TfL All-in TPI final year's forecast is extrapolated for the next 5 years, e.g. if the figure for 2020/21

is 3.3%, then that is used in each year until 2025/26. For projects with costs only in the medium term, they should select the appropriate index from the short term categories above in the Business Case Model spreadsheet and the costs are appropriately extended for the medium term.

Long Term (10+ Years)

For those projects / programmes that exceed the 10-year forecast period, the GDP Deflator should be used. Again for projects with costs only in the long term, they should select the appropriate index from the short term categories above in the Business Case Model spreadsheet and the costs are appropriately extended for the medium and long term.

Business Case Development: Ryan Taylor, [redacted]

Contracting

At the Contract Stage it will depend on whether we are awarding on a fixed price basis or target price/price adjustment for inflation. For the former the contractor takes the risk of inflation and we must allow for this in our estimate in (ii). In the latter the commercial representative incorporates the appropriate indices to be used in ITT. These are cost indices (not TPI) and currently we use BCIS Cost Indices, BEEMA or PAFI depending on which is appropriate for the particular trade/specialisation.

Once inflation has been contractualised, that assumption should be used in the business case rather than the TPI forecast.

Exclusions

The approach taken to create a suite of TfL Indices at different levels allows for most elements of work to be covered. However for bespoke / specialist works (for example digital signalling, rolling stock, etc.) which fall outside the available indices, the user should contact Commercial Procurement / Cost Estimating for further guidance:

Commercial Estimating, c [redacted]

4.3.3 Material and other costs

If material and other costs are expected to change in real terms over the appraisal period then these must be adjusted before discounting is applied. The use of these indices must be agreed with TfL Business Case Functional Lead.

Ryan Taylor, [redacted]

4.4 Optimism Bias

The Treasury's Green Book (2003) recommends that optimism bias should be included in appraisals (but not the project budget) to take account of the systematic tendency for appraisers to be overly optimistic about key parameters. The appraiser should use their best judgement as to what optimism bias to ensure the cost estimate that is as accurate as possible, whilst being sufficient to deliver the project but not be over padded or too high to skew value for money analysis.

The optimism bias value used should be based on this summary of DfT and Treasury guidance and knowledge of the maturity of the project cost estimate and experience as to whether there are any unforeseen eventualities. If there is nothing much to go wrong, especially if the work has been undertaken many times without a problem, then there is a case for only a small or no optimism bias. Optimism bias should be applied to both the base cost and risk provision. An explanation of the value used should be set out in the business case narrative.

The following table is upper bound Optimism Bias guidance from HM Treasury:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/191507/Optimism_bias.pdf

Category	Type	Upper Bound
Building Projects	Non-Standard	51%
	Standard	24%
Civil Engineering	Non-Standard	66%
	Standard	44%
Equipment / Development	-	200%
Outsourcing Opex	-	41%

These percentages relate to the average historic optimism bias found at the outline business case stage for traditionally procured projects and provide a first starting point and reasonable benchmark. Higher values of optimism bias may therefore be required at an earlier stage in the appraisal process. For other projects these upper bound estimates should be used as a starting point but can be reduced in line with how the contributing factors have been managed. The optimism bias with contributing factors taken into account can be derived from the tables in the Green Book Optimism Bias addendum.

The table below comes from the DfT WebTAG Guidance, converted to Pathway lifecycle stage:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/370867/TAG_Unit_A1.2_-_Scheme_Costs_January2014.pdf

Category	Types of projects	Pathway Stage		
		Stage 1	Stage 2	Stage 4
Roads	Motorway, Trunk roads, Local roads, Bicycle facilities, Pedestrian facilities, Park and ride, Bus lane schemes, Guided buses on wheels	44%*	15%	3%*
Rail	Metro, Light rail, Guided buses on tracks, Conventional rail, High speed rail	66%*	40%	6%*
Fixed links	Bridges and Tunnels	66%*	23%	6%*
Building projects	Stations and Terminal buildings	51%*	-	4%*
IT projects	IT system development	200%*	-	10%*

Sources: Flyvbjerg (2004) and Mott MacDonald (2002)*

Ryan Taylor, [redacted]

4.5 Foreign Exchange

It is important to consider whether a project has foreign currency exposure as this could significantly affect the outcome of the business case due to the volatility of currency exchange rates overtime.

It is also important that an adequate allowance is made to cover the uncertainty that arises from this potential future foreign currency rate volatility, which will increase the further away the planned expenditure is.

4.5.1 Treatment of Foreign Exchange in Appraisals

For the Base Cost estimate, the most accurate central forecast should be used for the year(s) of expenditure.

The FX rate will vary depending on the stability of the particular currency and becomes more uncertain, the further into the future the foreign currency is required. Foreign Exchange risk exposure should be captured in the Portfolio Risk Register in the early stage of a project but by the time contracts for delivery are agreed, the risk would move to be managed by the project. Either way, the risk needs to be reflected in the business case and benefit to cost ratio. It is important that the risk of exchange rate uncertainty balances budget requirements, without being so cautious as to have an overly negative affect on the BCR.

Group Treasury are responsible for ensuring that future exchange rate uncertainty is managed across TfL and will advise on appropriate FX rates and uncertainty values;

Group Treasury [redacted]

4.5.2 Managing Foreign Currency Exposure

Identifying FX risk exposure

TfL becomes exposed to foreign currency when it is procuring goods and services from suppliers who have a foreign currency supply chain. Whilst it is reasonable to assume that overseas suppliers will have underlying costs in a foreign currency, it is also possible for UK suppliers to incur similar costs if they are sourcing from abroad.

Some consideration needs to be given to the group of potential bidders and whether they are likely to have foreign currency supply chains. Once the currency mix is established, Group Treasury can provide information on these currencies and quantification on the amounts to include in the portfolio risk register. Once Foreign Exchange has been contractualised, the risk would move from the Portfolio Risk register to the project risk register.

Managing FX risk exposure

At individual project level, how FX risk is managed will depend on the type of Contract (e.g. whether fixed price or variable), its value and duration and current circumstances, such as currency rate uncertainty. Although it may be possible to pay in GBP, it may be more advantageous to pay in the foreign currency with TfL **hedging** the risk itself.

Hedging is undertaken where TfL has accepted the risk and seeks to manage this through agreeing to purchase the foreign currency required in the future to match the forecast payments. This provides the project with a known GBP equivalent cost up front (though there can be some small changes overtime where payment dates change).

Process Guidance

Guidance on managing foreign currency exposure can be found in the Pathway Foreign Currency Management – Policy and Process:

Add link to Foreign Currency Management – Policy and Process.

To ensure foreign exchange is managed cost effectively across TfL, Group Treasury should be informed of any Project with likely exposure to foreign currency at **Pathway Stage 1** and provided with updated foreign expenditure and dates at **Pathway Stage 2**. The way that foreign exchange is treated may need to be specified in the contract.

Once suppliers have been selected at **Pathway Stage 4**, any contracts to be paid for using foreign currency will have been confirmed. All Contracts with exposure to foreign currency should be discussed with Group Treasury before being awarded, to agree the payment mechanism.

Throughout delivery, forecasts for foreign currency expenditure and the FX uncertainty risk level should be based on latest Treasury figures.

4.6 Treatment of sunk costs in appraisals

When a change occurs to project costs, timescales or deliverables beyond original tolerances, it is necessary to review whether to continue. In these circumstances, it is important not to lose sight of the overall business case for the project. Thus the main analysis should always be based on the full project cost, i.e. what has been spent to date plus all future expenditure proposed. However, in deciding where best to allocate the scarce resources available to TfL it is also important to

understand the implications of halting a project prematurely and what return TfL would achieve from the future expenditure alone, especially when a large fraction of the total expenditure has already been incurred (i.e. "sunk costs").

Where the full cost appraisal no longer justifies a project, the business case should identify clearly the implications of not continuing with a project, taking into account the remaining spend, including the costs associated with bringing a project to a suitable conclusion. The "future" benefit/cost ratio then becomes: future benefits that could be achieved (as opposed to any already achieved), divided by future net costs (i.e. offset by costs of premature closure). This should be quoted as an additional item of business case information in the Appraisal Summary Table and will be the key factor in deciding whether to continue with the project.

In each analysis, i.e. overall business case and "future" business case, all costs, benefits and present value calculations should be based on current year prices. If the original analysis was carried out using parameters or appraisal methodology which has since been superseded, and a decision is required concerning a significant amount of remaining expenditure, it may also be necessary to convert to current BCDM parameters or use the updated methodology.

Business Case Development: Ryan Taylor, [redacted]

4.7 Enhanced Capital Allowance Tax Rebate

Tax rebates are available for certain energy efficient and water efficient equipment. This applies to plant, machinery and buildings and includes the cost of installation and transport as well as the equipment itself:
https://www.gov.uk/green-taxes-and-reliefs/capital-allowances-on-energyefficient-items

The Sponsor shall give consideration to the specification of Products that are included in the Governments Energy Technology List (ETL) or the Water Technology List (WTL). This is because investment in these products allows TfL to apply to Her Majesty's Revenue and Customs (HMRC) for an Enhanced Capital Allowance (ECA), in order to reclaim 19% of the Product cost (including transport and installation). This can make such technology cheaper when the reclaimed amount is taken into account.

The rebate may make a straightforward financial case for purchasing such equipment even if it is more expensive than standard equipment. Rebates should be estimated and entered as secondary income – to ensure that it is transparent and separate from the base costs. It should not be entered as income from third parties as this will only affect the standard sensitivity test benefit to cost ratio and it should be included in the standard benefit to cost ratio. To ensure that these rebates are actually claimed, processes should be in place to make sure that this takes place.

This equipment may also impact the whole life cost appraisal as well and may assist with carbon targets. Where a straightforward financial case can not be made, it may be appropriate to include this equipment (and claim the rebate) anyway to meet other objectives and policies.

LUL projects should comply with Cat 1 Standard S1011 Product Acceptance and Registration:
http://onespace.tfl.gov.uk/lu_/cms/CMSLibrary/S1/S1011.pdf

Guidance intended for all TfL even though it is located on the London Underground Intranet:
http://luintranet.tfl/ops_maintenance/safety_security/environment/755.html

Enhanced Capital Allowances Tool:
http://onespace.tfl.gov.uk/lu_/cms/pmf/SIGs/TfL%20PPM/TfL%20PPM%20Output%20Library/T%20ECA%20Tool.zip

If energy increases or decreases as a result of this project, the following Pathway Carbon and Energy Efficiency Plan Template should be completed: Carbon and Energy Efficiency Plan and calculations performed in the Carbon and Energy Efficiency Calculator.

Matthew Webb, [redacted]

4.8 Third Party Funding

The impact of any third party contributions on the business case for a scheme should be taken into account by assessing both the economic case (i.e. the traditional full costs to the public sector and full social benefits) and its financial attractiveness to TfL. First the benefit cost ratio should be calculated using the full cost of the scheme, without subtracting the third party contribution. If the project has a BCR greater than 1.5:1 it is economically worthwhile in the same way as other projects that have reached this benchmark. If so, the BCR should then be re-calculated, using the expected cost of the scheme to TfL after allowing for the third party contribution. This second ratio will enable TfL to compare the scheme against others when deciding on priorities. This standard sensitivity test is automatically calculated in the Business Case spreadsheet.

Any potential contributor should be made aware if there is a more efficient transport option than the one proposed. For example, a new Underground station, for which an external contribution may have been offered, may have a higher profile than other improvements to the transport infrastructure in the surrounding area, but it may not be the solution which minimises journey times or maximises modal shift to public transport. In such a case, the external contribution would distort the comparison.

As with other third party contributions, grants should not be offset against the cost of a project in the main appraisal. Where additional public money is involved, it is particularly important to assess the true economic worth of the project, and to highlight the option with the greatest transport benefits.

5. OPEX

5.1 Overview

Operating costs are all ongoing costs and expenses related to the operation of a business, or to the operation of an asset, device, equipment or facility. They are the cost of resources used by an organization just to maintain its existence. Operating costs include costs for maintenance, energy, overheads and resources associated with ongoing operations.

Where costs are likely to change in real terms over the life of the project, i.e. differently from the GDP standard measure of inflation, then specific indices must be used to estimate this effect. Staff costs are a good example, as historically, earnings have risen at a higher rate than RPI. This needs to be reflected in the calculation of future costs by using the likely real growth of earnings.

5.2 Estimating

The business case should clearly describe the different types of operational costs and the assumptions used to develop these. Key items to consider are;

- Reduced costs associated with the introduction of a new modern assets, or renewal of existing assets.
- Increased costs associated with the introduction of new assets
- Decreased costs as a result of asset disposal.
- Reduced operating costs through the introduction of new energy efficient equipment.
- Cost increases associated with increasing demand, either due to general population growth, or new users e.g. as a result of increased 'willingness to pay'.
- Increase in maintenance costs associated with ageing assets (e.g. due to increased level planned and / or reactive maintenance) – generally associated with the 'do nothing' or 'do minimum' base case.
- Risk mitigation costs, generally associated with keeping a non-compliant or ageing asset in service.

All estimates for operating costs should be agreed by the maintainer or other appropriate budget holder.

5.2.1 Staff Costs

Base Staff Costs

A staff resource cost calculator is available in the Business Case Data Book: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

This contains generic 2016/17 staff costs by grade. It includes base salary costs, bonuses, and uplift for pension and National Insurance. If a project is to release headcount, then this can be used to show the staff resource cost saving. Also consider the impact of reduced overhead costs in section 5.2.2.

If headcount is not released then it is still possible to include efficiency improvements in staff time in the financial effects (i.e. bottom) of the benefit to cost ratio and Net Present Value. It is

important to identify that this is not a cost saving however and it should be described as a cost avoided or a staff efficiency improvement that would free up staff time to spend on more value added activities. This effect should be clearly described in a business case to illustrate exactly how that time will be freed up.

If more specific information is known about the group of employees concerned, then the direct staff costs, including salary, bonus, pension and National Insurance should be used. This can be obtained from the HR Delivery Support and Change team.

Staff Cost Forecasts

Unless there are specific forecasts for the staff concerned, for example through a negotiated settlement, then it shall be assumed that staff costs will change in the same way as average standard inflation in the economy as a whole defined by the GDP Deflator – see Business Case Model spreadsheet: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

The impact of this assumption should be testing using sensitivity tests around this central case (zero inflation, GDP Deflator -1% / + 1% / +2%).

5.2.2 Energy Costs

Will energy consumption increase or decrease as a result of the project? The change should be estimated and the cost impact included in the cost – benefit analysis calculations.

The Carbon and Energy Efficiency Plan (Pathway Product) should be completed during Pathway Stage 2.

5.2.3 Overhead Costs

A variety of support services costs for typical expenditures have been set out in the Support Services Rate Card in the BCDM Data Book: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

Contact Property and Facilities or HR for more precise estimates.

5.2.4 Optimism Bias

There are no specific optimism bias levels for excess operating expenditure (except for outsourcing) but this should be considered in the analysis. For operating costs this might cover such factors as output specifications not being defined clearly enough, stakeholder and operator needs not fully understood, or forecast operating savings not being achieved. Where any of these outcomes are feasible, they should be the subject of sensitivity tests.

6. Lifecycle Cost

6.1 Overview

Lifecycle cost (also known as whole life cost) is the total discounted present day cost of ownership over the life of an asset, or group of assets. This should include;

- Upfront Project costs
- Future one off costs such as mid-life refurbishments and deferred renewals.
- Ongoing operational, inspection and maintenance costs
- Cost savings (or costs avoided)
- All associated revenue

In Business Case appraisals, lifecycle costs are usually split into Capex and Opex. However, lifecycle costs do enable different investment options to be compared and are therefore important when prioritising across a portfolio of projects. They also can be used to help justify the case for investment and are particularly important for projects with low social benefits, such as asset renewal interventions. The optimal solution is usually the option that delivers the lowest lifecycle cost.

Business cases for asset renewals should demonstrate that the preferred option will deliver optimal value by balancing lifecycle costs and benefits over the life of the asset.

For further information and guidance on writing a business case for asset renewals, refer to Chapter 22, Asset Management.

Lifecycle costs are also required for Value Management assessments, for the calculation of the Value for Money Ratio – see Chapter 12 for further details.

6.2 Estimating

Lifecycle costs are often uncertain, particularly for outline business cases, before feasibility has been undertaken. At these early stages of the project, high level estimates are often acceptable, providing the assumptions behind these are clearly stated and costs have been agreed with Asset Managers and / or Maintainers, as appropriate.

Lifecycle costs used for the main case should always be based on the most realistic estimates, with worst case costs used only for a sensitivity cases.

6.3 Worked Example – cyclical renewal of light bulbs on stations

The example evaluates the optimal timescales for replacing standard and long life bulbs at critical locations within LU stations.

- Option 1 – Standard light bulbs
- Option 2 – Long Life light bulbs

6.3.1 Costs

Planned Replacement	Bulbs are replaced via routine re-lamping programme i.e. all bulbs changed in batches so access costs are shared across multiple units	£20 per unit (Standard bulbs) £60 per unit (Long Life bulbs)
Unplanned Replacement	Bulbs replaced individually, including access cost.	£200 per unit (Standard bulbs), £250 per unit (Long Life bulbs)

6.3.2 Failure Rates

The following table shows forecast patterns of failure for each type of bulb:

	Infant mortality	Random failures	Age-related failures
Option 1: Standard	2%	.005/month	6-60 months
Option 2: Long Life	0.5%	.001/month	24-96 months

6.3.3 Method

Using a risk software package, specify the above failure patterns. For example, the '@Risk' package (provided as an add-on to Excel) allows the following representations for month of failure in a spreadsheet:

Standard bulb

Infant mortality, month 1 =RiskDiscrete({0,1},{0.98,0.02})

Random failure, months 2-5 = RiskCompound(RiskDiscrete({0,1},{0.98,0.02}),RiskIntUniform(2,5))

Normal distribution, months 6-60 = RiskNormal(35.5,12.5)

These formulas represent a 2% chance of failure in month 1, a 2% chance spread evenly across months 2-5, and a Normally distributed age-related failure with a mean of 35.5 months and a standard deviation of 12.5 months, based on evidence of past failure patterns.

Suppose these formulas are held in cells D4, E4, F4. The output cell bringing together the result of these possible outcomes would include an Excel expression which first looks for a failure in month 1, then in months 2-5, and if neither is present, uses the Normally distributed figure:

= RiskOutput ("Expiry month for Standard") + IF (D4 = 1,1, IF(E4>0, E4, F4))

Long Life bulb

Similarly the representations for Long Life bulbs could be:

Infant mortality (month 1) = RiskDiscrete ({0,1},{0.995,0.005})

Random failure months 2-23 = RiskCompound (RiskDiscrete({0,1}, {0.978,0.022}), RiskIntUniform(2,23))

Normal distribution. months 24-96 =RiskNormal(67,15)

(Note: An average of 0.001 failures per month over 22 months is equivalent to an overall probability of approximately 2.2%.)

6.3.4 Lifecycle Costs

Outputs from the above show the distribution of failure times for each type of bulb. Suppose the output cell for the Standard bulb is G4, then the probability percentiles for failure time after, say, 10,000 iterations could be captured by:

= RiskTarget (G4, C10)

= RiskTarget (G4, C11)

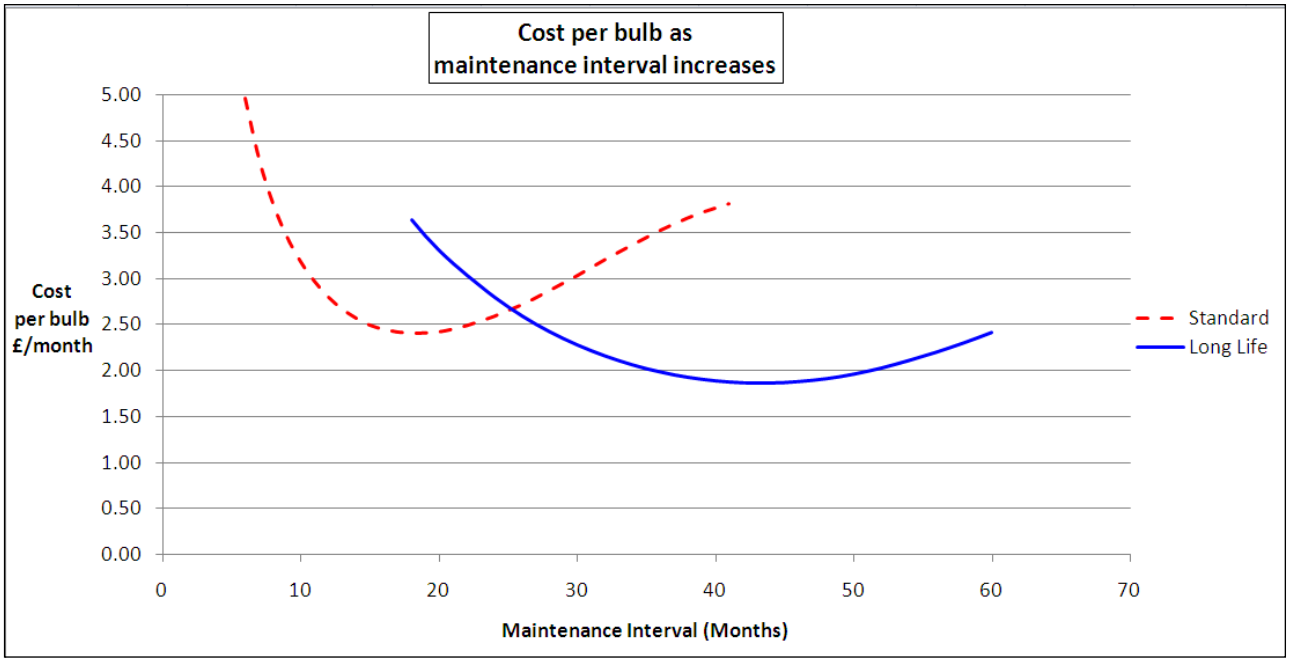
Etc.

where C10, C11, etc. contain 1, 2, etc. and the 'RiskTarget' function produces the probability of failure in up to 1 month, up to 2 months, etc. And for any particular period, for example 11 months, lifecycle cost per month based on a planned maintenance interval of that period is calculated by:

*= (20 + D14 * 200) / C14*

where £20 is the replacement cost per unit of Standard bulbs in a planned relamping programme, D14 contains the 'RiskTarget' probability of failure within 11 months as explained above, £200 is the replacement cost when failure occurs between planned replacements, and C14 contains the planned interval 11 months.

The results are shown in the figure below:



6.3.5 Conclusions

The first conclusion is that it is significantly cheaper to replace light bulbs in critical locations via the routine re-lamping programme as a planned activity rather than to wait for failure. For the Standard design the WLC reduces from about £5.40/month/unit (currently being experienced

with no planned replacement programme) to about £2.40/month/unit if replaced in planned batches with an 18-month interval, a reduction of about 56% in WLC.

The second conclusion is that it is economic to replace Standard light bulbs with Long Life units, with the replacement interval moved out to about 42 months (i.e. the longer life is optimally exploited). This option is estimated to reduce WLC further to about £1.90/month/unit, representing an overall saving of about 65% in WLC.

Any monetised reduction in CO_2 emissions would also feature in a standard appraisal, and would further support the cost-based advantage of long life bulbs.

6.3.6 Sensitivity Tests

This analysis assumes only one failure could occur between programmed replacements. However the probability of more than one failure, although small when the planned interval is relatively short, may have some impact on the conclusions. A sensitivity test could illustrate this.

Other tests could show how the conclusions are affected when differences between the bulb types in terms of cost, and in terms of reliability, are changed.

7. Revenue

For revenue generated from social benefits, see Section 20.2: 'Calculation of Revenue Effects from Social Benefits', but note this is included in the financial effects (i.e. the bottom of the benefit to cost ratio). The standard business case spreadsheet automatically calculates this and enters it into the correct place in the benefit to cost ratio once the relevant elasticities have been selected.

7.1 Non-Fares Income

Appraisals must, however, include any other changes in TfL income e.g. vending machines sales, and advertising. Income can be one off from say a sale of an asset or can be generated as an ongoing income stream such as rental from a retail space. It is increasingly important that these effects should be considered for everything that is done as TfL has to become operationally self-sufficient, which means that operating income must cover operating costs.

7.2 Commercial Development

Commercial Development opportunities shall be discussed with the Commercial Development team to take forward as appropriate in a controlled and prioritised manner. The bigger the space available and the more lucrative the location, the more likely TfL is to be able to obtain income from that asset and these should be fully investigated and exploited. It is important that the Commercial Development teams and the operating / planning teams work closely together to ensure that impacts during construction on the operational infrastructure are minimised and that the long term capacity growth of the infrastructure is not unduly limited.

7.3 Treatment in Business Cases

All financial flows need to be forecast for the period of the appraisal (life of the asset) and present values calculated as well as the budget impact in outturn values (this is the standard difference between the value for money "Economic Case" and affordability "Financial Case" that is required for all business cases. The standard business case spreadsheet on the Business Case Intranet page will output the figures in the required formats: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

In many instances it is not necessarily the case that a project will enable commercial development opportunities to be reaped. In order to make decision making as clear as possible the following principles shall apply:

- Calculate the classic case for investment based on the known full expenditure (excluding uncertain commercial development opportunities) and the social benefits to be achieved.

- Net off commercial development opportunities from the bottom of the benefit to cost ratio only if they have a reasonable degree of certainty and are directly attributable to the project. Fully acknowledge the risk and uncertainty so that decision makers can make an informed choice.

- Ensure that any benefit to cost ratio is a fair reflection of benefits and the costs that gives rise to those benefits – i.e. if a financial benefit has been included, the costs of obtaining that financial benefit are also included, and any social disbenefits such as disbenefits during construction.

- If costs and benefits are intertwined in a complex way then consider elevating analysis to a Programme or Portfolio level. This will show the overall value for money of the entire package of projects, even if an individual project within that, which may be an enabler, does not show value for money on its own.

- Project governance is determined by project Expected Final Cost (EFC) and some commercial development projects could have a small EFC but lead to a big impact either in terms of their overall financial impact or on knock on requirements for other projects. Despite the formal requirements of governance as defined by Standing Orders, a commercial property scheme that is likely to have a significant knock on impact should be discussed with the relevant operating area at the earliest opportunity to ensure that the maximum overall value and minimum overall disruption can be determined.

- The standard discount rate for all public sector appraisals is 3.5% and this is set in the standard business case spreadsheet. A separate inflation assumption must be set and not be combined with the discount rate for the purposes of appraisal. Standard or user defined inflation series are available in the business case spreadsheet.

- Internal Rates of Return (IRRs) are not a standard public sector metric but may be used by the private sector, so should be considered to inform discussions and negotiations with them. The standard metrics at TfL are the benefit to cost ratio and the Net Financial Effect (NFE) and payback period. These must be used and presented to ensure a consistent comparison with all other projects across the investment portfolio. Please note that if there are no social benefits from a scheme, then just a Net Financial Effect and payback period will be returned.

The “Commercial Case” in Five Case terminology is for commercial implications, either the up-front commercial relationships required to deliver the project or any ongoing impact on existing or required operational contracts.

8. Private Finance Initiatives

8.1 Categories of project for which the PFI should be considered

Commercial Finance should be consulted about projects that could potentially be financed under the PFI (or via other non-capital financing arrangements, e.g. Prudential Borrowing).

Commercial Finance: [redacted]

8.2 Appraisal issues

Where opportunities for pursuing the project under a Private Finance Initiative (PFI) are being progressed, the benefits and disbenefits of PFI funding need to be considered.

However, with any investment proposal, it must first be established that, irrespective of funding arrangements, there is a good business case for doing the project. Thus the business case should be such that the project would be worth doing within current investment priorities.

The next step will be to look at benefits and costs involved in PFI funding. This is a specialist area, but here is a list of possible benefits to be estimated when appraising a PFI option:

- benefits brought forward from the date when they could be delivered by the project if conventionally funded
- more project risk transferred than possible with conventional 'design, supply and maintain' contracts with payment by performance
- increased passenger benefits and revenues, if target performance levels achieved
- penalty payments, if target performance levels not achieved
- asset provider being responsible for maintenance as well -as a result the supplier has more interest in designing the asset to perform well
- worthwhile project enhancements beyond original scope

Tax savings offered by the supplier are regarded as costs to the exchequer, and hence to the taxpayer. They should therefore be ignored as potential benefits.

PFI funding also has the following potential disbenefits:

- delays through the tendering process, especially if abortive
- extra interest paid on the contractor's loan, via continuing lease payments, compared with the lower cost of government borrowing if the project is conventionally funded
- premium for transfer of risk
- decreased passenger disbenefits and revenues, if performance levels likely from a conventionally funded project are not achieved
- termination of contract costs (e.g. termination would usually occur if performance is unacceptable for specified period of time)

- TfL's sourcing strategy in each area aims to ensure that more than one supplier stays in the market, to maintain the benefits of competitive pricing. The choice of PFI funding arrangements may adversely affect this strategy.

(These are not exhaustive lists.) Estimates of all potential benefits and costs should be provided, with estimated probabilities where outcomes are uncertain.

If enhancements to the original project are offered, these should be appraised incrementally – again, to see whether the enhancements would be worth incorporating within current investment priorities.

The appraisal approach in general (and in particular, discounting rates for future payments and benefits) will need to be discussed with TfL Business Case Development and with the DfT.

Business Case Development: Ryan Taylor, [redacted]

8.3 Five Case Best Practice

In Treasury Five Case Best Practice methodology, PFI information would be included in the following cases:

Strategic Case – What is the case for change?

An objective of the organisation may be to deliver change through financial arrangements that do not have a significant up front capital investment and instead be delivered through on-going payments like PFI. This may be on short term affordability or cash-flow grounds. If this is the case, then it may limit options in the Economic Case to a PFI delivery methodology.

Economic Case – What is the best public value solution?

The impact on value for money of the different funding approaches should be set out. Like for like comparisons of the options are necessary so the various scope options need to be evaluated using a common approach. This should be undertaken using a traditional evaluation of the costs as if the project is being delivered through the standard methodology (public sector comparator). A financing evaluation should then be undertaken on the preferred solution. This would normally be undertaken by Commercial Finance but a summary should be included in the Business Case Narrative illustrating why the best approach is to deliver the project using a PFI.

Financial Case – Is the project affordable?

This case identifies how the initiative is to be funded. Usually this just involves showing how the initiative is accommodated in the business plan / budget but is more complicated where more innovative funding arrangements are in place such as a PFI. In this case the affordability of the different funding approaches should be set out. It may be that the PFI approach is the only affordable funding approach.

Commercial Case – Is the project commercially viable?

What high level commercial arrangements are necessary to deliver using a PFI approach? Is there an on-going operating concession or is it just for delivery and maintenance? Who will take any revenue? Are there any knock on commercial impact on other contracts?

Management Case – Is the project deliverable?

Are any specific high level governance or risk management issues that need to be acknowledged? What benefit realisation work is necessary to prove the success of the project, specifically with respect to the PFI deal.

9. Specific Case Guidance

9.1 Financial Effect Only Schemes

If a project does not have any impact on social benefits, then a benefit to cost ratio is not an appropriate metric to measure value and a purely financial impact analysis is the appropriate approach. A Net Financial Effect (NFE) and payback period will automatically be generated in the standard Business Case Model spreadsheet if this is the case and no social benefits are entered. Types of projects that typically fall into this category are:

- Business efficiency schemes,
- Organisational change
- Staff accommodation projects
- IM Projects
- Investing in depot facilities
- Commercial development projects

Further information is provided on some of these below.

9.2 Staff accommodation projects

Accommodation projects have two main effects:

More efficient use of office space

The use of good design and modern system furniture (and IT systems through reduced space requirements for filing etc.) can significantly reduce the amount of space required for staff, whilst at the same time providing an acceptable working environment. Small projects may not enable sites to be released or sold, but nevertheless cumulatively they contribute to savings. For this reason the space saved can be valued in an appraisal, provided it is usable. See the Support Services Cost Assumptions in the BCDM Data Book: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

Improvement in staff morale

Improved accommodation can lead to reduced staff absenteeism and turnover, improved productivity, and (seen as part of the employment package) reduced staff costs. However, researching the relative valuations that staff themselves would put on accommodation improvements, as opposed to improvements in other working conditions, could raise sensitive industrial relations issues. In the absence of such valuations, the appraisal should indicate whether the increased accommodation expenditure remains proportionate (especially by comparing the percentage of total salary cost with that for comparable groups of staff), and quantify any known problems of absenteeism and turnover which may in part be caused by poor accommodation. Decision makers will then need to judge whether the cost of improving the staff environment is likely to be justified by improvements in morale leading to reduced staff costs (absenteeism and turnover), and performance (increased productivity and customer satisfaction).

Similarly, where equipment is provided to help staff carry out their duties, it must be fit for purpose. If not, there will be a loss of morale which may outweigh any savings through not improving the equipment.

9.3 Projects in support services (e.g. IT projects)

In principle, these projects generate the same types of benefits as other projects, but where necessary TfL Business Case Development should be consulted about quantification of the benefits. A number of such projects are discussed below and a worked example is shown in 9.3.1.

Business Case Development: Ryan Taylor, [redacted]

Cost Savings

Many IT projects, for example, are direct cost saving projects which result in more efficient staff operation. This can result in direct staff savings, which are readily quantified although users tend to quote "improved productivity" without quantifying what direct effects on costs will result. Ongoing benefits from project investment will be reflected in users' operating budgets and budget holders will be expected to achieve claims of improved productivity. It is therefore important that realistic and achievable quantification of such benefits from the users are obtained.

Improved Service

Many projects are intended to improve the output of a unit in terms of improved service. In most cases, it is possible to put a value on the improved performance (e.g. reduced train cancellations or better bus regularity) using the principles in this manual.

Corporate IT Projects

The benefits expected from corporate IT projects are less well defined. For example, the project management system PROCON is generally recognised as being important in improving the management of projects but it is difficult to assess the value of that benefit.

Management Information Systems

Similar problems arise with management information systems which are intended to improve the effectiveness of managers by providing better information on which they can base their decisions. Since it is difficult to value the output of managers, it follows that it is difficult to value changes in that output.

In some cases it may be informative to authorising bodies to state what improvement in the "output" of the manager is required to justify the project e.g. number of trains in service.

Marketing Campaigns

This type of project would include advertising campaigns, public relations campaigns, etc. Whether funded by operating or capital expenditure, the project should have a properly presented business case, with objectives and deliverables, costs and benefits. An advertising campaign, for example, would usually be associated with a service improvement initiative, and the business case would need to be demonstrated in terms of the wider business objectives.

Training Initiatives

Training initiatives have an effect similar to Management Information Systems (above) in that they are aimed at improving the performance of staff. The benefits obtained will depend on the functions of the staff. For example, training of depot staff might result in lower costs and/or fewer train cancellations, whereas training of station staff could result in improved MSS scores for knowledge and helpfulness of staff.

9.3.1 Support Services Example

BUSINESS CASE FOR AN I.T. PROJECT

(NB. The facts and figures in this example are entirely fictitious.)

Introduction

It is the aim of the project team to compile a comprehensive database of relevant asset cost information for use in future cost estimation and procurement. Due to the fast expanding manual record system, searching for historical cost information is likely to prove increasingly difficult as time goes by. It is estimated that there are currently 20,000 relevant documents, making a total of 50,000 pages, in the filing systems. A number of different approaches to the document management problem have been reviewed.

Option 1

In the existing manual process, there are daily searches for asset cost data which is held in three different filing systems. This process is highly inflexible and time consuming, and with the frequent removal and replacement of documents, there is a risk that these may become damaged, misfiled or lost.

Option2

In this option, the data would be photocopied and put into a separate asset cost filing system, while a computer database would hold a catalogue of the copy documents. Whilst this would give increased flexibility to searching, some of the problems of removal and replacement of documents remain. Also, the amount of information to be stored would place a strain upon the existing computer network.

Option 3

Finally, the use of computer software online to retrieve scanned images was reviewed. Such systems offer increased and more flexible search facilities, immediate access to documents, and the advantages of Optical Character Recognition.

A cost-benefit analysis showed that a) using a computer database to catalogue the copy documents was more cost effective than a purely manual system, and b) using computer software to retrieve scanned images was more cost effective than the computer cataloguing system. A summary analysis of the options is shown on the following page.

Assumptions

a) *Copying of documents into new filing system, and producing computerised reference list*

This process would, at a rate of 200 documents per day, take an estimated 5 months to complete, which at current salaries would cost £23,800.

b) *Scanning in / coding of documents into new database*

The preferred agency quote for scanning in the 50,000 pages and coding the appropriate database references is £27,000.

c) *Searching for documents*

From diaries kept over a recent period of three weeks, the time spent searching for documents is approximately 10% of total staff time. It is assumed that this could be reduced by a half if a computerised list were available, but with the more sophisticated database software online it is assumed that the search time could be reduced by three-quarters.

d) *Handling of hard copies of documents*

Currently, the relevant member of staff spends about 20% of his time photocopying and re-filing documents. As with c) above, it is assumed that this time could be reduced by half if a purpose-built filing system for asset cost data is available. With electronic copies on a database, there would be further improvements, although the need for hard copies would not be completely eliminated. Again, it is assumed that with the database the handling time would be reduced by three-quarters.

e) *Treatment of reduced staff time in the appraisal*

It is assumed that the staff time freed up can be usefully deployed elsewhere on cost estimation work, for example in improving turnaround times, increased work on cost versus reliability, etc. It is not envisaged at this stage that the staff numbers would be reduced.

Business Case Summary

(Operating costs are discounted over the life of the system - 5 years. As usual, capital costs are assumed to occur in year 0, while resulting changes in operating costs occur in years 1-5.)

Capital costs	**Option 1 Existing Manual System** £ PV	**Option 2 Computerised Catalogue of Manual Documents** £ PV	**Option 3 Database of Scanned-in Documents** £ PV	**Increment of Option 3 over Option 1** £ PV
Copying documents / storing in new files / producing reference lists		-23,800		
Scanning in documents			-27,000	
Database software, including Optical Character Recognition			-6,900	
Total	0	-23,800	-33,900	- 33,900
Operating cost savings				
Time spent finding relevant documentation -estimated currently as10% of total working time for 6 staff in section (Total = £15,000 p.a.)	-63,200	-31,600	-15,800	
Time spent handling hard copies of documents -currently estimated as 20% of total working time of 1 admin person in section (Total = £3,800 p.a.)	-16,000	-8,000	-4,000	
Total	-79,200	-39,600	-19,800	59,400
Overall advantage of Option 3 over Option 1				25,500

The table shows that Option 3 is preferable to Option 1 by £25,500 (PV), and as stated earlier, Option 3 also has an incremental advantage over Option 2. The use of a computer database to retrieve scanned images was therefore found to be the most effective and efficient option.

As a sensitivity test, if the time spent finding relevant documentation is only 5%, instead of 10%, of staff working time, Option 3 is still the most favourable, though the advantage over Option 1 is reduced to less than £2,000 (PV).

This example illustrates the following aspects of such financial appraisals:

- where possible, more than one alternative option should be generated, so that decision makers are not left thinking "What if...?"
- the increment of each option over other options should be shown (in this example, only the increment of Option 3 over Option 1 is shown, although it is made clear that Option 3 is also advantageous when compared with Option 2)
- capital costs and operating costs should be shown separately
- it is important to state the predicted life of any assets to be procured, and discount the operating cost effects over that period of years
- the sources of estimates should be stated
- it should be made clear whether any staff time saved is intended to result in a reduction in the number of staff budgeted, and if not, it is helpful to indicate how the freed up time might be deployed
- in the summary table, costs and benefits should be itemised where space permits
- appropriate sensitivity tests, particularly exploring areas where there is most uncertainty, should be applied
- although it is not demonstrated in this particular example, where it is not possible to quantify an impact via a saving in staff time, the impact should be described in terms of the number of people affected, the frequency of impact, and the typical extent of the impact on each occasion.

9.4 The appraisal of leases

The appraisal of projects which have a leasing option should be carried out as for "capital" projects with leasing as an alternative option. The comparison of purchase and leasing options will involve different annual cash flow profiles and the discount rate will have a considerable effect on the Present Values for the options.

Therefore, when evaluating lease proposals, as a sensitivity test, in addition to the standard 3.5% discount rate, evaluation at a range of discount rates for all cash and benefit flows in the appraisal should be carried out for both lease and purchase options.

Regarding finance leases, there is a general presumption against nationalised industries entering into this form of borrowing arrangement, since it is generally more expensive than paying for the assets concerned via Government borrowing.

9.5 Property

Many appraisals will simply entail comparing financial benefits against costs, to see whether the net financial effect is positive. However some projects, including station developments, will have social benefits, as well as an accompanying revenue effect. The appraisal of these benefits should be

carried out as described in section 10: 'Benefits Overview' using values for Bus and/or Underground passengers depending on the modes affected. In the case of interchange schemes TfL Business Case Development should be consulted on appropriate values.

Business Case Development: Ryan Taylor, [redacted]

Examples of the types of appraisal issues that can arise in other TfL subsidiaries are given in the following two sections.

9.6 Museum

Business cases should normally demonstrate that projects have a positive net financial effect. However, the Museum is governed by legislation which specifies a "duty ... to provide and maintain suitable accommodation for ... relics". Therefore projects associated with keeping the museum accommodation in good repair may be justified on statutory grounds alone.

When projects are not based on this statutory requirement, and the business case shows a negative net financial effect, the appraisal should estimate what levels of various possible benefits would be required to make the net financial effect positive. These benefits might include:

- revenue from increased attendance levels
- revenue from increased use of the museum shop
- revenue from increased TfL travel to and from the museum
- revenue from improved "corporate image", or from increased knowledge of TfL services, leading to an ongoing increase in TfL travel
- revenue from increased entry prices

As with other London attractions, the long term trend is towards lower attendances because of steadily increasing competition. Therefore any estimated attendance level resulting from a project may be compared with whatever decreased attendance level the long term trend would predict.

An improvement will often be expected to lead to increased attendance, but to help pay for it, entry prices may also be raised. Here it is necessary to estimate the net effect on revenue, which will require an estimate of elasticity - the relationship between a percentage rise in price and the corresponding percentage change in demand. For this, TfL Business Case Development should be consulted

Business Case Development: Ryan Taylor, [redacted]

9.7 Ticketing Facilities

Projects to improve existing systems can bring benefits through reduced queuing time. Although this queuing is not part of the "entry to exit" journey time, any time saving has an equivalent benefit and should be calculated using the usual value of time / weighting.

9.8 Returns from Advertising

Studies into the impact on revenues of various forms of advertising have shown widely varying results. Past analysis carried out by LUL Marketing shows that some advertising campaigns, in retrospect, had relatively weak business cases, whilst others showed a good revenue return. One of

the key effects can be to accelerate the increase in demand for an improved service, which would otherwise take much longer to build up.

10. Benefits Overview

10.1 Overview

As a reminder, the objective of a business case is to inform and then document decision making. The basic questions that a business case must answer are:

(1) What is the case for change? The **Strategic Case** involves defining the investment objectives i.e. what are the generic benefits to be obtained? The Strategic Case can also illustrate the organisational strategies that are being used to evaluate the options such as Surface Outcomes, The Mayors Transport Strategy or The Six Priorities.

(2) What is the best public value solution? The **Economic Case** is to enable the best public value option to be identified. This involves identifying the best option and showing value for money of the different options. Identifying the best option can use several different methods. The traditional benefit to cost ratio or Net Financial Effect must be calculated and referred to, which is the basis for the quantifications throughout this manual. Multi-Criteria Assessment (MCA) is set out in section 11, where any supporting statistics can be present to support a defined and consistent strategy. This allows benefits that can not be monetised easily to be represented and taken into account in decision making. Value Management is set out in section 12 and can also be used to support option selection by showing the best strategic fit against objectives. Value for money is more difficult to prove than option selection. A benefit to cost ratio shows absolute value for money because monetised costs are set against monetised benefits. Where a good benefit to cost ratio does not exist, then the proposal is not necessarily poor value for money, it is just a case that the wide ranging evidence of the effects of benefits has to be present and the decision maker make an informed decision as to whether in their opinion the benefits are worth the cost.

10.2 The Need for Quantification

Whilst every business case must be justified on the basis of a rational and convincing narrative, the quantification of benefits demonstrates rigour and robustness in the consideration, and allows the business to more easily prioritise investment decisions.

All significant benefits and disbenefits should be quantified as far as is possible. Where benefits can be monetised, a direct comparison of the monetary equivalence to the investment costs can be made. This is termed the Benefit to Cost Ratio (BCR). Although the methods of calculation will vary from case to case, there are a number of standard methods which should be followed. This manual describes those most commonly required for TfL appraisals, including those covering non-investment decisions such as train and bus service changes, closures of secondary entrances or booking offices, changes in station opening hours etc.

In all cases it is helpful to lay out the calculations in the form of a spreadsheet so that it is easy to change data and test sensitivity. Examples of appraisals are included throughout this manual alongside the method that they use.

However, not all projects have a direct effect on passenger benefits. For example, a proposal to improve office productivity by implementing an IT system may have a number of effects on costs but will have no direct effect on passenger benefits, so only the financial effects analysis needs to be shown.

Research into new methods is on-going, and advice on methodology can be obtained from TfL Business Case Development.

Business Case Development: Ryan Taylor, [redacted]

10.3 Benefit Identification

The first step in producing a business case is to undertake investment objective / strategic driver analysis. This enables the true benefits of an intervention to be identified. A business case should describe the true benefits of a project and not just those that can be monetised into the benefit to cost ratio. If the true benefits are not described then senior management and external stakeholders will not have faith in the business case process and see it as a purely box ticking exercise.

Once the investment objectives have been identified, benefit mapping can take place which then leads to a clear view of how to describe benefits in a business case. Techniques such as Multi-Criteria Assessment (MCA) can then be applied and Management of Value (MoV) as well as being more informed about the benefits to monetise through Cost Benefit Analysis (CBA).

A business case should describe the most significant impacts first and continue describing them until the extra effort is deemed immaterial to the case. It is important that disbenefits are considered as well as benefits, including temporary disbenefits during the construction phase.

10.4 Principles of User Benefit Quantification

The quantification of user benefits is based on the concept of "willingness to pay" - that users would be prepared to pay for improvements to the service offered – which in turn enables a value to be placed on improvements.

Each type of benefit should be fully explained in the business case, and in particular where benefits are monetised, the elements contributing to the calculation of annual benefit should be detailed in the business case narrative.

Some travel attributes are not related either to the time taken or the number of trips made (i.e. demand, see following section). For example, safety benefits are calculated in terms of the number of incidents per annum which are avoided by improvements to sections of the system. The ways of calculating such benefits are given in the sections that follow.

10.5 Models Used To Quantify Benefits across TFL

10.5.1 Overview

To decide on the best value investment proposals, it is necessary to understand the likely impacts of these improvements to London's complex transport network and its users. In some cases it is possible to estimate these impacts in an intuitive way, but in most cases, investment in London's infrastructure would have both direct and indirect effects, and estimating the extent of these effects is an ambitious task. TfL maintains a set of modelling tools to estimate a wide range of impacts of changes to the transport supply.

Developing models to a sufficient standard, and using these models to inform the appraisal process, requires a level of expertise that should not be underestimated. Support in the use of modelling tools should always be sought from the relevant business area and model custodians.

Forecasts based on models are often a critical input into the appraisal process, but it is equally important to make the best possible use of observed data. This can include trends in traffic growth, information on travel behaviour and user preferences, and socio-demographic information from household surveys and other sources. Direct use of data, without modelling, does not present an explicit picture of the networks in possible future scenarios, but it is simpler to interpret and relatively free from the multiple (sometimes hidden) assumptions needed to create forecasts. Further information on data that is readily available, together with the Analytics function provided by Customer Experience, can be found in the sections that follow. A comprehensive study could combine hard data, information on observed patterns, together with model-based forecasts; the exact approach should be judged on a case-by-case basis. TfL holds a wealth of datasets that can facilitate such analysis.

At the end of each of the following sections, the commonly used models are outlined. These gives a brief overview of the processes involved in understanding the impacts of interventions and to estimate the relevant non-financial benefits. A summary of the models in common use to generate information for the appraisal process is included in Table 10-1 below. 'Appendix A: Models and Simulation Tools' provides greater detail on the individual tools, and also contains a glossary of key terms used.

There are also some plain English guides on the Internet:
http://www.tfl.gov.uk/corporate/publications-and-reports/strategic-transport-and-land-use-models

10.5.2 Summary of Commonly Used Models

Some of the models most commonly used across TfL, to provide inputs to business case studies, are described in Table 10-1 below. Additional detail is provided in 'Appendix A: Models and Simulation Tools'. Modelling tools are regularly updated, modified, introduced or superseded; the table is therefore not exhaustive. It is advised to consult with the custodians of the different tools regarding any application.

Table 10-1: Models Commonly Used to Produce Business Case Inputs

Objective	Model name	Features
Land use and transport interaction modelling	LonLUTI	Estimates land use changes, migration of population between areas, employment trends, economic trends
Demand modelling	LTS LoRDM LUTE	Models trip generation, mode split, trip distribution
Strategic public transport modelling	RailPlan DPTM MOIRA	Public transport assignment
Strategic highway modelling	HAMs	Highway assignment, cycling assignment
London Underground operational modelling	TSM JTC SSM HSRT TVM	Represents the detailed interaction between asset characteristics, and between assets and their users

	RES	
Tactical highway modelling	ONE	Operation of highway network, covering a wide area, but without change to trip making decisions
Micro-simulation highway modelling	VISSIM TRANSYT LINSIG	Detailed understanding of journey times and queuing at single junctions, or a localised network of linked junctions.
Bespoke strategic models	CEM CYPET	For specific project needs
Pedestrian modelling	LEGION PEDROUTE PEDS	Detailed relationship between infrastructure and journey time, including the effects of crowding
Connectivity assessment tools	WebCAT PTAL CAPITAL ATOS	To quantify improvements in connectivity
Emissions modelling	EAT	To assess pollution impacts

10.5.3 Optimism Bias in Benefits

There are no specific Optimism Bias levels for benefits, but the overstatement of benefits (or understatement of disbenefits) should be considered. This could be due to the effects of design or scope reduction, offsetting disbenefits being underestimated, projected demand growth rates not being achieved, or other projects effectively superseding the scheme. Where any of these outcomes are feasible, they should be the subject of sensitivity tests in the business case. Sensitivity tests are a very useful way of illustrating the potential for an investment to cease to be value for money. It is good practice to undertake these and provide the risks and ranges in a business case and investment authority paper to decision makers.

11. Multi-Criteria Assessment (MCA)

11.1 Overview

Multi-Criteria Assessment (MCA) is technique for capturing the wider benefits of a project and presenting them through a recognised strategy framework.

The Strategic Assessment Framework (SAF) is the single standard TfL multi-criteria analysis tool to be used to asses the contribution of a project, programme or portfolio to various organisational strategies.

Multi criteria analysis techniques similar to SAF are a standard appraisal approach used to capture impacts that are wider than just those entering formal cost benefit analysis. Impacts are grouped into various categories for presentational purposes.

SAF should be used for:

- Assessing contribution to the Mayor's Transport Strategy
- Assessing contribution to Surface Outcomes
- Assessing contribution to economic growth
- Assessing the contribution to other narratives developed in recent business planning processes such as: Living, Working, Growing; The 4 Pillars of the TfL Story; the 20 priorities introduced in 2014; and the top 6 priorities defined by the Executive Committee.
- Sustainability assessment for optioneering
- Health Assessment (replacing some templates used previously)

In the early stages of a project / programme or portfolio, SAF can be used for optioneering. Throughout the lifecycle it should then be used to continually monitor the preferred option for contribution to those organisational strategies to allow intervention if the benefits set out are no longer meeting original expectations.

By filling in the single input sheet in SAF, all of the assessments above will automatically be produced in their standard format and a separate exercise will no longer be required for each. Using the input sheet in SAF also prevents any assessment contradicting any other.

SAF should be used alongside other tools such as lifecycle value software (e.g. SALVO, used primarily in asset management areas) and value management techniques (which is also used for option selection). However SAF is required for all projects, programmes or portfolios and the justification in a business case should revolve around a recognised set of criteria as set out in SAF.

Relevant sustainability issues such as environment, social and economic should be considered by reviewing the proposed deployment of resources (revenue or capital) using the Strategic Assessment Framework. This should be used for all sustainability assessments on projects with an estimated final cost (EFC) greater than £10m. It is good practice to undertake multi-criteria assessments using SAF for all significant projects, perhaps as little as £1m EFC, so that the full range of impacts have been considered at an early stage. The conclusions, including possible changes to scope, can then be incorporated into project planning earlier than if the impacts were not considered until a later stage in the project lifecycle.

11.2 SAF is useful at all lifecycle stages:

- Before Stage 1: Defining what objectives are expected to be affected by the intervention to help determine whether a project should be initiated.
- Stage 1: Strategic driver analysis and benefits mapping should be an early activity in producing a business case. The results should be used to inform SAF, and any resulting SAF exercise should feed back to refine strategic driver analysis and Benefits Mapping. This then frames the whole rationale for the intervention that is explained in the business case from this point on rather than explaining the basis for the cost benefit analysis (which should be included but is not the starting point).
- Stage 2: SAF can be used to move from a long list to a short list of options (this may occur in stage 1) and can be used to refine the options further.
- Stage 3/4: SAF should be kept up to date for the preferred option as costs and benefits evolve and a revalidation of the single option decision should be made if significant changes occur.
- Stage 5/6: SAF should be used to monitor project delivery to ensure that the benefits set out at the end of stage 4 are still expected to be delivered. The information gained from benefit realisation monitoring, tracking and assessment process should be fed through to an updated SAF. The sustainability and health assessments in particular include a record of agreed mitigation actions, which should be monitored and followed up during delivery.
- Beyond Stage 6: As above, SAF should continue to be updated using information from the benefits realisation process to help evaluate / illustrate whether the benefits expected at the end of Stage 4 have been delivered. A wider narrative on expected benefits over the whole lifecycle (from the earliest versions) should be included to draw lessons and help improve future forecasting ability.

Significant impacts should be explained in the business case narrative – either positive or negative. SAF should be kept up to date through the lifecycle and archived for all lifecycle stages and major changes.

11.3 Completing SAF

Completing the SAF input sheet requires sufficient knowledge of the options being assessed. The recommended approach is through a workshop attended by key contributors who jointly have all the necessary knowledge. Agreeing what to feed into the input sheet is best done through dialogue during the workshop. It is also recommended to include in these workshops individuals who have worked with SAF before to ensure consistency between the different projects or programmes.

The SAF input sheet contains a set of criteria, and evidence should be entered for each. A rating between -3 and +3 should be entered matching the evidence provided. It is not acceptable to provide ratings only as the credibility of the assessment depends entirely on whether the textual evidence is sensible. It also depends on whether the conversion of the evidence to a rating is fair. Detailed guidance is provided within SAF.

SAF does not add up all of the evidence into one final rating as this would not reflect the complex balance between the various assessment criteria.

11.4 SAF Links and Contacts

SAF Intranet page: http://source.tfl/OurCompany/11717.aspx

- *Surface Outcomes and SAF support within Surface:*
  Tanya Durlen, [redacted]
- *SAF use within Rail and London Underground:*
  Kirsty Baker, [redacted]
- *SAF technical support:*
  Ben Warwick, [redacted]
- *SAF methodology:*
  Ali Inayathusein, [redacted]
- *Sustainability Assessments in SAF:*
  Helen Woolston [redacted]
- *Health Assessments in SAF:*
  Lucy Saunders, [redacted]
- *Strategic Driver workshops and benefits mapping:*
  Ben Ganney, [redacted]

11.5 Quantifications Supporting MCA

Sections 14 - 19 describe the benefits most often found in transport business cases and these can also be used to support MCA. These need to be supplemented by further wider statistics however to provide evidence for other significant impacts. It is reasonable to use any relevant statistic to provide evidence for an effect but over time some of these will need to be standardised with robust best practice approaches set out to ensure that there is a consistent and high standard approach being used. Some example quantifications supporting MCA:

- Number of homes access is opened up for.
- Number of jobs that have been redistributed from other areas.
- Standard business Key Performance Indicators (KPIs).
- Customer satisfaction scores.
- Deprivation Indices.

12. Value Management

12.1 Overview

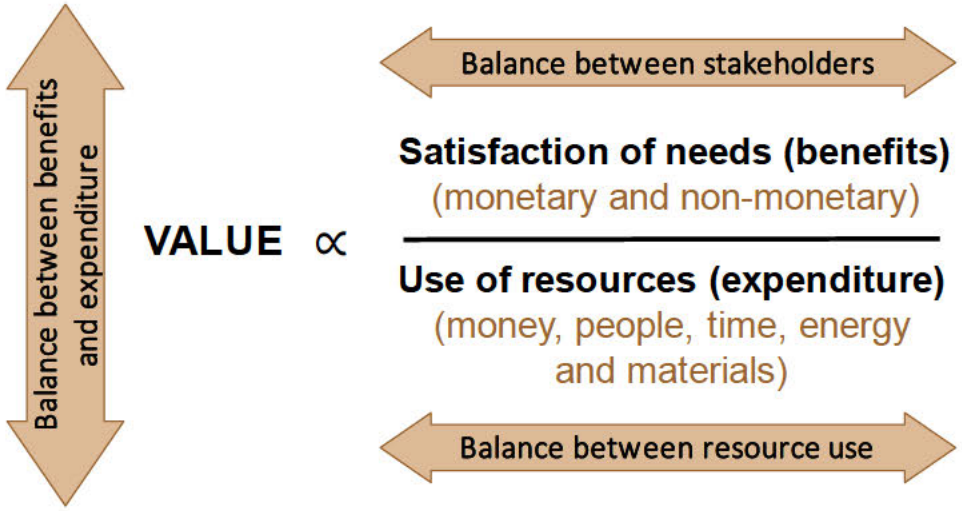
An effective Business Case focuses attention on the delivery of outcomes and benefits, which are of value to the business as a whole. Failure to manage the business case, keep it live and make the necessary value based decisions are one of the main causes of project and programme failure.

12.2 What is Value?

Value is subjective, with different people applying different criteria to assess whether they are getting good value. Value is not just a matter of minimising cost and when applied in the project management environment, is effectively a measure of value for money.

According to the definition of Value given by EN 1325-1, value may be described, in the context of Value Management (VM), as the relationship between the satisfaction of need and the resources used in achieving that satisfaction.

Value can be represented as the ratio of satisfaction of needs (represented by monetary and non-monetary benefits, which bring the value) to use of resources (represented by expenditure in money, people, time, energy and materials – usually reflected in measurable cost). A value methodology focuses on improving value by identifying alternative ways to satisfy those needs.



Value is not absolute, but relative, and may be viewed differently by different parties in differing situations. Generally achieving good value requires balancing a series of conflicting parameters to arrive at an optimum position.

The optimisation of value is achieved by balancing the amount to which needs are satisfied against the whole life resources utilised in so doing. It is important to realise that value may be improved by increasing the satisfaction of need even if the resources used in doing so increase, provided that the satisfaction of need increases more than the increase in the use of resources.

When considering value, there is also a need to recognise that stakeholder perceptions change over time. This explains why a project started on the basis of agreed objectives might be delivered in alignment with those, but fails to impress or satisfy its stakeholders as much when it is completed

years later. This reinforces the iterative approach often taken within TfL in applying benefits, risk and value management. Objectives need to be checked or revalidated at logical intervals to provide the opportunity to change priorities within the project to optimise its outcome and maximise stakeholder satisfaction.

Link to the new Lifecycle Value handbook:
http://onespace.tfl.gov.uk/lu_/cms/pmf/SIGs/TfL%20PPM/TfL%20PPM%20Output%20Library/H%20Lifecycle%20Value%20Handbook.docx

12.3 Value management

Value Management (VM) and Benefits Management can be seen as mutually supportive disciplines and as such are most effective when they operate in an integrated manner. They are concerned with delivering value for money in relation to ensuring:

- During initiation, each initiative, represents the optimum use of available funds
- That TfL can easily demonstrate that the case for change will deliver value to the key stakeholders
- The management of benefits is delivered as cost effectively as possible. In short, the benefits of benefits management should exceed the cost of benefits management

Value management helps to identify the value drivers behind the project, programme or delivery portfolio, based on those identified by the different stakeholders. It then uses this information to check that the proposal will add value to the organisation based on these drivers. The value drivers may differ when considered from project, programme or delivery portfolio levels.

The aim of value management is to resolve differences about project objectives and achieve a common consensus among stakeholders. This can only be done with active participation of the key stakeholders. Surface Transport, in particular, often experience very diverse views from stakeholder groups towards some of their schemes and VM offers a way of trying to get those stakeholders to recognize different perspectives and agree a way forward. As London Underground has greater ownership of their assets, VM is more often about establishing the priority of work amongst the different internal stakeholders. VM does not profess to find optimal answers; it is solely concerned with establishing a common decision framework around which participants can think and communicate.

12.4 Techniques

Link to the new Lifecycle Value handbook:
http://onespace.tfl.gov.uk/lu_/cms/pmf/SIGs/TfL%20PPM/TfL%20PPM%20Output%20Library/H%20Lifecycle%20Value%20Handbook.docx

Whilst all objectives are important and should be delivered in full for a successful outcome, some will be more important than others. **Value drivers** are used to describe those things which contribute to the value of the project and are readily understood. This reflection of criticality is indicated by weighting the relative importance of each value driver. To provide a true reflection of the requirements for success, value drivers should be independent of each other.

A **value tree** is a diagram that shows the relationship between, and the hierarchy of, value drivers. Once a value tree has been developed, it is possible to prioritise the relative importance of the primary value drivers. The resulting diagram is called a **value profile**. Because many of the

judgements in prioritising value drivers may be subjective (albeit balanced by involvement of key stakeholders) it is good practice to apply sensitivity analysis to the finished model.

The value profile may be used to quantify value and provide a means of analysing current performance against desired performance, thus focusing attention on where effort needs to be applied to improve value.

This exercise can be conducted at any level from portfolio to project. At a higher portfolio or strategy level, the value drivers should match a consistent and recognised strategy such as the Mayor's Transport Strategy or Surface Outcomes. At the project level they may be bespoke drivers of that individual project.

Often it is necessary to choose between a few options to assess which provides the best value for money. When choosing between many different options, how is it possible to decide on the best way forward? This is especially challenging if the choices are quite different from one another.

The **value index** provides a measure of how well an option or project satisfies an individual value driver or the aggregate of all value drivers. It represents a measure of customer satisfaction. Once the value profile has been formed, the team needs to agree an appropriate metric for each value driver. For each metric the team needs to agree a range, usually from 1 to 10 to provide a relatively simple method of assessing performance.

The product of the value driver weighting and the performance rating provides a number which is known as the **value score**. The sum of all value scores across all value drivers is the **value index**. By adopting the ranges of 1-10, the value index must lie between 100 and 1000. As a rule of thumb, a value index of 350 or less indicates poor performance, whereas an index exceeding 750 is regarded as good. Using current Cabinet Office guidance, the value index is a relevant option evaluation measure when money is unlimited.

Primary Objectives (Value Drivers)			Smooth traffic flow and achieve reliable journeys to and through the networ	Create safer junctions for cyclists and other vulnerable road users	Enhance London's image as a leading city for cycling and active travel	Facilitate an increase and modal shift to cycling (and walking) by creating better infrastructure	Improve the urban realm and make the road network a more pleasant place to use/be	Address severance and create faster, simpler journeys for cyclists and pedestrians	Develop innovative solutions for London's roads	Spare	Value Index	Value for Money Ratio	Perf. Rankin
Option	**Whole Life Cost (£m)**	**Relative Importance (%)**	13.6%	27.1%	15.3%	5.1%	6.8%	8.5%	23.7%	0.0%			
1. Off-carriageway	25	Performance Rating (1-10)	9	2	1	2	2	2	1	0	255.93	102.4	1
		Value Score	122.03	54.24	15.25	10.17	13.56	16.95	23.73	0.00			
2. On-carriageway, build-outs, raised entries	400	Performance Rating (1-10)	8	8	5	3	4	4	3	0	549.15	13.7	2
		Value Score	108.47	216.95	76.27	15.25	27.12	33.90	71.19	0.00			
3. Continental roundabout	900	Performance Rating (1-10)	2	7	9	7	3	5	9	0	666.10	7.4	3
		Value Score	27.12	189.83	137.29	35.59	20.34	42.37	213.56	0.00			
4. Signalised crossroads	900	Performance Rating (1-10)	1	3	1	2	1	3	1	0	176.27	2.0	4
		Value Score	13.56	81.36	15.25	10.17	6.78	25.42	23.73	0.00			

The **value for money ratio** shows an assessment of relative value for money, taking into account whole life costs.

Whole life costs and not simply capital costs should be the basis for value decisions. There have been a number of examples where options with higher initial capital costs have been approved due to the lower cost of ownership. For example, the rolling stock procurement approach used for New Tube for London (NTfL) has been very conscious of aspects such as future energy costs and how decisions taken early can have a knock-on effect in the long term.

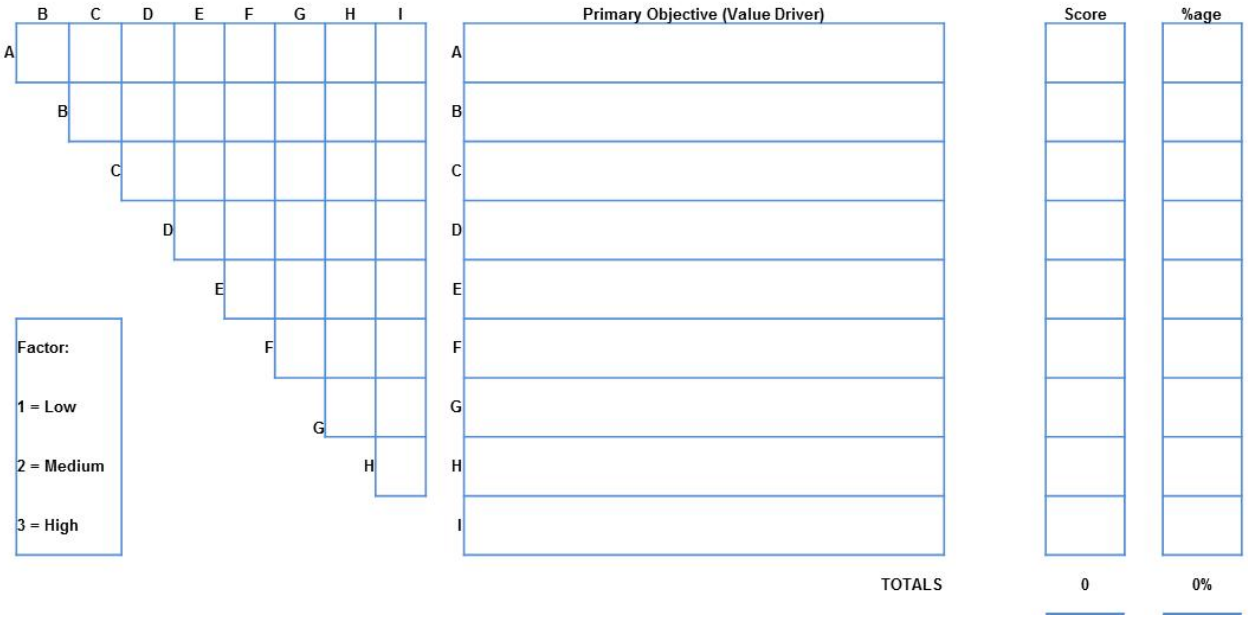
To calculate the value for money ratio, the value index should be divided by the total estimated lifecycle financial impact, to provide a value for money ratio. A project with a very high value index may not give the best value for money if it costs significantly more than an alternative that provides only slightly lower performance.

It is also essential that if financial savings or additional revenue are one of the value drivers for a project, that they are taken out of the top of the value ratio and entered into the whole life financial impact number on the bottom. The whole point of this is to create a number that is as similar as possible to a benefit to cost ratio. Robustness principles still hold for these alternative statistics and consistency across the organisation is important.

Paired comparison

Paired comparison analysis helps to work out the importance of a number of options or drivers relative to one another. This makes it easier to choose the most important problem to solve, or to pick the solution that will be most effective. It also helps set priorities where there are conflicting demands on resources. The tool is particularly useful where you don't have objective data to use to make decisions allowing you to compare different, subjective options.

The purpose of paired comparison is to assess the importance of each of the attributes to the respondents and to determine the weights the respondents attach to the different levels of the attributes. At the simplest level, paired comparisons are made by each respondent among a set of items using a binary scale (1-3) that indicates which of the two choices are most preferred, or whatever other judgement the respondent is asked to make in comparing the two.



Many of the assessments resulting from the value management process will be subjective, but the essential characteristic of value management is that the decisions are a consensus view of everyone involved in the process.

In accordance with Pathway, the scope of the value process and in particular the application of the techniques will vary according to the size and type of project or programme under consideration and the business area where it is being implemented.

The tools and techniques can be applied during any stage of the development lifecycle, as you move through from stage to stage and the focus will evolve, but typically, the greatest benefits and resource savings are achieved early. At this point, the basic information may have been established, but major design and development resources have yet to be committed.

Using value management later in the lifecycle is often a question of balancing the variables to maximise value. It builds on the information generated to assist in making decisions; for example, the selection of options, based on value, informs the project and design briefs and provides a mechanism to enhance the benefits whilst reducing or making better use of resources.

Function analysis provides an opportunity to assess which functions offer the most scope for value-adding change, leading to greater creativity.

Two key questions that may be asked at this stage are:

- Why are we doing it and what are the alternatives?
- How can it be done differently and/or better?

The tools and techniques described can be applied more than once. Early application helps to get started in the right direction, and repeated application helps to refine the direction based on new or changing information. For example, techniques may be applied as a quick response to address a particular problem.

12.5 Value Management Through Project Delivery

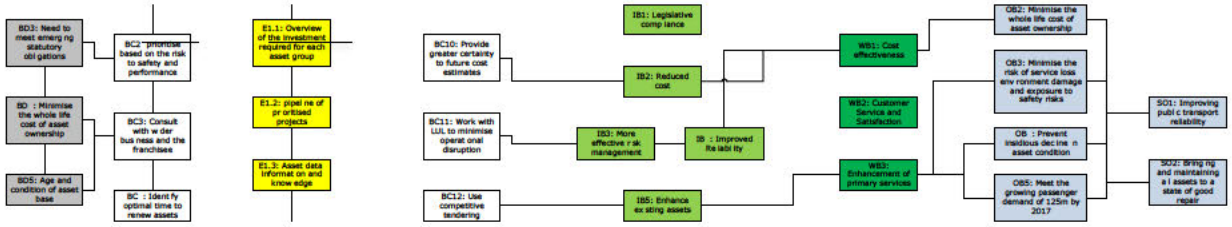
The greatest opportunity to influence value delivered is at the planning and design phases of asset life as once the asset is installed, most of the lifecycle costs and benefits become fixed. It is therefore important time is taken in these earlier project stages to identify the solution that delivers greatest value, by balancing cost and benefits. When determining the value of different options, it is important, that non monetised benefits and project drivers are considered, rather than just focussing on the resultant BCR. This can be done through the use of Value Management Assessments (or Mulit-Critera Assessment see section 11).

Benefits can often change as a project progresses, so even if the project delivers on time and to budget, the value delivered may reduce unless benefits are regularly reviewed. It is therefore important to review both costs and benefits at each stage gate to evaluate changes to ‘value’. If costs increase and / or benefits decrease too much, the project may need to be stopped, or de-scoped, so budget can be diverted to higher value projects.

Table 12-1: Template for Tracking Life Cycle Value Changes

	Gate 1	Gate 2	Gate 3	Gate 4	Gate 5	Gate 6	Benefits Realisation
Project Capex £							
Project Risk £							
Net Future Opex £							
Net Future Capex £							
Net Revenue £							
Net Financial Effect £NPV							
Monetised Benefit £NPV							
Lifecycle value:							
BCR							
NPV							
Non Monetised Benefits							

Benefits Mapping



Link to the benefits guidance handbook:
http://onespace.tfl.gov.uk/lu_/cms/pmf/SIGs/TfL%20PPM/TfL%20PPM%20Output%20Library/H%20Benefits%20Handbook.docx

Benefits (and dis-benefits) do not typically happen in isolation. The realisation of some benefits will typically depend on activities and projects, organisational changes, or on the realisation of other benefits. These dependencies will play an important part in the prioritisation of activities, so it is important to recognise and identify them.

The purpose of benefits mapping is to provide a structure for identifying and mapping benefits. There are a variety of techniques available, which fundamentally link outputs delivered by the project/programme to intermediate or end/wider benefits. The intermediate benefits are identified to be measurable, with their realisation reflecting the achievement of the wider benefits, which contribute to both internal and external Strategic Objectives. The dependency relationships in a benefits map show how project outputs ultimately lead to the achievement of strategic objectives.

In essence the diagram is a route map of how change and new capabilities delivered by the project/programme lead to the creation of enhancement of benefits to the business, customers and staff. The inter-relationship and dependencies between project outputs and business benefits are represented using a cause and effect model. This is often referred to as a Benefits Dependency Map.

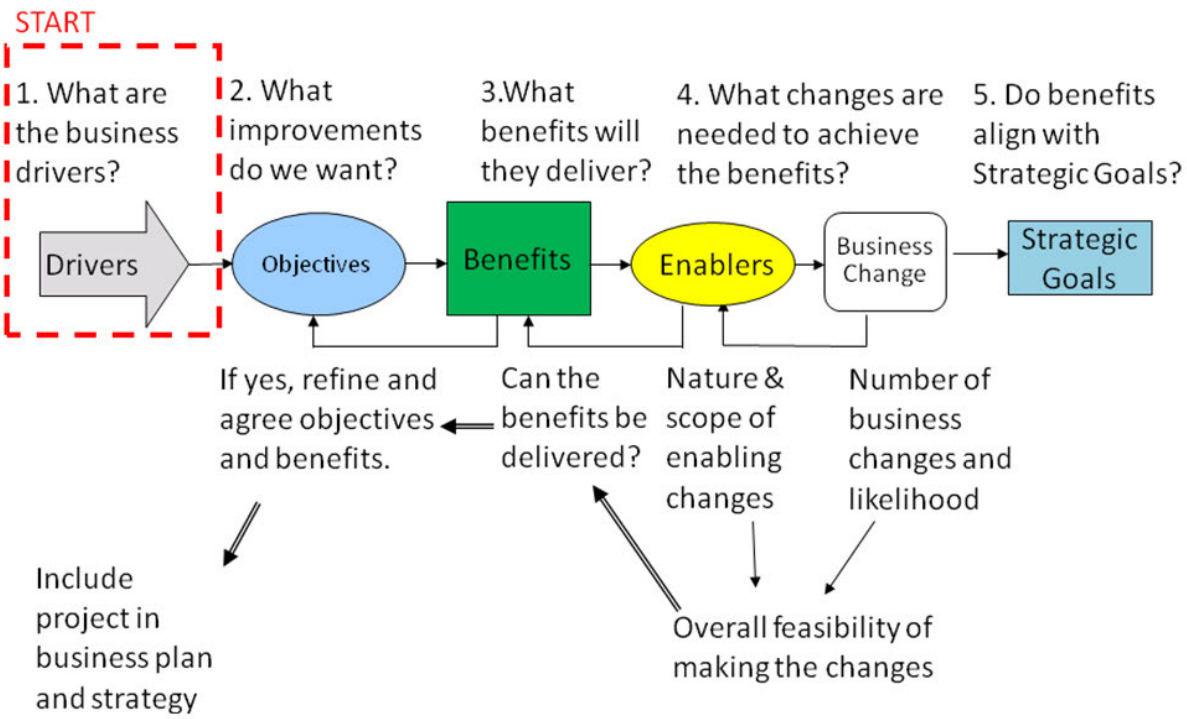
Benefits mapping is typically used as a tool to support early benefits identification. Benefits identification is an iterative process and may require several attempts to agree a final version and

so should remain flexible and open to new and emerging benefits and dis-benefits. It is often the case that as benefits are worked through some of the existing benefits will cease to be relevant or meaningful and therefore benefits should be re-visited, critically evaluated and, where necessary, amended on a regular basis.

One of the key benefits of benefit mapping is often said to be the active engagement and support of key stakeholders in the process of identifying the key objects on the map through workshops and dialogue.

The main objective of a benefits workshop is to help illustrate the overall benefits of the project/programme on a one page diagram. This diagram can amongst other things act as an important communications tool to assist the Sponsor in demonstrating the improvements and getting buy-in and support for the change. During the project, the diagram can be used as a scorecard to demonstrate progress and there have also been occasions where benefits maps have been used to assess benefits realisation post-project.

Benefits maps can be used throughout the life of the project/programme to analyse the impacts on benefits caused by changes in direction or changes in strategy as a whole.



13. Demand

13.1 Overview

A lot of the benefits in the sections that follow are based on a number of people affected (trips made) multiplied by a monetary valuation. Estimating the number of people affected is therefore half of the problem in deriving a total benefit.

It is important to make sure that the total number of people affected is calculated robustly. There are different sources for this such as:

- Counts and Surveys (automatic or manual).
- Revenue information.
- Modelling forecasts.

Revenue information may not include staff, police and those without tickets. In addition, all journeys, including those originating on Network Rail (and dealt with through the clearance procedures) and all journeys made on period and return tickets are allocated to the stations and sections of line on which each actual journey takes place.

Beyond the standard counters, there are some innovative ways of estimating demand. CCTV, face or people recognition technology or weight sensors on vehicles can automatically detect the numbers of people. This can even provide real time information on loadings.

Modelling forecasts are built up from social, economic and demographic data and are useful for understanding how background demand will change over time.

It is also important to understand the differences in terminology.

- Entries and Exits are purely numbers of people moving through gates and may not be reconciled because some stations are open and it is possible to enter or exit without passing through a gate. These are usually automatically counted unless a survey is undertaken.
- Boarders and alighters should reconcile to the same figure in a network over a day or longer time period because the same number of people who get on a service, must get off. On shorter time periods this may not be the case as people may board during the peak and alight during the inter-peak.
- Trips are a journey from one origin to a destination for a specific purpose.
- A trip stage or journey leg is a part of a journey from or to an origin, destination or place of interchange.
- Passengers / People – individuals making a journey, the most common unit for a monetary valuation.
- Vehicles – may carry more than one person so the monetary values will be different.

- PCUs – Passenger Car Units – a common unit of space on a road. For example a car, bus, truck or bicycles all have different PCU factors for the amount of space they take up.

Demand data may already be combined into a demand matrix or data set (for example from LTS, Railplan, RODS or BODS). These can tell us the origin and destination movements through a network, or may tell us the specific movements through a road junction or the passageways of a station.

13.2 Generic Demand Advice

It is essential to get a good understanding of how many people are using the area affected by a scheme. Rules of thumb such as the average number of people on a bus should not be being used. For public transport services there is a wealth of information to use to get a good view on how many people are currently using affected services. For vehicles, walking and cycling it is very difficult to get a good estimate and the demand patterns can change substantially from area to area over the course of different time periods. Because of this, basic count or demand information must be obtained in order to robustly estimate benefits. This can then be used to annualise benefits from modelled periods to other times.

It can not be assumed that all people will get the same level of benefit in all time periods. For instance, a congestion or crowding relief scheme may only benefit peak users as there could be adequate free flow capacity during other periods.

Thought on how demand is assumed to change over time is also needed. It is often not sufficient to just model one year and assume that the benefits can apply to all other years. The overall consistent rule is that demand should change in line with forecasts being produced by the LTS demand forecasting specialists (usually for the 20x1 and 20x6 years each decade) unless there are specific local trends that deviate away from this. Local trends should not be extrapolated beyond the final LTS forecasting year and should be curtailed if it is thought that that trend could not possibly continue long term.

Sensitivity tests around demand assumptions are thoroughly recommended as this is often an area of significant uncertainty.

The appraisal requirements above are just one part of a sponsor's requirements. It is also necessary to understand how much demand a scheme could accommodate. This may be necessary for both safety reasons and to understand the future proofing of the proposal. One off events could result in demand peaks on certain days far exceeding the usual demand flows and the limit of infrastructure put in place should be understood.

13.3 Rail and Underground Demand Data

Station and line usage data, are available from LU Transport Planning and from the Customer Experience Directorate.

Underground demand: Sarah Scott [redacted]

Ticketing Data: Customer Experience Analytics Managers, [redacted]

LUL carries out annual programmes of passenger counts and large scale surveys of travel patterns, such as the Rolling Origin and Destination Survey (RODS). Gateline counts, Oyster records, and bespoke surveys at ungated entrances are also used. These sources generate a wealth of historical

passenger demand data, which is available to support business case development. Available data varies from network level to individual stations, from annual figures to data by 15 minutes.

LU Transport Planning: Howard Wong, [redacted] in the first instance.

13.3.1 LU network demand

Rail and Underground Transport Planning have developed a demand data tool, PRESTO, to extract and compare historical data for LU stations and lines. This is easy to use and significantly saves time finding the right information.

The official network passenger journey figures (provided by Finance Revenue Analysis) is different to the number of passengers entering the system through station entrances/exits, because passengers entering can use non-LU services (e.g. Stratford) and LU passengers can also enter the network without passing through the entrances (e.g. Highbury & Islington).

The number of passengers entering and exiting LU stations, on a typical day, is available by 15 minute time segment.

There are more boarders across the network than the number of passenger journeys because a journey can involve more than one train as passengers makes interchanges. RODS Data can be used to understand the number of boarders across the network. The origin-destination matrix between stations across the network and route choices is also available.

13.3.2 LU line demand

The Rail Origin-Destination Survey (RODS), conducted by LU, provides passenger routing information and which lines passengers use to complete their journeys. With that LU can work out how many passengers travel on each line, by individual line section. This information offers insight in the loading and crowding across a line, and key locations where many passengers get on and off trains.

The RODS Data is available to all TfL staff. This link can be used to access:

- The annual number of boarders/demand for each line.
- Typical line load between two stations on each line is available by 15 minutes time segment, for weekday, Saturday and Sunday.
- Distance travelled on each line in terms of passenger-km and numbers of boarders and alighters for each line at each station.
- Origin-destination matrix between stations on the same line is also available, please request through LU Passenger Demand Queries.

13.3.3 LU station demand

LU holds entry and exit counts representing a typical day, taking into account gateline entry/exit counts across the whole network, and bespoke survey results at locations where there are no gates. Known as the Annual Counts data set, it is available in 15-minute periods, for weekday / Saturday / Sunday, for each station. Annualised station entry/exit count data is also available.

Latest entry/exit counts for each station and the annualised figures are available within the Counts Data.

Movements within a station (e.g. from ticket hall to eastbound platform) are available within the RODS Data

13.3.4 London Overground and Tramlink demand

The Overground Origin Destination Data (OODD) is a dataset of information about passenger journeys on the Overground Network. A range of data sources have been used to compile this dataset including Oyster PAYG data, passenger counts, and gateline data. The data has been validated against data available from the Overground Loadweigh system.

The Tramlink Origin Destination Dataset (TODD) contains similar information about passenger journeys on the Tramlink Network.

13.3.5 DLR demand

DLR demand is recorded through Automatic Passenger Counters at all stations. Historical entry/exit data is stored in 20-minute intervals. This can be requested through LU Passenger Demand Queries.

13.4 Surface Demand Data

Surface Transport also has a wealth of demand information.

13.4.1 Bus Data

Bus demand data is available from Buses and from the Customer Experience Directorate.

Bus demand: Customer Experience Analytics Managers, [redacted]

Bus demand: Alex Phillips, [redacted]

Some generic bus data is available on the Internet publications and reports section:
http://www.tfl.gov.uk/corporate/publications-and-reports/buses
Contains usage by route over the past four years as well as other data.

http://www.tfl.gov.uk/corporate/publications-and-reports/buses-performance-data
also contains other useful data.

Bus data is also available from the BODS team. This includes:

- Origin – Destination movements by route, location or region.
- Passengers by route, location, or region.
- Patterns over time.
- Future forecasts.
- Bus station usage.
- Passenger profiles by:

- Ticket type
- Journey purpose
- Frequency of use
- Age / Sex / Social Economic Group / Working status

- Service Data, e.g. kilometres operated as % of scheduled
  - Average waiting time (QSIs)
  - Average passenger load per bus
  - Average fare per km

Alex Phillips, [redacted]

13.4.2 Other Motorised Highway Mode Data

There is a significant database of usage for other highway modes from counters, surveys or pre-processed information in models. This includes:

- Link flows by vehicle type / aggregate / by time period
- Turning movements by vehicle type / aggregate / by time period
- Forecast growth in traffic

Data: Andy Emmonds, [redacted]

One Model: Andy Emmonds, [redacted]

13.4.3 Cycling & Walking Data

There has been a lack of data on cycling and walking demand. Some initiatives are underway to address this including:

- Cycling demand forecasting work in Group Planning
- SITS programme – better automatic counters to replace SCOOT
- Ongoing cycling monitoring
- Walking evidence database

Cycling Demand Forecasting: Ali Inayathusein [redacted]

Cycling Data: Joe Stordy, [redacted]

Count Data: Andy Emmonds, [redacted]

13.5 Customer Experience Analytics

Customer Experience Analytics is the custodian of TfL's ticketing and journey data. Customer transactions are recorded on a central system, which can be interrogated to provide historical records of Oyster and magnetic ticket sales, discount card usage, Oyster card credit, journey patterns, station and bus route demand, and various other metrics. Although Analytics does not provide a modelling service as such, the data available can support scenario modelling by demonstrating what actually happened when the same or similar scenarios occurred in the past. For example, by tracking passenger movements over time using Oyster and Contactless Payment Card data (which accounts for around 90 per cent of trips), it is possible to show the effect of delays, diversions and other interventions on customer demand and behaviour.

Full sales and journey data is only held for a period of 8 weeks, with some degree of summarisation after this. For sales, after 8 weeks the exact time of transaction is replaced with the day of transaction, while for journeys, after 8 weeks the data is aggregated and cannot be linked to individual cards. To illustrate this, an analysis of data from the past 8 weeks could show, for example, how the users of a particular station changed their travel patterns in response to a closure of the station; whereas an analysis of data from more than 8 weeks ago could only show the total demand for surrounding stations or bus routes without being able to pinpoint the users of the closed station.

Also note that because customers are not required to 'tap off' buses, actual bus journeys are not recorded. However, Analytics has developed a tool called Origin Destination Interchange (ODX), which predicts bus journey behaviour based on interchange taps at stations and on other buses. ODX can be used to estimate route loadings, bus stop usage and patterns of multi-modal travel.

Customer Experience Analytics Managers [redacted]

13.6 New demand arising from external changes

Increases in demand can arise from service improvements, or sometimes from external changes without any alteration to TfL's services. In the case of external changes (e.g. new office blocks, a new shopping centre, etc.) the increased demand is usually predicted by estimating the number of new commuting, shopping or leisure trips that will be generated, and multiplying this by the proportion of trips likely to be made using TfL's services (modal share).

However, it cannot be assumed that this will be the net increase in TfL trips. For example, many trips to a new shopping centre may simply replace TfL trips to other shopping centres. In the worst case, a new development with good parking facilities in outer London could conceivably result in a reduction in TfL trips, if companies relocate from inner London, where there are few parking facilities for commuters. But since it is reasonable to expect some net increase following most new developments, the working assumption shall be that half the predicted number of new trips are a net gain to TfL, unless there is evidence for an alternative assumption.

13.7 Modelling Inadequate Existing Layouts With Future Demand

For many schemes – particularly London Underground station congestion relief schemes – it has been recognised that the do-minimum (or do-nothing) layout does not work with the predicted future demand. In reality this means that operational controls will need to be put in place to ensure the safe running of the site. In estimating congestion relief benefits of a do-something design however it will overstate the benefits if the do-minimum model is allowed to contain unrealistic congested time. This occurs because no re-routing can take place in the model (to say,

an alternative nearby station) because it is just the station concerned that is modelled. In the absence of a network model that can adequately reflect this re-routing, it should be assumed that demand is scaled back to the point that the do-minimum station can just about cope. To these time benefits, a manual adjustment of the capped demand should be added that makes an assumption about where the demand is diverted to and the additional time involved. This can then be added as a manual increase in the base time impacts. This is not a simple task and should be considered carefully. It may be the case that other nearby stations can also not cope with the additional influx.

13.8 Annualisation Factors

Deriving robust annualisation factors to convert modelled benefits to annual is an important step in undertaking robust cost-benefit analysis.

Some annualisation factors are provided in the journey time calculator: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

There is also a section in the BCDM Data Book: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

However each case must be considered on its own. This should take into account what periods are being modelled and what periods those modelled benefits are assumed to also transfer to.

The day (or longer) to annual factors are fairly certain. Intra-day annualisation factors are more difficult as they can vary wildly from location to location.

It is recommended that if data does not already exist, at the very least counts are undertaken and profiled over the period from 7am to 7pm for the different user classes such as motorists, HGVs, OGVs, Cyclists and Pedestrians. This will allow robust bespoke annualisation of demand.

Annualising just based on demand profiles may still not be sufficient. It may be that benefits depend on the level of crowding or congestion and that benefits as modelled in the peaks are not applicable to other time periods. An inter-peak model could be used to model uncongested time periods and this is more appropriate to extend to other uncongested time than to extend peak model results.

13.9 Demand Modelling Tools

The term “demand modelling” generally refers to the standard four-stage modelling process (see Appendix A.6 for more information on this). The assignment model, at the bottom of the four-stage hierarchy, is sometimes developed separately due to its high level of network detail, and plugged into the demand model. Therefore, when describing a demand model, it is common to focus on the trip generation, mode choice and trip distribution elements, and leave the detail of the assignment model for a separate discussion.

NB: the assignment model is often used independently, especially in relatively small-scale studies, where it can be assumed that an intervention will only affect route choices, and the demand matrix remains constant. By contrast, a demand model cannot be run without assignment models plugged into it as part of its iterative loop, to provide travel costs between origin-destination pairs.

TfL's demand models are strategic in that they cover the whole city and beyond, primarily examining major trends at a high level rather than the detailed performance of local areas within London.

In summary, demand modelling is not always necessary, depending on the scale of the proposed infrastructure change, and when it is undertaken, generates input for other tools which in turn provide the benefit forecasts to inform the appraisal process.

Tools: LTS, LoRDM, LUTE

14. Time

14.1 Overview

Time elements are often the most significant area of impact in business cases, so we must estimate them as accurately as possible. We must also estimate as best we can because transport efficiency is the bread and butter activity for TfL. Stakeholders EXPECT TfL to consider these impacts, different types of time impact and the different users who may be affected.

Quantifications of time savings are based on behavioural values of time which are derived from observation of passenger trade-offs between saving time and spending money. Values are based on research by TfL and the DfT. The current values are given in the BCDM Data Book: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

Passengers value time for the various stages of a journey (e.g. walking, waiting, travelling) differently and so weighting factors are applied to the component elements of the trip to reflect the extent to which passengers like or dislike particular stages of a journey. Weighting factors are set out in the BCDM Data Book: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

The weighted time saving per passenger is then multiplied by the number of passengers and the value of time to calculate the total benefit (expressed in £s).

Most calculations of this nature will use computer models to calculate journey times, congestion etc. (see Section 10.5 and Appendix A: Models and Simulation Tools).

In addition to changes in mean journey time, changes in reliability, as measured by standard deviation, may be monetised. A reduction in the standard deviation of in-vehicle journey time for a public transport mode is valued as if it were a reduction in the mean journey time. (In the case of waiting time, a reduction in standard deviation would be weighted in the same way as for mean journey time.) For private transport, a reduction in standard deviation of journey time is valued at 0.8 times the same reduction in mean journey time.

If significant time disbenefits during construction occur, then an attempt must be made to estimate them and include them in the cost-benefit analysis.

14.2 Estimating Time Impacts

There are several different ways to estimate time impacts. In the early stages of analysis, then a multi-criteria approach may be sufficient – so just rank options or projects with a low, medium or high, positive or negative impact. A basic or rougher informed estimate can also be estimated using the journey time calculator spreadsheet see 14.7.1.

Beyond that, then models of various levels of complexity can be used depending on how complicate the scheme in question is. For very large impact schemes, a full demand model should be used (i.e. LTS see 13.9) that can calculate induced demand and affect mode shift. For simpler but still significant schemes a strategic model should be used (i.e. HAM (see 14.7.3) or Railplan (see 14.7.2)) that can calculate more strategic route diversions such as a Westminster to Greenwich trip diverting away from Elephant and Castle to travel via Vauxhall / Peckham.

For local models a junction specific model could be used (either microsimulation or something less detailed or even just focussing on signal timings).

Models can also be nested so that the impacts for different movements are taken from different models. They can quantify different effects and it is important that all significant impacts are included from the different models to the best of our ability and bearing in mind the cost of the analysis. Strategic route diversion impacts could be taken from strategic models for instance, more detailed impacts at the junction concerned could be taken from a microsimulation and very specific time impacts taken from signal optimisation. Specialist advice should be sought form the relevant modelling experts.

14.3 Forecasts of value of time

The value of time is based on willingness to pay. For forecasting purposes, and as recommended by DfT WebTAG, these values are assumed to grow in line with real increases in GDP per capita. This is the same for both work and non-work purposes. The Values of Time (VoTs) and the growth rates are set out in the BCDM Data Book http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

Business Case Development: Ryan Taylor [redacted]

14.4 Explaining Time Impacts

The sponsor needs to be in full command of the impacts of their scheme. They need to know the various trade offs in impacts including how the different time impacts interact. It is essential when justifying a scheme that the significant impacts are clearly explained so that the robustness of the calculations can be understood and so that the layman can understand why TfL is progressing a scheme and that stakeholders can see that the impact on them has been considered.

Impacts should be set out by user class i.e. cars, freight, cyclists, bus users and pedestrians. Different types of time impacts should be set out i.e. is it reduced travel time, reduced crowded / congested time, reduced waiting time, reduced walking time, improved reliability etc.

The impacts by geographical location may be important. It may be that users across London may benefit but a small area has disbenefits, or it may be the other way round. All transport models can produce useful graphics to show how different zones get benefits or disbenefits to different extents and these can be shown if there is a significant impact to set out.

It is also recommended that to prove the robustness of estimates, the business case should highlight the top few movements (i.e. those with the biggest generalised cost impacts). These top movements should be explained with the demand and time saving (plus type of time) clearly set out.

14.5 Reliability / Disruption

14.5.1 Overview

There are three primary ways in which reliability can be calculated. The first is to obtain a standard deviation of journey times from a simulation assignment model. The second approach is to pre-estimate the effect of incident types in an evidence database and use directly as a time benefit. The third approach is to apply value of time weights to additional minutes of delay or lateness. All of these approaches are used at TfL.

14.5.2 Simulation Modelling

Models such as the train service model in LU and highway simulation models are capable of outputting standard deviation over a number of runs, however the causes of delay / unrelaibility are also entered as inputs, so careful consideration must be given as to whether reliability is being adequately represented.

14.5.3 NACHS (Nominally Accumulated Customer Hours) System

This is a database of incident types and the resultant impact on LUL's lines and passenger journey times. It is derived from output from the Train Service Model, the Network Model and pedestrian simulation models (see Section A.9: 'London Underground Operational Modelling' for more information on these models). It was originally constructed to support the penalty payment mechanism under the PPP contract but has since evolved for extensive general use.

The database provides quantified estimates of journey time changes due to service reliability (benefits and disbenefits) without resorting to specialist models. It is openly available but the LU Transport Planning Team can provide guidance and interpretation and it is recommended that they are consulted about figures used in building business cases. The database is founded on the existing network and its validity therefore decreases with substantive network changes. Caution should also be exercised when multiple impacts are occurring simultaneously (as an example, impacts will be different if another line is closed for engineering works).

LU Transport Planning: Sandra Weddell, [redacted]

14.5.4 Additional Minutes of Delay / Lateness

Value of time weights for London Underground additional minutes of delay are available in the BCDM data book: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

The Rail Industry Passenger Demand Forecasting handbook (PDFH) uses a similar approach of valuations for minutes late compared to timetable.

LU Transport Planning: Sandra Weddell, [redacted]

14.6 Accessibility for People with Impaired Mobility

Changes in accessibility for those with impaired mobility can in principle be estimated using analysis of time impacts, however there is limited modelling capability to represent different degrees of impaired mobility networks.

A Step-Free Railplan model has been developed but this was primarily developed for connectivity analysis (WebCAT) and not for robust analysis of journey time impacts. It is hoped that this can be extended and be validated for this purpose. It is also only suitable for analysing the needs of people who require an entirely step free network – i.e. those with wheelchairs and those with buggies / luggage / elderly uncomfortable with using escalators etc. This requires a good knowledge of what proportion of demand has this requirement.

The other major segment of mobility impaired demand is that which could use a stair free network, i.e people with buggies who are comfortable using escalators etc. A model has not yet been developed to quantify time benefits for this group. Again, having a good knowledge of the

proportions or levels of demand for this type of network is as important as having a modelling tool with that capability.

There are of course other types of mobility impairments. The principle should be to try and quantify the time improvement with an investment and the number of people likely to benefit.

The key stations were chosen on the basis of providing:

- a good geographical spread across London, with all local authorities, lines and most branches served
- above average station usage
- significant interchange traffic between lines or with other modes
- Access to particular local facilities, e.g. a main shopping centre, a leisure centre, a hospital, etc.

In view of the case for providing step-free access across the network of key stations, business cases for individual stations in this network can be based on the overall business case, provided that the likely costs and benefits are broadly in line with the assumptions in the overall business case.

A summary of the factors to be investigated is as follows:

- any substantial divergence from the estimated cost assumed in the overall business case
- any substantial decrease in the estimated benefits assumed in the overall business case (for example, arising from an excessively lengthy route from street level to platform)
- any disproportionately high disbenefits during project implementation (especially where they outweigh the benefits following completion)
- the implications of removing a station from the proposed network, i.e. if there are no nearby stations in the network and if possible substitute stations lack the attributes (see above) intended for key stations, the disadvantage of removing this station as a potential origin and destination may be understated
- any unusually high level of synergy which can be secured by carrying out accessibility works at the same time as a general station refurbishment -this will also be relevant to stations which are not included in the key network

Group Planning – Equality and Corporate Sustainability: *Lawrence Thurbin,* [redacted]

The main benefits for entirely new mobility impaired users, who previously did not travel but who now can are more significantly related to health and wellbeing rather than time improvements. Being able to more actively participate in society will improve both mental and physical health. An attempt should be made to quantify the likely numbers of people affected but at present there is a limited ability to monetise this figure into the benefit to cost ratio.

14.7 Connectivity

Connectivity has previously been referred to as “accessibility”, but this has been confused with the effects of step-free access for users with a range of needs. We now use the term “connectivity” instead, and it is expected that this will be reconciled in future versions of statutory documents such as the London Plan.

PTAL (Public Transport Access Level) is the formal measure of connectivity used as a key input into discussions about housing densities, parking provision and other policy matters. PTAL is a powerful measure due to its simple presentation, although some aspects of connectivity are not covered by this measure. Travel time mapping using measures such as TIM and CAPITAL provides complementary insight on levels of connectivity, and can be undertaken for any mode of transport.

Information on PTAL and TIM in a range of scenarios, for locations throughout London, is available on the Web-based Connectivity Assessment Toolkit, WebCAT. WebCAT can be accessed at www.tfl.gov.uk/webcat. It allows users to create their own maps of PTAL or travel times.

Detailed information on WebCAT is available on the Planning with WebCAT page: https://www.tfl.gov.uk/info-for/urban-planning-and-construction/planning-with-webcat

The page also contains a link to a comprehensive guidebook on connectivity assessment with a wide range of graphical examples.

Connectivity changes can be demonstrated in the Strategic Case to show generic improvements for a scheme or can be used to support the Economic Case for different options and support value for money judgement where it is a significant contributor to the argument being made. This demonstration can take the form of either graphic representation or connectivity metrics.

WebCAT team, [redacted]

14.8 Time Modelling Tools

14.8.1 Journey Time Calculator

The Journey Time Calculator (JTC) is a basic spreadsheet tool available on the Business Case intranet page: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx
It should be used for basic analysis of journey time impacts. All it does is multiply:

- Demand (flow for period multiplied by annualisation factor)
- Time impact (before compared to after)
- Value of Time

It is useful in the early stages of projects to estimate the likely impact of the project. I.e. an informed estimate is that 4 minutes could be saved for bus trips down a particular corridor as a result of various bus priority measures. This indicates potential demand for money or allows a rudimentary comparison of options at an early stage without more complicated, expensive and time taking modelling. It can also be used to calculate simple journey time changes.

What it won't do is estimate any impact of re-routing to avoid the area or estimate induced trips through an area. It will also not be useful for more complicated "network" effects because of the ability of the inputter to specify all potential movements.

The spreadsheet can also be used to undertake the annualisation of model outputs, but it was not originally designed for this and will be revised in the future to better suit this work flow.

14.8.2 Strategic Public Transport Modelling

Models in this group focus on the route choices of public transport users. They have a key role in estimating expected travel times, wait times and levels of crowding. The techniques used within

TfL encompass all types of public transport. Therefore, the choice between bus, tube, rail, Overground, DLR and tram (and to some extent walking) is analysed as a choice of a route rather than the choice of a mode. This choice also includes the decision of whether and where to transfer between routes. Most operational aspects of the public transport service are not coded in great detail in such models, and their design is done using other models (described in subsequent sections).

Tools: RAILPLAN, Docklands Public Transport Model (DPTM), MOIRA.

14.8.3 Strategic Highway Modelling

TfL's strategic highway models look at the way car drivers choose their routes from their origins to their destinations, through London's highway network. Routing decisions affect the levels of congestion, which also has important environmental and wider economic impacts.

Tools: HAMs

14.8.4 London Underground Operational Modelling

Models in this group focus on the detailed operations of the London Underground, including the underground trains, stations and supporting systems. They generally do not look at factors beyond the operations of the tube, and therefore in most cases they require some demand inputs from other models.

Tools: Train Service Model (TSM), Journey Time Capability model (JTC), Station Service Model, Heat Strain Risk Tool (HSRT), Tunnel Ventilation Model (TVM), Railway Engineering Simulator (RES).

14.8.5 Tactical Highway Modelling

"Tactical modelling" is not a standard term in transport modelling, but it is used in TfL to refer to highway assignment models with more network detail than in the strategic highway models. TfL's tactical model is used primarily for assessing operational traffic management options for the short term, unlike the strategic highway models which are mainly used to assess long-term investments and policies. Unlike TfL's strategic highway models, the tactical model is not used as part of a full four-stage modelling process, and therefore it does not examine how levels of congestion are likely to affect trip generation, mode choice and distribution.

Tools: Operational Network Evaluator (ONE)

14.8.6 Microsimulation Modelling

Traffic microsimulation provides the maximum "zoom in" to examine in detail how individual road users interact with each other. Microsimulation models normally take the level of demand, including the routes used by each road user, from the outputs of highway assignment models. They then consider the specific movements of individual vehicles (e.g. from which lane to which lane they wish to turn, when they accelerate or when they slow down) to examine how delays, queues and congestion are created. Road Space Management has produced comprehensive guidelines, covering the recommended approach to micro-simulation modelling and other techniques of highway modelling as used in Surface Transport; this should be a primary reference point when considering the use of micro-simulation or "tactical" highway modelling.

Tools: VISSIM, LinSig, TRANSYT.

14.8.7 Bespoke strategic models

There will always be cases where existing modelling tools do not cover the type of analysis or forecasting required. In such cases it is common to develop bespoke tools, often in a spreadsheet, tailored for the needs of the relevant study. One specific model in this category is described below. Other models exist or can be developed if needed. If the need arises, this can be discussed and scoped with help from the Strategic Analysis team, TfL Planning. Contact Chris Hyde or Yaron Hollander.

Tools: CEM

14.8.8 Pedestrian Modelling

The Station Capacity Analysis Team has the role of ensuring the best use of the existing and proposed space within stations for meeting passengers' needs, including that they have a quick and congestion free flow through from entrance to platform. A number of tools are available to analyse the movement of pedestrians. Most of these are used to design stations at a micro level, for either normal operation or for emergency evacuations, however there are also examples of the use (of Legion) in analysing pedestrian spaces in a wider context. Analysis of pedestrian modelling forms an integral part of the design for schemes aimed to reduce congestion at stations. The modelling can demonstrate the effectiveness and longevity of the scheme, whilst also providing social costs to feed into the necessary business cases

Tools: Static Toolkit, PEDS, Pedroute, Legion.

14.8.9 Cycle Modelling

Cycle modelling has improved significantly over the past few years. Within TfL the Cynemon model (Cyling Network Modeling for London) has been developed to predict cyling route choice and user benefits as a result of certain types of interventions. Bespoke demand forecasting tools have been developed for forecasting demand for specific initiatives. CLoHAM has also been used.

Tools: CLOHAM for cycling, CYPET, Cynemon

14.8.10 Connectivity Assessment Tools

Strictly speaking, TfL's connectivity assessment tools are not models, as they do not generate estimates of future demand or levels of performance. The connectivity tools are used to measure and present information about London's transport system, including travel times and other features. This information is converted from other sources into maps and graphs. WebCAT on www.tfl.gov.uk/webcat is an effective tool for accessing some commonly-viewed sets of model outputs.

Tools: WebCAT, PTAL, TIM.

15. Safety

15.1 Overview

Safety is part of the TfL culture and evaluation decisions across the business should be made with safety in mind. Safety impacts are one of the main long standing areas of monetisation in transport projects.

The latest monetised figures for use in benefit calculations are in the BCDM Data Book: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

Different areas of the business have different processes that are followed.

15.2 Principles

Considerable expenditure is undertaken by TfL to minimise the occurrence of incidents which could lead to loss of life or injury or damage to assets. Because expenditure is expressed in financial terms, in order to compare the magnitude of the health and safety benefits with the expenditure and arrive at an estimate of whether or not the expenditure is worthwhile, the benefits must also be expressed in financial terms.

In principle, appraisal of such projects is straightforward. If the probable frequency (expressed as number per annum) of an event occurring and the probable outcome if the event occurred (expressed financially) are known, then multiplying these two numbers is the probable cost per annum of the risk. If as a result of the expenditure the magnitude of either or both of these two quantities is reduced then the reduction in annual costs can be ascertained and used in appraisal calculations in the same manner as any other benefit.

If an event has a probable occurrence frequency once every 10 years, and the most likely consequent cost is £1m, then the probability per annum is 1/10 and the probable cost per annum is 1/10 times £1m i.e. £100,000. This can be treated as a discounted cash flow and compared with the cost of eliminating the hazard.

Ideally the probabilities will be based on historical data but for many events historical data is sparse. Indeed a major function of health and safety appraisal is to identify events which have never happened and to estimate the probable frequency and severity.

Requirements of legislation (the Health and Safety at Work Act) stipulate that expenditure to reduce hazards must be incurred up to the point where the remaining risk is "as low as reasonably practicable" (ALARP). The 'Safety Decision Making' standard describes the approach to demonstrating ALARP in Rail and Underground, and the method and parameters to be used when assessing the value of health and safety benefits.

15.3 Quantified Risk Assessment (QRA)

The first step is to quantify the health and safety risk. This requires the combination of the consequences and likelihood of all the outcomes from the incidents to be considered. Quantification of this risk requires assigning frequencies and probabilities to all the contributing factors leading to an event. For example, for a car to skid off a road, there may need to be a

combination of a wet road, bald tyres and excessive speed. If say 10,000 cars per annum use this road, there are 20% wet days, 1% of cars have bald tyres, and 10% are speeding, then the expected frequency of skidding is given by:

10,000 x 20/100 x 1/100 x 10/100 = 2 per year

The safety consequences of a car skidding may depend on the number of people in the car, the likelihood of the car colliding with a solid object such as a tree or another car etc. If say an analysis of the consequences gave the result that a skid on this road would give a 94% chance of no fatality, a 5% chance of a single fatality and a 1% chance of 4 fatalities, then the expected risk of a fatality (in the probabilistic sense) due to skidding is:

2 per year x [(5/100 x 1) + (1/100 x 4)] = 0.18 fatalities per year

A similar evaluation could be carried out to ascertain the expected risk of major injury etc.

Clearly, combining these probabilities becomes increasingly complicated as the number of contributing factors and possible outcomes increases. Here, fault tree and consequence (event) tree techniques are useful to map out the logic of the accident scenarios and to apply the mathematical operations on the assigned probability and outcome data to produce the quantitative estimates of the expected risk.

For LUL railway operations, such fault and consequence tree techniques have been employed to quantify the risk of fatality from those events (known as "top events") with the potential to cause major injury or fatality to LUL passengers (and staff involved in such incidents). These top events, and LUL Quantified Risk Assessment modelling in general, are discussed in Section 4 of the LUL Safety Certification and Authorisation Document: http://luintranet.tfl/static/documents/coo/forms/lu_safety_certification_and_safety_authorisation_(january_2017).pdf. A list of top events can be found in the 'Safety Decision Making' standard, section 5: http://onespace.tfl.gov.uk/lu_/cms/CMSLibrary/S1/S1521.pdf. The top event may be extremely rare but the large number of contributing events can occur relatively frequently and these frequencies can be observed or estimated.

Nicola Perrins, [redacted]

The implementation of options may reduce risk by:

- reducing the likelihood of the base events which initiate the accident sequence (i.e., improve "prevention") and/or
- reducing the likelihood of the contributing failure of control measures should these base events occur (i.e., improve "protection"), and/or
- improving the emergency response should the accident occur to reduce the number and severity of casualties (i.e. improve "accident mitigation")

Although as a general principle the priority for safety attention shall be in the order: prevention / protection / accident mitigation, a project option which affects any of the above can be modelled to assess the risk reduction associated with implementation. Usually this can be done using the existing Fault Tree and Consequence Analysis, though where a project has no impact on the "top events", a separate analysis may have to be carried out.

Health, Safety and Environment in rail and Underground is responsible for ensuring the maintenance of the models and data relating to the assessment of top event risks. Section 3 of the

'Assessment and Management of Health Safety and Environmental Risk' standard: http://onespace.tfl.gov.uk/lu_/cms/CMSLibrary/S1/S1526.pdf describes the respective roles of LUL and suppliers in projects requiring Quantitative Risk Assessments. The aim is to ensure that future QRAs build upon existing analysis and understanding. Section 3 also provides guidance on the application of fault tree and event tree techniques.

15.4 Valuation of Safety Benefits

The output of the QRA (above) will be the probable number of fatalities and/or injuries per annum before and after the implementation of the initiative. The health and safety benefit is the risk reduction arising from implementation, and a valuation can be assigned to this by applying monetary values to the avoidance of fatalities and/or injuries (see below).

15.5 Treatment of Safety Benefits in Appraisals

Benefits arise from three types of risk reduction, relating to:

- Injuries or fatalities to customers / users
- Injuries or fatalities to staff or other non-passengers (e.g. trespassers)
- Material damage and service disruption.
- Originally, these were all covered in one figure applied for each fatality, but in current appraisals each benefit must be quantified separately.

The current approach places a reference value of £1.9m (at 2016/17 prices) on the avoidance of a fatality, with a possible gross disproportion multiplier of 3 (giving £5.7m) applied, depending on the maximum risk to an individual.

The multiplier of 3, depending on the above factor, addresses the aspect of the ALARP principle which requires safety measures to be implemented unless the cost etc. is disproportionately greater than the safety benefit obtained. The ALARP case should be investigated using the value of £1.9m, and if this fails, £5.7m. If the case fails using £1.9m but succeeds using £5.7m, the individual risk should be examined to see which of these two valuations is more justified (see 15.6 below). An estimate of the reduction in risk of "major" and "minor" injuries should also be included, either by reference to the Fatality and Weighted Injury Factor for top events, see 15.6, or preferably by assessing the risk separately and applying weightings of (for rail appraisals) 0.1 and 0.005 respectively to the appropriate fatality value. The fatalities and weighted injuries can then be added together to form a single 'Fatality and Weighted Injuries' value.

The ALARP judgement should consider the health and safety benefits against the cost of implementation. Avoidance of loss of revenue, e.g. from material damage or service disruption should be set against the implementation cost.

The £1.9m represents the casualty related costs, which includes lost output, human costs and medical and ambulance costs. Material damage and service disruption should be included in addition to this.

15.6 Summary of (Quantitative) Appraisal Procedure

In outline, the procedure is this. Do a risk assessment appraisal using the ALARP principle. All costs should be included, but only direct safety-related benefits and risk-related revenues. Then (even if the project is warranted by ALARP) do the full appraisal with all costs and benefits, with VPF (Value

of Preventing a Fatality) at the lower limit, using the upper limit of VPF as a sensitivity test if the case fails.

The details are as follows:

Risk assessment appraisal (ALARP)

In the preparation of a safety cost benefit analysis, both the qualitative and quantitative safety issues need to be considered. This section concentrates on the quantitative side for a summary of the qualitative assessment see Section 15.12.

Steps:

1) Quantify the risk in question (expected fatalities per annum).
2) Use a VPF of £1.9m.
3) Obtain the total annual value of avoiding fatalities by multiplying by the change in annual risk of fatalities.
4) Injuries
    - If possible, the risks of major and minor injuries should be estimated separately. The values of major and minor injuries are taken as 0.1 and 0.005 respectively times the appropriate value of a fatality. Major injuries are defined as:
        - any fracture or dislocation other than to fingers, thumbs, or toes
        - any amputation
        - loss of sight or permanent damage to an eye
        - any other injury or illness requiring detention in hospital
    - But if separate estimation of injuries is not possible:
        - where the risk arises from a "top event", include the total annual value of major and minor injuries using a single figure from the Fatality and Weighted Injuries Table F1 and multiplying this by the total annual value of fatalities prevented, as obtained above

Table 15-1: Fatalities and Weighted Injuries Factors for LU Top Events

Top Event	Main Scenarios	Fatalities and weighted injuries
Arcing	traction earth faults	1.4
Collision Between Trains	collision between trains (end to end/side on)	1.4
	side swipe collision	1.0
Collision Hazard	collision with a floodgate	1.3
	collision with a lineside structure / tunnel wall	1.0
	collision with a terminal	1.1
	collision with a platform	1.1
Derailment	derailment on LU infrastructure	1.2
	derailment on NR infrastructure	1.2
Escalator Fires	fires on metal escalators	1.0

Top Event	Main Scenarios	Fatalities and weighted injuries
	fires on modified escalators	1.0
Escalator Incidents	Escalator incidents	1.0
	falls on escalators	1.0
Explosion	explosions from internal and external sources	1.1
Flooding	direct flooding from River Thames	1.0
	indirect flooding from River Thames	1.2
Lift Fires	lift machine room fire	1.0
	lift car fire	1.0
	lift shaft fire	1.0
Lift Incidents	lift incidents	1.0
On Train Incidents	spurious door opening	1.0
	unauthorised use of Inter-car doors	1.0
Platform Train Interface	passenger falls from the platform	1.0
	passenger struck by train whilst on the platform	1.0
	passenger falls between train and the platform	1.0
	passenger dragged along the platform	1.0
Power Failure	affecting train service	1.4
	affecting stations	1.0
Stairs & Assaults	falls on stairs	1.0
	assaults	1.0
Station Fires	public area fires	1.2
	non-public area fires	1.2
	interlock room fires	1.0
Structural Failures	tunnels and bridges	1.0
	stations and buildings	1.4
	earth structures and drainage	1.2
Train Fires	under car fires in tunnel	1.4
	under car fires above ground	1.0
	in car fires in tunnel	1.4
	in car fires above ground	1.0
Tunnel Fires	tunnel fires (including track fires)	1.4
Unauthorised Access to Track	person on track	1.0
Ventilation Hazard	train held in section	1.4
	authorised track detrainment without protection	1.0
	self detrainment	1.0

Appraise the project solely on the health and safety benefits of preventing fatalities and injuries as described above. Other passenger benefits (including time savings) should not be included at this stage. However any operating cost savings or additions resulting from the project should be taken into account. Revenue derived from health and safety benefits should be deducted from the costs. Revenue (but to reiterate, not the associated passenger benefits) arising from the avoidance of risk of disruption should also be included, as should the cost of any material damage avoided.

Calculate the B/C Ratio. If this is > 1.0, the quantitative appraisal indicates support for the project, and the quantitative conclusion should be used to inform and support the qualitative arguments.

If the B/C Ratio is < 1.0, the project should be reappraised using a VPF of £5.7m (only for the safety benefits -continue to use £1.9m for the revenue derived from safety benefits). If the ratio is still < 1.0, the quantitative appraisal does not indicate support for the project, and once again the quantitative conclusion should be used to support the qualitative arguments. (If the risk is relatively large but the case is not made for a particular project, alternative ways of reducing the risk should be considered.)

If the B/C Ratio is < 1.0 with VPF £1.9m but >1.0 with VPF £5.7m, the maximum level of risk to an individual needs to be assessed, to see whether the risk falls within the maximum acceptable level specified by the Health and Safety Executive. For example, consider a risk which has been quantified using the total number of passenger journeys per annum to assess the consequences from the hazard in question. In this case, the "most at risk" individual would be assumed to make 500 journeys per annum (provided that the hazard is encountered in both directions, e.g. to and from work). The base case expected number of fatalities per annum (or equivalent fatalities, which includes injuries) is then factored down to give the maximum risk to an individual:

$$\textit{maximum risk to an individual p.a.} = \textit{expected no. of fatalities p.a.} \times \frac{500}{\textit{total passenger journeys affected p.a.}}$$

If the maximum level of risk to an individual is found to be high (i.e. greater than 1 in 100,000 which can also be written as > 10-5), then the quantitative assessment should be based on a VPF of £5.7m. NB. If the maximum level of risk to an individual is greater than 1 in 10,000 p.a. for customers, or 1 in 1,000 p.a. for staff, the risk would normally be regarded as intolerable and as such would warrant some urgent action to reduce the risk. (See the LUL standard Safety Decision Making.)

If the maximum risk to an individual is less than or close to 1 in 10,000,000 (a risk of 10-7), then it should be considered if the risk to the most exposed individuals from the specific hazards under consideration make a significant contribution to this overall risk. See the LUL standard Safety Decision Making.

If the maximum risk to an individual from this particular hazard is in the area between 10-5 and 10-7, then the overall risk to that individual needs to be considered. Here, £1.9m (rather than £5.7m) should be used only if it can be claimed with confidence that the overall risk to the individual is less than 10-5.

15.7 Full Appraisal

A full appraisal beyond the safety impacts should also be carried out. Even if the project is justified by ALARP, the full appraisal will establish the total benefits achievable.

Appraise the project using £1.9m as the VPF but include passenger benefits (based on time savings) from avoided disruption, together with those passenger benefits and generated revenues which are not associated with the avoidance of risk. These could be generated by, for example, improved appearance of station, removal of speed restrictions, etc.

Calculate the B/C Ratio based on the total benefits and compare with a benchmark of 1.5:1.

If the case fails on this basis (and the ALARP criterion also failed to justify the project), carry out a sensitivity test using £5.7m VPF (but again with revenue calculated on the basis of £1.9m VPF).

15.8 Treatment of Values in Appraisal

The values of passenger life and injuries to customers are based on attitude research on willingness to pay, and should therefore be treated as a passenger benefit, with benefits in future years inflated to take account of real growth in the Value of Time (this reflect the growth in income and therefore willingness to pay value).

The preferred approach to discounting safety benefits is to discount by 3.5% along with all other benefits and inflate the benefits by the growth in income (VoT growth). This should be done, as with other income related benefits in our standard business case spreadsheets. The Office of Rail And Road (ORR) has slightly simplified guidance that suggests discounting benefits by 1.5% and costs by 3.5%. The ORR benefits discounting automatically combines the 3.5% standard Treasury Green Book discount rate and a 2% growth in income, resulting in the net figure of 1.5%. The TfL approach is easier in that the business case spreadsheets are set up with a more refined growth in income coded in to inflate benefits and this allows a consistent approach to be applied to all other income related benefits such as time and ambience.

Incidents involving passengers do have an effect on demand and the normal elasticity should be applied to the health and safety benefit, based on the reference preventative fatality valuation of £1.9m, to calculate the risk of loss of revenue.

Where the potential incident prevented will reduce staff fatalities and/or injuries, the same approach should be applied - treating the improvement as social benefit but with no impact on revenue. However, for injuries, the effect on operating costs of, for example, sick cover should be included.

15.9 Summarising Complex QRAs

Inevitably major quantified risk assessments can be complex, and there can be a temptation to present results in a purely numeric form, avoiding any description of the risks themselves and their consequences. For example, a study of electrical hazards in an Underground depot could be summarised as:

“The total risk to individuals is 6.37E-4 p.a. and is therefore not ALARP.”

However the maximum risk to individuals is only one factor in the appraisal and the summary should focus instead on:

- the nature of the hazard
- the risk of an incident
- the average consequence of an incident

- the overall probable loss of life

The headline findings could therefore be:

Hazard	Probability of incident (p.a.)	Average consequence (fatalities per incident)	Expected fatalities (p.a.)
Electrocution during inspections	0.31	0.096	0.030
Electrocution during train movements (mainly as they move off to enter service)	0.090	0.096	0.0087
Electrocution while staff moving around depot (slips/trips, inadvertent contact, or damaged equipment)	0.064	0.096	0.0061
Train enters service with overhead supply lead still inserted	0.29	0.030*	0.0086
Total			0.0534

Overall risk is low, but in worst case fire caused by arcing results in estimated 10 fatalities

This is an unusually complex QRA and many others could be summarised by a table with only one or two lines. With safety, there is always an obligation to examine all possible options, even when risks are comparatively low. It is difficult for authorising bodies to do this unless the business case gives a reasonable summary of the nature of the risks. Hence the need for a standard summarising procedure as outlined above.

15.10 London Underground

The LUL safety management system includes various standards which are important points of reference. These include:

a) Assurance:
http://luintranet.tfl/static/documents/coo/forms/lu_safety_certification_and_safety_authorisation_(january_2017).pdf.

This standard requires that changes are assessed for health, safety and environment impacts. Where there could be an impact, it requires that a Change Assurance Plan is produced, demonstrating that health, safety and the environment will not be degraded and/or that the proposed option is that which will reduce risks to as low as reasonably practicable (ALARP).

Any Change Assurance Plan should clearly identify the requirements for any safety controls and their management during and following implementation of change. Assessment of the safety implications of change should be undertaken at an early stage in the development of options so that the costs, feasibility, etc. of such controls can be properly reflected in the business case.

b) Safety Decision Making: http://onespace.tfl.gov.uk/lu_/cms/CMSLibrary/S1/S1521.pdf.

This standard provides guidance on the structure of safety cost benefit analysis, and describes the basis for demonstrating that risks are ALARP.

ALARP judgements should be based on a structured qualitative evaluation of the health and safety issues based on operational and engineering experience, supported and informed by quantitative analysis where possible. The corporate standard for assessing the monetary valuation of reductions in risk is given in 'Safety Decision Making'.

Nicola Perrins [redacted]

15.11 Surface

Within Surface the Health and Safety teams and the Environment teams are separate. The Head of Health and Safety within Surface is:

Catherine Behan, [redacted]

The principle of estimating safety benefits should be the same – estimate the change in the number of accidents as a result of the scheme and then apply the monetary valuation.

The number of collisions at particular locations can be obtained from the ACCSTATS database.

Sandra Cowland [redacted] *Michael Pilch,* [redacted]

There are various alternative statistics for the value of preventing an accident by severity and road class available in the DfT WebTAG unit A4.1 Chapter 2: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275364/webtag-tag-unit-a4-1-social-impact-appraisal.pdf#nameddest=chptr02

These should be uprated to appraisal base year prices and values in the BCDM Data Book (can be done automatically): http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

The Road Safety Audit Team in the Asset Management Directorate is the primary contact for safety appraisals. They are a team of accredited specialists and are experienced in the field of road safety, including collision investigation and potential collision reduction and the associated appraisal.

Andrew Coventry, [redacted] *Mark Borrett* [redacted] *Anya Bownes,* [redacted] *Shane Martin,* [redacted]

The Design Team in Road Space Management also have expertise in infrastructure design with respect to safety.

Samuel Barnes, [redacted]

15.12 Qualitative Approach

Safety is an emotive issue and the true worth of investing in safety can go beyond the quantitative calculations described above. Decision makers should take these wider considerations into account when deciding whether to approve a project. The role of the business case is to present the evidence and arguments to enable that decision making, so qualitative arguments should be included if they are of material consideration.

For example, there is a disproportionate coverage of rail and cycling fatalities compared to other vehicles by the press and this has an effect on the reputation of TfL and attractiveness of those modes of transport. This can lead to knock on implications for the uptake of cycling for example.

15.13 Contacts

Further advice, for instance on Bus or corporate projects, may be obtained from Health, Safety and Environment on the quantification of risks, and from TfL Business Case Development on appraisal methodology.

- ***Advice on health, safety and environmental risk:***
  Nicola Perrins, [redacted]
- ***BCDM appraisal methodology:***
  Ryan Taylor, [redacted]
- ***Risk in appraisal methodology:***
  Simon Motley, [redacted]

16. Ambience / Amenity

16.1 Overview

Ambience valuations relate to improvements to the environment of journeys, and are based upon market research into how much per trip a passenger is willing to pay for improvements. The factors for which willingness to pay valuation data are available in the Ambience Benefits Calculator on the Business Case Intranet page: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx and cover all modes including public transport, cars, walking and cycling.

Where possible, values of improvements should be used to monetise the benefit of improving various aspects of a journey. The Valuing Urban Real Toolkit (See section 16.4) can also be used to assess ambience scores for the Urban Realm using PERS.

Note carefully the different usage data required. For example, in Underground projects the appraisal of improvements to ticket halls relates to station entries alone, whereas for "access" areas improvements are relevant to both entries and exits.

There is no comparable body of research regarding movements in Customer Satisfaction Scores equivalent to that for Customer Priorities; the practice of forecasting changes in CSS and placing values on these predicted changes is useful for benefit realisation and to indicate effects in a quantified way but they can not feed into a benefit to cost ratio.

16.2 DfT WebTAG

WebTAG provides more general guidance on ambience under Journey Quality in unit A4.1: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/386743/TAG_Unit_A4.1_-_Social_Impact_Appraisal_November2014.pdf

The WebTAG methodology has journey attributes split into three categories, two of which have further sub-categories:

- Traveller Care (facilities and information)
    - cleanliness
    - facilities
    - information
    - environment
- Traveller views (view and pleasantness of the external surroundings)
- Traveller stress
    - frustration with inability to make normal progress on a journey
    - fear of potential accidents
    - uncertainty about the correct journey route

The assessment of each of these is on a simple scale of Beneficial/ Neutral/Adverse (as compared to the base option) with guidance on the extent (slight/moderate/large).

If a DfT business case is being submitted, the TfL ambience value estimates should enable an evidence based assessment of the categories above.

Similarly unit A3 includes guidance on Environmental Assessments that include the impact on Townscape:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/372739/TAG_Unit_A3_Environmental_Impact_Appraisal_November2014.pdf

16.3 Townscape / Urban Realm

Townscape and Urban Realm considerations are increasingly important areas in transport appraisal and increasingly TfL seeks not just to create functional spaces but spaces where people want to be. Where important it should certainly be mentioned in the strategic narrative part of the business case document with as much supporting quantification as necessary to form the argument. There are several different ways of recording the impact in a business case:

(1) As a Wider Impact under "Townscape", in the Appraisal Summary Table or in multi-criteria assessment. This can include various levels of quantification. See Section 16.3.

(2) Some elements can be monetised using the existing ambience benefits in the Ambience Benefits Calculator: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

(3) The Urban Realm Toolkit draws together several aspects of the urban environment. See Section 16.4 for more information.

The table below contains links to other sections that show how aspects of the urban realm can be monetised and included in the TfL benefit to cost ratio.

Impact	Into TfL BCR?
Climate change	WebTAG tool (Section 18.7)
Employee productivity	Only from Absenteeism (Section 17.3)
User experience of the public realm	Ambience Benefits Calculator / Urban Realm Toolkit
Noise	WebTAG tool: (Section 18.5)
Improvement in Safety	Section 15: Safety
Increase in physical activity	HEAT (Section 17.3)
Improved air quality	WebTAG tools (Section 18.6)
Crime reduction	Use calculator in BCDM Data Book. Section 16.5

For monetised benefits for user experience of the public realm there are two main approaches and it is for the Sponsor to decide which is appropriate for their scheme.

The Valuing Urban Realm Toolkit is good for monetised ambience benefits as well as estimating impact on Residential Land Values and Retail Rents. The monetisation of ambience will yield different results to using the raw Ambience Benefits Calculator monetisations as the assessment of the levels of the attributes is different and VUR splits assessment into places and links. It is not possible to mix and match attributes between VUR and Ambience Benefits Calculator because this will lead to double counting and inconsistency.

VUR is most suitable for streetscape and urban realm enhancements with lots of ambience improvements, which basically means Town Centres, Urban Realm, Better Junctions and streetscape projects.

The downsides are that VUR is difficult to audit (Sponsors do need to explain the basis for their benefits) and it is difficult to run sensitivity tests and a username and login is required for an external website. Sponsors also need to be aware that they should be careful about using some of the outputs and methodology in VUR as some of the quantification formulas are out of date. A checklist of all the VUR outputs is provided in Table O-1 and an assessment of where the quantifications / monetisations should come from.

The Ambience Benefits Calculator figures should be used directly in most cases apart from those areas listed above.

The decision to use the VUR toolkit or Ambience Benefits Calculator approach is entirely down to the Sponsor.

16.4 Valuing Urban Realm Toolkit

16.4.1 Overview

The TfL Urban Realm Toolkit (spreadsheet) has been developed to draw together the benefits of investing in the Urban Realm.

This section summarises the guidance for this tool but is not a user guide. The toolkit and user guide can be from TfL Urban Design:

Robin Buckle, [redacted]

16.4.2 Concept

The Valuing Urban Realm (VUR) Toolkit has been developed to provide monetary values for proposed improvements to public space and provide objective, evidence-based justifications for investment.

While the inherent appeal of high quality public space is evident to any observer, its positive characteristics can be difficult to quantify. Traditionally, urban realm projects are quantified via measures such as time savings or safety benefits, dismissing the significant wider benefits of improved ambience.

The Valuing Urban Realm Toolkit is used to evaluate the socio-economic benefits of public urban realm investment and can compare different magnitudes of interventions, for example a straightforward de-clutter versus a more significant streetscape reconfiguration. Streetscape evaluation is carried out using the Pedestrian Environment Review System (PERS).

16.4.3 Monetisation of Benefits

The Urban Realm Toolkit provides a monetary valuation for the different benefits and produces a benefit to cost ratio. The benefit to cost ratio that is output is compliant with DfT WebTAG methodology (and therefore the BCDM) but some additional elements such as Land Values are monetised and should not enter the benefit to cost ratio.

Instead these monetisations are used to support multi-criteria assessments and can be quoted in the strategic narrative of a business case and an appraisal summary table but it should be made clear that they are not included into the standard benefit to cost ratio. An example of this is the retail impact and residential property price impact. There is no agreement that these are social benefits, as the benefits accrue to those owning the assets however those who are aspiring to be asset owners clearly receive disbenefits as they are less likely to be able to afford the asset. For this reason, these elements in particular can be used as supporting evidence in a business case narrative, particularly when being used to justify funding proposals, but they should never enter the benefit to cost ratio.

The Urban Realm Toolkit is best used for the following elements, highlighted in bold in the table below:

- B6 Retail Impact (Retail Rents)
- B7 Residential Property Price Impact
- D2 User experience of the Urban Realm

For the other elements, it is either better to use models and calculators that are kept up to date, particularly the suite of calculators provided by the DfT: https://www.gov.uk/government/publications/webtag-environmental-impacts-worksheets or other standard TfL models or they are qualitative in nature.

The list of Urban Realm Toolkit sections does however provide a useful checklist of elements to be considered when producing an Urban Realm business case.

Urban Realm business cases should demonstrate that the optimal value solution has been determined, and the toolkit is appropriate for this optioneering.

A guide to the different elements is provided in the table below, along with guidance on what to do with the output.

Table 16-1: Urban Realm Toolkit Sections – BCR Admissibility

Policy Objectives	Code	Impact	Can this go in the BCR?
Climate Change	A1	Mode shift	Yes – Use WebTAG tool (Section 18.7)
	A2	Embedded emissions	Yes – Use WebTAG tool (Section 18.7) – but more difficult to estimate
	A3	Climate change adaption	No – Qualitative
Economic Growth	B1	Improved local connectivity	Yes – Use classic approach to estimating journey time changes (Models or JT Calculator)
	B2	Tourism	No – Qualitative
	B3	Inward investment	No – Qualitative

	B4	Employee productivity	Yes – Only from Absenteeism (section 17.3.2) using tool in BCDM Data Book
	B5	Agglomeration	No – Qualitative – Doubt significant
	B6	**Retail impact**	**No – use as supporting evidence.**
	B7	**Residential property price impact**	**No – use as supporting evidence.**
Equality of Opportunity	C1	Inclusive design	No – Qualitative
	C2	Reduction in severance	No – Qualitative
	C3	Diversity and adaptability	No – Qualitative
Quality of Life & Healthy Natural Environment	D1	Improved local connectivity / Access to amenities	Yes – Use classic approach to estimating journey time changes (Models or JT Calculator)
	D2	**User experience of the public realm**	**Yes**
	D3	Noise	Yes – Use WebTAG tool (Section 18.5)
	D4	Heritage and local character	No – Qualitative
	D5	Natural landscape	No – Qualitative
	D6	Biodiversity	No – Qualitative
	D7	Enhanced community and social capital	No – Qualitative
Safety, Security & Health	E1	Reduction in accidents / collisions	Yes – Use monetisation from Section 15: Safety
	E2	Reduction in non-vehicular accidents	No – Qualitative
	E3	Increase in physical activity	Yes – Use HEAT (section 17)
	E4	Improved mental health and reduced stress	No – Qualitative
	E5	Improved air quality	Yes – Use WebTAG tools (Section 18.6)
	E6	Crime reduction	Yes – Use calculator BCDM Data Book

16.4.4 PERS

Pedestrian Environment Review Software (PERS) audits are a consistent way of evaluating changes to the pedestrian environment. These are used as the basis for the user experience of the urban realm benefits in the Urban Realm Toolkit.

More information can be found on the TRL website:
https://www.trlsoftware.co.uk/products/street_auditing/pers

TfL has unlimited licences for PERS.

Spencer Clark, [redacted]

16.5 Crime

Crime reductions can be monetised but must be the net total change in crime. If an area is redeveloped and crime is reduced, then some of this may be diverted to other areas. A Crime Calculator is provided in the BCDM Data Book to assist with monetisations.

17. Health

17.1 Overview

The biggest health impact of transport schemes in London is usually their role in facilitating people being more physically active by walking or cycling for part or whole trips. For more information and evidence on the health benefits of transport see TfL's health action plan "Improving the health of Londoners: transport action plan": http://www.tfl.gov.uk/cdn/static/cms/documents/improving-the-health-of-londoners-transport-action-plan.pdf

All business cases (not just walking and cycling projects) should consider these health impacts in line with TfL policy, including monetising the health benefits using the World Health Organisation Health Economic Assessment Tool (WHO HEAT) and the Sickness Absence Reduction tool (SART). Links are provided to these tools in section 17.3.

The TfL Public Health Specialist is building up a portfolio of examples of TfL business cases which have included HEAT calculations which can access by contacting Lucy Saunders, likewise please send her your business cases so she can add them to the portfolio for others to benefit from.

Lucy Saunders [redacted]

The Health Economic Assessment Tool gives a conservative estimate. It only measures the benefits of regular physical activity, not the impacts of road traffic collisions, air pollution or other health benefits. In addition it only measures mortality (deaths) not morbidity (illness). In other words it measures the reduced risk of death that results from people being regularly physically active and applies a monetary value to all the lives 'saved' by being more active. It does not measure the health and social care cost-savings, the cost savings of people not getting ill, or the economic benefits of reduced sickness absence, it only measures reduced deaths.

Benefits from reduced sickness can be covered in part through the benefits of reduced absenteeism. It should be noted that these are business rather than consumer benefits.

17.2 DfT WebTAG

WebTAG guidance can be found on the following link:
https://www.gov.uk/government/publications/webtag-tag-unit-a5-1-active-mode-appraisal

If an assessment of impact on Physical fitness is required, there is further DfT WebTAG guidance on the following link:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275364/webtag-tag-unit-a4-1-social-impact-appraisal.pdf#nameddest=chptr03

17.3 Health Assessment Tools

17.3.1 Health Economic Assessment Tool (HEAT)

This tool monetises the health benefits of reduced mortality (risk of death) from increasing physical activity.

The tool is available online: http://www.heatwalkingcycling.org

The user guide for the tool is available here:
http://www.euro.who.int/en/health-topics/environment-and-health/Transport-and-health/publications/2014/health-economic-assessment-tools-heat-for-walking-and-for-cycling.-methodology-and-user-guide.-economic-assessment-of-transport-infrastructure-and-policies.-2014-update

You can also access an online tutorial here:
http://www.heatwalkingcycling.org/index.php?pg=training&id=

This tool underestimates health benefits of physical activity as it only includes the reduced risk of death to people who take more exercise not their reduced burden of illness. However the health benefits of reduced risk of death are very large and can be a significant input to a business case.

A local guidance manual 'Valuing the health benefits of transport schemes' in London has been developed and is available on request from Lucy Saunders. If you would like training or have any questions about using the WHO HEAT tool or including health impacts in your business case please contact our Public Health Specialist Lucy Saunders.

Lucy Saunders [redacted]

17.3.2 Sickness Absence Reduction Tool (SART)

Benefits from reduced sickness amongst employees can be demonstrated, in part, by reduced sickness absence from work. It should be noted that these are business rather than consumer benefits.

A review of up to date literature identified three important sources, two of which are endorsed by the National Institute for Health and Care Excellence, which demonstrated a sickness absence reduction in the order of 25% from being physically active. It is deemed reasonable to use a 25% reduction in sickness absence from physical activity for people who shift from spending less than 30 minutes walking and/or cycling per week to more than 30 minutes (including accumulated short trips and trip stages walked or cycled).

In the UK the average absence of employees is 5.3 days per year (CBI Survey 2012[1]). Therefore, for each employee who takes up regular physical exercise in the form of a walking or cycling intervention, the annual benefit to employers is likely to be (on average) at least 1.3 days gross salary costs (25% of 5.3 days).

In order to calculate the benefits, this figure needs to be combined with the average gross salary costs per working day and the number of affected working people. The median gross weekly pay for London is £670.8 (ONS 2016[2]). This is divided by 5 to convert to a gross daily pay of £134 (2016 prices and values).

[1] CBI Fit for Purpose: Absence and workplace health survey 2013: http://www.cbi.org.uk/media/2150120/cbi-pfizer_absence___workplace_health_2013.pdf
[2] ASHE ONS 2016 Annual Survey of Hours and Earnings, 2016 Provisional Results: https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/bulletins/annualsurveyofhoursandearnings/2016provisionalresults#regional-earnings

The number of working people affected may be calculated from the average proportion of cyclists and walkers who are employed (65%[3]) as a proportion of the total number of people expected to use the facility produced by TfL.

Calculations of the benefit to employers where n = total number of new active travellers (more than 30 minutes per week) using facility:

1) Total number of sickness days saved by employers as a result of TfL facility

= (65% of n) x (25% of 5.3 days)

= (0.65 x n) x (0.25 x 5.3)

= Y days per year

2) Total annual financial benefit to employers (£)

= Y days x £134 [daily median gross pay for London]

= £Z per year

17.4 Health Examples

17.4.1 Health Impact

Below is an example of how the World Health Organisation Health Economic Assessment Tool (WHO HEAT) has recently been used in TfL.

The Business Case for the Cycling Vision included a cost benefit analysis, which gave a benefit to cost ratio of 2.9:1. Net benefits totalled £3.1 billion and included business, environmental and public realm benefits as well as health. Health benefits were equivalent to £2,173m over the 15 year appraisal period from 2026 (prevention of 165 premature deaths per year), which was second in sum only to journey time benefits.

HEAT was used to calculate the health benefits of increasing cycle mode share across London from two per cent before the intervention to five per cent after the intervention.

Table 17-1: Cycling Vision HEAT Input – data and assumptions

	Pre-intervention (2009 data)	**Post-intervention (2026 estimated total)**
Total number of trips observed	513,540 cycle trips on an average day	1,450,682 cycle trips on an average day (excluding trips derived from population growth)
Number of individuals cycling	1,767,323 (cycling population)	2,926,666 (estimated cycling population)
How many days per year do people cycle?	53 days a year in 2009	90 days a year in 2026.
Average cycle trip distance	3km	3km

[3] London Travel Demands Survey (LTDS), 2010/11 to 2012/13

What proportion of trips are return journeys?	100%	100%
How long are the benefits sustained?		15 years

Further examples of HEAT and SART being applied to transport schemes in London and elsewhere are included in our local guidance manual 'Valuing the health benefits of transport schemes' for London, it is available on request from Lucy Saunders.

Lucy Saunders, [redacted]

17.4.2 Sickness Absence Impact

Using the statistics in 17.3.2 the sickness absence reduction benefits are calculated for the upgrade of public realm at local town centre, which is estimated to deliver 915 additional cyclists, of whom 20% are expected to be new cyclist i.e. n=183.

183 x 0.65 =119 of these are in employment

119 cyclists x 1.325 average days off sick prevented by cycling per year

157.68 = y = total days off sick prevented each year by these cyclists

£30,479 / 228 = £133.68 = savings per each day of sickness absence avoided

158 x £134 = z = £21145 saved each year as a result of sickness absence avoided by regular active travel.

18. Environment

18.1 Overview

Starting at project inception and throughout the project lifecycle, relevant environmental issues should be considered by reviewing the proposed deployment of resources (revenue or capital) using the Strategic Assessment Framework. This should be used for all sustainability assessment on projects with an Estimated Final Cost (EFC) greater than £10m.

The conclusions, including possible changes to scope, can then be incorporated into project planning earlier than if environmental impacts were not considered until the project submission stage.

It is important to ensure that proposals for new expenditure take into account environmental issues, and that any opportunities for environmental improvement are identified and exploited.

In the presentation of a business case, any significant environmental issues need to be outlined within the assessment, e.g. any specific features that are required to comply with environmental legislation or to make environmental improvements. In particular, where an environmental review of the investment has previously been carried out, the business case should comment on any significant issues which the project was expected to address.

Note that where planning permission is sought or the Transport and Works Act procedure is being applied, an Environmental Impact Assessment (EIA) may be required, at the discretion of the Secretary of State for Transport (TWAO) or local authority. An EIA may be required. See the national guidance below for descriptions of when EIAs are likely to be required for various types of development.

For national guidance see: https://www.gov.uk/guidance/environmental-impact-assessment

EIAs:
Group Planning: Neil Kedar, [redacted]

Sustainability Assessments:
Helen Woolston [redacted]

18.2 Environmental Checklist

A Pathway Sustainability Assessment should be completed regularly at the different lifecycle stages. This will prompt thinking on what environmental impacts are taking place. The Strategic Assessment Framework (SAF) can also be used for this. The checklist below is a similar list of items that should be considered to prompt thinking and consideration of environmental impacts. It can be used to consider impacts on smaller projects that don't require a Sustainability Assessment. Not all of these can be monetised but if the effect is significant, then the effect should be highlighted in the business case with as much monetisation, quantification or qualitative assessment as is possible.

As with all areas of potential impacts, all possible environmental impacts should be considered when preparing a case. The Strategic Assessment Framework or Sustainability Assessment can act as places to record these impacts. If the impact is considered to be low or negligible, then no

further work is necessary. The amount of effort being put in to assess impacts must be proportional to the impact that it will have on decision making. If the impact is small or negligible, then it is ok not to undertake further more significant assessment.

18.2.1 Emissions to air

Will the project generate emissions to air?

- Are they of environmental concern? (e.g. greenhouse gases, ozone depleters, particulates (black smoke), NOx)
- There is various legislation and Mayoral requirements relating to these emissions?
- Are alternatives available that have lower emissions?
- Will the new asset result in more or less emissions?

18.2.2 Discharges to water / effluent

Will the project change the quality or quantity of discharges to water?

- Are they of environmental concern? (substances contained in discharges)
- Are any additional discharge consents required?
- Are there alternative approaches that will result in reductions in the quantity of the discharges?
- Are there alternatives that will improve the quality of the water discharged?

18.2.3 Contaminated land

Is the site to be used contaminated?

- What measures will be taken to ensure that environmental risk is reduced during the demolition, excavation and construction period?
- What measures will be taken to ensure that environmental risk is reduced during the subsequent use of the site?
- Can an alternative site be used?
- Does Land Remediation Relief (Tax Rebate) apply in a similar way to energy projects (see 4.7). https://www.gov.uk/hmrc-internal-manuals/corporate-intangibles-research-and-development-manual/cird60015

18.2.4 Noise and vibration

Will there be a change in levels of noise and vibration as a result of the project?

- Is there an option which would generate less noise?
- Can construction work be carried out at less sensitive times?
- Can measures be implemented which will reduce noise or vibration (e.g. barriers, screening, etc.)?
- What are the operational implications of increased levels of noise or vibration? (e.g. reduced speed and frequency, hours of operation)

18.2.5 Resource Use and Waste

Will a significant amount of resources be used or waste be generated by the project?

- Can materials and resources used be minimised (e.g. through design)?
- Does our used materials or waste have a value that can be realised (e.g. from reuse, scrap value of old trains)?
- Have costs of materials and waster transport and disposal been quantified?
- Will the levels of operational waste subsequently be increased?
- Provision must be made for the segregation of waste during the lifetime of the facility (legal requirement)?
- Can parts of the old asset be utilised as an input to this or other projects?
- Can the waste be reduces, reused, recycled or recovered?
- Has minimising waste been considered as part of a refurbishment / renewal decision?
- Will hazardous waste (e.g. asbestos, clinical waste) be generated? How will this be dealt with?

18.2.6 Dust

Will the project lead to increased levels or circulation of dust?

- Can measures be included within the project to reduce dust?

18.2.7 Energy use

Will energy consumption increase or decrease as a result of this project? Complete Carbon and Energy Efficiency Plan (Pathway Product).

- Have energy efficient options been investigated (e.g. lighting, pumps, motors, air handling units etc.)?
- Is there an opportunity for incorporating renewable energy technology?
- For refurbishment and new build, does the project include metering of the site?
- On London Underground, have the impacts of additional energy consumption on tunnel temperatures been considered?

18.2.8 Water consumption

Will water use increase or decrease as a result of this project?

- Can ‘greywater’ be recycled? (there may be issues with storage)
- Can rainwater be collected from site?
- For refurbishment and new build, does the project include metering of the site?
- Is the impact on drainage sustainable?

18.2.9 Biodiversity

Will any natural habitats be disturbed as a result of this project?

- Are there any tree preservation orders?
- Are there invasive plant or animal species?
- Is the presence of any protected species suspected at the site?
- How will these issues be dealt with (e.g. species relocation, instructions to contractors etc.)?
- Can the timing of the project be adjusted to avoid a nesting season?
- What reinstatement works will be undertaken as part of the project?
- Does the project provide opportunities for enhancing the wildlife value of the site?
- Does the project provide opportunities for enhancing green infrastructure?

18.2.10 Historic Environment

Does the project have an impact on sites of heritage importance?

- Does the project include works on a building that currently has, or is being considered for, national or local 'Listed' status?
- Is the site adjacent to buildings that are 'Listed'?
- Does the site contain any features of significant design or architectural value?
- Is the site within a conservation area?
- What measures will be taken to ensure that the heritage value of the site is preserved?

18.2.11 Materials

Does the project involve the use of hazardous or other environmentally sensitive materials?

- Are any of the following materials involved: Mercury, Asbestos, HCFCs, Halons, Solvents (degreasing, cleansing etc.), other cleaning chemicals, acids, Cadmium, lead, nickel, zinc, chromium?
- Are there alternatives that are more environmentally acceptable? (e.g. galvanising rather than cadmium plating)
- Are there independently environmentally certified materials that could be used? (e.g. Forest Stewardship Council timber)

18.2.12 Storage of hazardous materials

Will the project result in long term storage of hazardous materials (e.g. fuels, oils, anti-freeze)?

- What are the additional materials now being stored?
- How are they to be stored?
- Are additional bunds, interceptors, etc. required?
- Is the storage facility sited near to the point of use?

18.2.13 Modal shift

Will the project produce a significant modal shift (i.e. greater than 1m trips p.a.) ?

- Approximately what level of modal shift is expected?

- What levels of local, and overall, emission reduction will this result in?

18.2.14 Extreme Weather and Climate Change Adaption

- Does the project have opportunity for installing sustainable drainage?
- Has the project designed according to weather parameters over its whole design life, using the UK Climate Projections?

18.3 Identifying the best practicable environmental option

Where the appraisal raises significant environmental issues, the following general principles should be applied:

- Identify best practice within the industry (or outside if appropriate).
- Identify costs and whether they would be any higher for TfL to apply
- If cost not excessive i.e. not greater than the benefits generated by adopting the option (see Section 18.4) adopt this option and state reasoning in business case
- If cost considered excessive state why this is considered to be the case and make a qualitative statement to this effect in the business case.

18.4 Monetisation

Quantification of environmental impacts may be appropriate where major projects or policy questions are being considered. At present, several impacts can be quantified and monetised into the benefit to cost ratio. These include:

- Noise (see section 18.5 below)
- Air Quality (NOx, PM10) (see section 18.6 below)
- Climate Change (Greenhouse Gases) (see section 18.7 below)
- Journey Ambience / Townscape (see section 16 above)
- Physical Fitness / Health (see section 17 above)

For guidance on each of these, please see the sections referenced. Some of these aspects may only be partially covered by the quantifications and monetisation, so it is still important to describe the full benefits where they are significant.

For any other areas of monetisation, it may be possible to use a sensitivity test or present the evidence in the narrative or tabulated in an appraisal summary table. Please contact TfL Business Case Development to discuss what is appropriate.

Many environmental considerations can be captured by full consideration of efficiency gains and disposal costs (i.e. look at whole life costs) in the initial benefit-cost equation.

What is permissible to include in the BCR:
Ryan Taylor, [redacted]

(If a project risks a considerable erosion of TfL's environmental performance, or offers a considerable improvement which cannot be quantified under existing BCDM methodologies):
Neil Kedar, [redacted]

18.5 Noise

18.5.1 Overview

Noise impacts include:

- Annoyance;
- Sleep disturbance; and
- Health, including heart disease, stress and dementia.

The impact of noise should be considered in business cases when appraising a scheme. This includes the impact of:

- The ongoing operational impact of the scheme to be introduced; and
- The impact during construction.

18.5.2 Methodology

The ongoing operational impact of the scheme to be introduced

The basis for this methodology is the DfT WebTAG unit A3:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/487684/TAG_unit_a3_envir_imp_app_dec_15.pdf

The WebTAG unit above contains links to noise quantification tools for:

- Road Traffic Noise
- Railway Noise
- Aviation Noise

An assessment needs to take place on the population affected by that noise. This is estimated based on the number of households experiencing different levels of decibels either during the daytime or over night for both with/without scheme alternatives. The impacts should be assessed for the opening year and at least one other forecast year.

This is monetised using the DfT WebTAG Noise workbook:
https://www.gov.uk/government/publications/webtag-environmental-impacts-worksheets

The benefits should be grown in real terms by the growth in real incomes, i.e. the real increase in GDP per capita. This is the same as the Value of Time growth rate in either the TfL business case spreadsheet, BCDM Data Book or the DfT WebTAG data book.

The impact during construction

The impact during construction is the primary concern of many people affected by the construction of a scheme. It is therefore imperative that this impact is considered in the business case appraisal. The impact can be assessed in the same way as the operational impact above. The data needed is the expected change in decibels either during the day and / or overnight multiplied by the number of households affected.

18.5.3 Difference through the Project Lifecycle

In Pathway Stage 1 (Outcome definition) the potential impact should be considered. If there is a significant impact during construction or once implemented, then noise should be assessed during Pathway Stage 2 (Feasibility) to inform the cost – benefit analysis and option selection. Benefit realisation measures should be attached (baseline and estimated impact) at this stage as well. During Pathway Stage 3 and 4, the estimates should be updated with improved information on the option being progressed. By the end of Pathway Stage 4, the pre-implementation baseline measures should be recorded for benefit realisation purposes and this should be monitored through implementation and assessed again once the scheme has transitioned into operations.

18.5.4 Further Links

More detail is provided in the Department for Transport WebTAG appraisal guidance: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/487684/TAG_unit_a3_envir_imp_app_dec_15.pdf

Further information can be provided from the Health, Safety and Environment Team:

- ***Sustainability Assessments:***
  Helen Woolston [redacted]
- ***Noise:***
  Jon Colclough [redacted]

18.6 Air Quality (NOx, PM10)

18.6.1 Overview

Poor air quality damages health and quality of life. It is estimated that poor air quality (specifically fine particles) contribute to an equivalent of 9,500 deaths in London each year (https://www.theguardian.com/environment/2015/jul/15/nearly-9500-people-die-each-year-in-london-because-of-air-pollution-study), which is twice as many as previously thought. The EU has set binding targets for the reduction of air pollution to levels at to protect health, and these have in turn shaped the UK's national air quality targets.

Within London, the Mayor together with the local authorities has statutory responsibility for air quality and must achieve air quality objectives for seven pollutants. In those locations where the objectives are unlikely to be achieved, Air Quality Management Areas must be designated. All London Boroughs have declared such Air Quality Management Areas, the majority covering the entire administrative area. The declaration of an AQMA requires the relevant local authority to review the potential abatement techniques available to achieve the air quality objectives and develop an Action Plan. For more information see the Mayor's Air Quality Strategy.

Air quality in London currently does not meet the EU limit values for nitrogen dioxide (NO2) which were to be met by 2010, and the UK is facing infraction proceedings from the European Commission. The UK government reported compliance with the PM10 limit values for London and the rest of the UK in the most recent reporting year (2012); however there are still locations in London, which could be considered at risk of exceeding the limit values in future reporting years.

Road transport is responsible for around half of NOx, PM10 and PM2.5 (fine particle) emissions in London (London Atmospheric Emissions Inventory 2013: https://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory-2013)

18.6.2 When should Air Quality impacts be evaluated?

An air pollution assessment should be commensurate with the scale of the project. The following guidelines should be followed:

- Highway schemes which have a minimal impact on traffic volumes or speed may not require detailed assessment unless there are particular local sensitivities, for example, traffic congestion or high levels of exposure to poor air quality such as in Air Quality Focus Areas (https://data.london.gov.uk/dataset/air-quality-focus-areas).
- Where a project is expected to have an impact in an AQMA (http://uk-air.defra.gov.uk/aqma), project sponsors should contact the relevant local authority Environmental Health Officer to ensure the project is consistent with the relevant AQMA Action Plan.
- In general, where the air pollution impact of a project is not neutral, some form of assessment and quantification of the impacts should be attempted.

Lucy Parkin, [redacted]

18.6.3 How should Air Quality impacts be measured?

In all cases, the assessment should be undertaken by comparing the without-scheme and the with-scheme levels for the relevant 'Objective Year', or, where a scheme opens after these dates, for the scheme opening year. Where project impacts are expected to build up from the opening year, an assessment of their impacts when the build up period is complete should be made.

For smaller projects, particularly those where small scale impacts are expected to be dispersed across a wide geographic area, it may be sufficient to simply record an estimation of the overall change in emission levels. (For example, converting the LBSL ancillary vehicle fleet from diesel power to a cleaner fuel could be quantified in terms of a change in the overall annual PM10 and NO2 emissions from the fleet, using best estimates of emission rates based on existing knowledge of fleet usage and vehicle performance.)

Where impacts are anticipated on a particular corridor or corridors, a screening approach similar to that suggested within DfT WebTAG Unit A.3.3 (https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275262/webtag-tag-unit-a3-environmental-impact-appraisal.pdf#nameddest=chptr03) should be used. This initial assessment determines if more detailed and specialised air quality modelling is appropriate. The approach is to assess the area adjacent to the route in 50m bands up to a maximum of 200m (beyond which there will be assumed to be no effect) simply to see how many properties are likely to be affected positively or adversely, and to check whether any AQMA is included.

If there is reason to believe the impacts are likely to be significant, a second stage follows where detailed modelling provides estimated impacts across the four bands using the following data:

Distance from road centre	No. of properties in band	Impacts measured at this distance from road centre	PM_{10} annual mean	NO_2 annual mean
Up to 50 m		20m		
50 m to 100 m		70m		

100 m to 150 m		115m		
150 m to 200 m		175m		

18.6.4 How should Air Quality impacts be presented?

The Treasury Green Book sets out three approaches for the valuation of changes in air pollutant emissions;

Approach	Methodology	When to be applied
Damage Cost	Proportionate analysis (derived from I-P Assessment below) to estimate approximate air quality impacts.	Used in the majority of cases to value changes to air quality that does not effect legal compliance and quality impacts are <£50m (NPV)
Impact Pathway	Detailed analysis that values the air quality impacts and assess how these affect health and environmental outcomes. *Requires consultation with Defra.* [redacted]	Used to value changes to air quality that does not effect legal compliance and quality impacts are >£50m (NPV)
Abatement Cost	Application of a £/tonne Marginal Abatement Cost (MAC) that would be incurred in order to achieve compliance. *Requires consultation with Defra where impact is >£50m* [redacted]	Applicable in limited circumstances, where changes to air quality are likely to effect legal compliance – either by causing, removing or changing the level of compliance.

Damage Cost Approach

The scheme impact is summarised as the difference the scheme produces in the annual mean g/m3 at each distance, multiplied by the number of properties in that band, and totalled over the four bands. In addition, a qualitative comment will provide an indicator as to whether the scheme will cause an Air Quality Strategy objective to be exceeded and / or whether an exceedance has been removed. Further comments can be included if the scheme will have an impact on air quality in a Focus Area.

For fuller details, see WebTAG unit A3.3:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275262/webtag-tag-unit-a3-environmental-impact-appraisal.pdf#nameddest=chptr03

A WebTAG Air Quality valuation workbook (to record impacts) and Local Air Quality workbook (to convert impacts into a monetised value) are available on the following link:
https://www.gov.uk/government/publications/webtag-environmental-impacts-worksheets

TfL Planning maintain the London Atmospheric Emissions Inventory (http://data.london.gov.uk/search/node/LAEI) and associated Emissions Assessment Tool.

For further information on the inventory or tools:

Lucy Parkin [redacted]

Abatement Cost Approach

The abatement approach is appropriate only where pollution is already in breach of legally binding obligations, or where this is expected as a result of the policy under consideration. The abatement cost approach supplements the existing damage based approach by considering the cost of any action necessary to comply with legal obligations.

If legally binding obligations are not met remedial actions will be needed to restore compliance, or fines will be imposed. Consequently decisions that result in non-compliance may create substantial financial liabilities. The abatement cost approach recognises this, and values any changes in air quality that exceed an obligation at the cost of subsequently restoring compliance. This approach used marginal abatement cost (MAC) methodologies developed by the Inter Departmental Group on Costs and Benefits (Air Quality) (IGCB(A)) and published in HMT supplementary Green Book guidance.

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/197893/pu1500-air-quality-greenbook-supp2013.pdf

If a change in air pollution is partly within an obligation and partly in excess of it, abatement costs should only be applied to the latter change with damage costs used to value the part of the change that maintains compliance.

To determine whether a proposal will affect compliance, the following 3 stages are required;

- Estimate current concentrations in affected areas;
- Determine changes in concentrations as a result of the proposal (either Damage Cost or Impact Pathway Assessment, as appropriate)
- Determine impact on relevant legally-binding obligations

The UK legally binding obligations are set in EU directives, primarily the Air Quality Directive.

The current information on state of compliance for different pollutants is available at:
https://www.gov.uk/air-quality-economic-analysis

Having estimated the change in air quality, the monetary cost estimate of this change is calculated using the unit abatement cost. There are two methods to value changes in air quality using abatement costs, depending upon the scale of the impacts;

1. Estimate the scale of the change in air quality using unit costs in terms of marginal cost of emissions (usually £/tonne). Unit costs are derived from Marginal Abatement Cost (MAC) curves, which reflect abatement potential and cost of different abatement technologies. The unit costs only present an extract from the complete MACC and therefore only produce an indicative estimate. As such, this approach is only recommended where

    - As an initial assessment if a wide range of policy options which may the require a more comprehensive assessment; or
    - Where air quality impacts are expected to be <£50m NPV.

2. Where a decision is likely to have a significant impact on compliance (i.e. NPV >£50m) then more detailed analysis is recommended to determine the most appropriate MAC value. This method can include existing tools such as the marginal abatement cost curves e.g. for NOx and

for particulate matter (PM). The flexibility of this approach provides a more accurate estimate than the single figure applied in Stage 1 above. Further advice can be sought from Defra, [redacted]

Although based the methodology is based on cost of compliance, MAC valuations are an alternative approach for calculating benefits and should therefore go into the top of the equation when calculating the BCR.

Further guidance on the abatement cost approach can be found at;

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/197898/pb13912-airquality-abatement-cost-guide.pdf

18.7 Climate Change (Greenhouse Gases)

18.7.1 Overview

The Climate Change Act 2008 sets out the approach to managing and responding to climate change in the UK based on a legally binding target to reduce greenhouse gas emissions to at least 80% below base year (1990 or 1995 depending on the gas) levels by 2050. There are increasingly harsh targets to achieve at five year intervals in order to achieve the overall reduction and each sector is expected to play its part in taking action to achieve these targets.

Carbon dioxide (CO_2) is by far the most important greenhouse gas. Calculation of the emissions impact of projects should be based on CO_2 equivalent emissions (CO_2e).

The Mayor's Climate Mitigation And Energy Strategy (2011) adopts a target of 60% reduction in CO_2 emissions by 2025, with interim targets for 2015 and 2020.

The Mayor's Transport Strategy focuses on three key themes:

- Improved operational efficiency – to minimise unnecessary CO_2 emissions
- Supporting and enabling the development and use of low carbon vehicles, technology and energy.
- Carbon efficient mode choice – to improve the attractiveness of low carbon modes such as walking, cycling and public transport and to enable the movement of freight by water and rail.

For more details see Mayors Transport Strategy:
https://www.london.gov.uk/what-we-do/transport/our-vision-transport/mayors-transport-strategy

18.7.2 When should the impact on Greenhouse Gases be evaluated?

An appraisal of the change in CO_2 production should be made for:

- Projects which significantly alters private and/or public transport traffic volumes, or creates modal shift.

- Projects where replacement of existing technologies or infrastructure will generate a significant change in energy use and therefore CO_2 production, for example on stations and in offices.

18.7.3 How Should Greenhouse Gas impacts be measured?

Changes in the amount of energy or fuel should be estimated, converted to carbon emissions and monetised using the DfT Greenhouse Gas spreadsheet.

Fuel Consumption

Monetary values are calculated per tonne of carbon released into the atmosphere.

The amount of fuel consumed, and therefore the amount of carbon emitted, per vehicle kilometre varies considerably by vehicle type. Therefore, for all modes, predictions of emissions will be more accurate the more disaggregated the data is on traffic flow by vehicle type. For example, for National Rail, data disaggregated by individual engine types will lead to more accurate estimates of emissions. Similarly for roads, more disaggregated data on traffic flow by vehicle type (e.g. car, light goods vehicle, rigid HGV, articulated HGV and coaches/buses) will lead to more accurate estimates. Grossly aggregated data can lead to significant errors and expert opinion may be required in order to determine the validity of any conclusions drawn from numerical differences in calculated emissions.

WebTAG provides some guidance specific to roads and National Rail. For road traffic, Unit A1-3 (section 5.1.4)
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275245/webtag-tag-unit-a1-3-user-and-provider-impacts.pdf#nameddest=chptr05
provides a formula:
$L = (a + b.v + c.v^2 + d.v^3) / v$
for calculating fuel consumption in litres per km at any given average speed (v) kph.

The parameters a, b, c, d are tabulated in the WebTAG databook table A1.3.8 for vehicle categories, e.g. petrol car, diesel car, average car, petrol light goods vehicle, etc. Table A1.3.11 shows how these parameters change over time, which includes assumptions about the biofuel blend (a percentage of biofuel is blended into road transport fuel and gas oil).

Operating costs, which include fuel consumption are output as standard from software and models such as TUBA, the HAM models and Micro-simulation models. In addition CO2 emissions are output to enable them to be monetised in the WebTAG Greenhouse Gas calculator.

For National Rail, the DfT have recommended energy consumption rates by stock type. The DfT can be contacted for this information [redacted] The agreed consumption rates for Control Period 5 (2014-19) are also available on the Network Rail website:
https://www.networkrail.co.uk/industry-commercial-partners/information-operating-companies/cp5-access-charges/

Electricity Use

A calculator tool attached to the Carbon & Energy Efficiency Plan (CEEP – Pathway Product) can be used to calculate the CO_2 impact of changes in electricity and gas consumption. Contact the Energy & Carbon Strategy team in Rail and Underground.

James Ingram, [redacted]

For London Underground the Railway Engineering Simulator (RES) model is the best source of line by line energy consumption.

Tony Lightfoot [redacted]

For other energy consumption and carbon assumptions support in Rail and Underground:

James Ingram, [redacted]

It is also important to distinguish between the traded (i.e. European Union Emissions Trading System) and non-traded sectors. Electricity used for transport is in the traded section, as is aviation fuel. Emissions from other types of transport fuel are in the non-traded sector. This segregation is clear in the DfT workbook linked at the end of section 8.3 below. All other energy derived from electricity is in the traded sector.

For more detail on the Department of Energy and Climate Change guidance, refer to:
https://www.gov.uk/government/collections/carbon-valuation--2

This provides a link to the very detailed paper 'Carbon valuation in UK policy appraisal: a revised approach':
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/245334/1_20090715105804_e___carbonvaluationinukpolicyappraisal.pdf

A much simpler summary 'A brief guide to the new carbon values and their use in economic appraisal':
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48184/3136-guide-carbon-valuation-methodology.pdf

18.7.4 How should Greenhouse Gas impacts be presented?

A brief description of the reason for the change, together with the absolute change (tonnes pa) should be presented. Where possible, a percentage change should also be calculated, (e.g. x% reduction in CO_2 emissions from a particular vehicle fleet).

The present value of monetised social costs for all years in the appraisal period is calculated. If the impact represents increased carbon emissions this monetised value is negative and is termed 'social disbenefit', while if there are reduced emissions the value is positive and is termed 'social benefit'. The value is added to any other social benefits produced by the project before the benefit:cost ratio is calculated.

For presentations in DfT format, the entry in the Overall Assessment column of the Appraisal Summary Table should be the present value of monetised social costs for all years in the appraisal period (and the same value goes in the appropriate row of the 'Analysis of Monetised Costs and Benefits' table). The Quantitative Measure is the total change in tonnes of CO_2 equivalent (CO_2e) over the appraisal period (a positive number indicating an increase in carbon dioxide emissions, and a negative number a decrease). The Qualitative Comment should be used to indicate any special features of the appraisal, along with an indication of the key drivers which are responsible for any change in conditions. Any uncertainties involved in the calculation of emissions should also be identified in the qualitative column.

Important note: In analyses done for the DfT using the software package TUBA, the greenhouse gas impacts will be automatically calculated, but currently only for changes in private transport on highways. It follows that greenhouse gas impacts arising from changes in highway traffic should not be calculated separately from the impacts automatically generated by TUBA, while public transport impacts currently have to be calculated outside TUBA.

For fuller details see the relevant WebTAG unit:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275262/webtag-tag-unit-a3-environmental-impact-appraisal.pdf#nameddest=chptr04

WebTAG Greenhouse gas spreadsheet calculator:
https://www.gov.uk/government/publications/webtag-environmental-impacts-worksheets

18.7.5 Carbon Reduction Commitment

The Carbon Reduction Commitment (CRC) is a mandatory emissions trading scheme that aims to incentive energy (and carbon) savings in large, non energy intensive public and private organisations. It is enabled via the Climate Change Act which became law in November 2008. As a Climate Change Bill commitment, the scheme is aiming for an 80 per cent reduction in carbon dioxide (CO_2) emissions by 2050.

18.7.6 Other Useful Resources

TfL Planning maintain the transport aspect of the London Energy and Greenhouse Gas Emissions Inventory (LEGGI) https://data.london.gov.uk/dataset/leggi2012, and a related Emissions Assessment Tool.

Claire Cheriyan [redacted]

Environmental impacts in appraisals (in particular CO^2 reductions):
Helen Woolston [redacted]

For energy price expectations, please refer to section 5.2.2.

18.8 Emissions Modelling Tools

Vehicle movements generate emissions of carbon dioxide, nitrogen oxides and other solid particles. Analysis of these emissions is needed to understand the likely environmental impacts of policies, schemes and programmes. Our ability to forecast emissions is constrained by our ability to forecast the composition of the traffic itself. Emissions modelling is therefore an area characterised by very high levels of uncertainty, affected by all the inherent uncertainties of the models forecasting future levels of demand, in addition to uncertainties related to the complexity of the emission process itself, and how it would change by future technology.

Tools: EAT model

19. Economy

19.1 Overview

Economic benefits can only be included in appraisals for schemes that have a large transformation effect. They are complicated and difficult to estimate and it is only worth putting in the effort for the largest of initiatives.

For all schemes the actual process of realising impacts on the economy from transport interventions (Transmission mechanism) should be set out. For larger schemes further steps can be taken towards quantification but for smaller schemes the effects should not be overly emphasised if they have not been subject to rigorous verification.

19.2 DfT WebTAG

The Department for Transport has recently consulted on changes to guidance for Economic benefits. Benefits in a benefit to cost ratio must represent value to society as a whole as estimated through welfare economics (i.e. increase in utility to individuals). Economic benefits however are calculated in a slightly different way and which effectively represent uplift to Gross Domestic Product (GDP). Some of these are deemed to be net additional value that can be added to the benefit to cost ratio and some are double counts of the classic transport benefits or not proven to be net additional. Because of this only some benefits can be added to the benefit to cost ratio.

If a wider GVA figure has been calculated then it should be presented in multi-criteria analysis framework and made explicitly clear to the decision maker to what extent it is net additional or a different way of looking at the same thing. All the benefits in an Appraisal Summary Table (AST) should not be added together to produce a bottom line benefit to cost ratio, as this will be a flawed representation of value for money.

For WebTAG guidance on Wider Impacts:
https://www.gov.uk/government/publications/webtag-tag-unit-a2-1-wider-impacts

Key points in this guidance are as follows.

- It is acceptable to monetise some economic benefits (net increase in GDP), however they should be combined into a sensitivity benefit to cost ratio rather than be presented as a central case. They should be described as economic benefits rather than social benefits as many people point to associated disbenefits such as the affordability of houses.
- Land Values are acceptable to illustrate an impact on certain groups and to make a case for funding from the beneficiaries of transport investment however they are not considered a social or economic benefit that can be included in the benefit to cost ratio or GVA. The main use of Land Values is to inform of the potential value that private developers are receiving from transport investment to enable an informed negotiation to take place to obtain funding.
- The economic impact on local economies (such as a local high street) is largely redistributive. Effects can be quantified and used to illustrate an effect but they should also not enter the benefit to cost ratio.

There are several experts around the business in quantifying wider impacts. Please contact TfL Business Case Development to discuss requirements and to put you in touch with local experts.

Business Case Development: [redacted]

For WebTAG guidance on Regeneration: https://www.gov.uk/government/publications/webtag-tag-unit-a2-2-regeneration-impacts

- The regeneration impact itself is defined quite narrowly, as the increase in employment enabled by the transport proposal in a regeneration area.
- A regeneration area is not simply an area of opportunity, but an officially defined area of disadvantage. (Typically this would be an area defined in a Regional Economic Strategy, e.g. the London Plan, as being among the 20% most deprived areas in the Region.)
- While the total increase in employment in a regeneration area can be indicated, the summary assessment is based only on increased employment for residents of the area.
- It is not necessary to show that this increased employment is an overall net increase (unless there is potential abstraction of jobs from another regeneration area). By the same token, it is not admissible to add the net economic value of any jobs created to the transport benefits to form a single economic benefit. (What is being measured here is a distributive, not an additional, impact. And apart from this, it is likely that there would be costs other than transport costs associated with the creation of new jobs, which would need to be included in an overall cost benefit analysis.)
- It is necessary to show why transport is effectively a constraint on increased employment in the area (and thus why transport improvements will lead to new employment opportunities).
- Any project in a regeneration area with expenditure over £5m requires an Economic Impact Report (EIR) to be prepared. This involves a separate, more detailed submission but the principles are the same as for Wider Economic Impacts in general. In particular, a survey of employers may be needed to support the forecast that improved transport would lead to growth in employment. Guidance is included within the above WebTAG reference.

19.3 Quantifications Supporting Multi-Criteria Assessment

There are a number of quantifications that support economic effects that can be used in appraisals to support the achievement of objectives and strategies but which are not allowed to enter the benefit to cost ratio. These should be entered into the relevant objective in the Strategic Assessment Framework and can enter the Appraisal Summary Table (AST) if material. See Multi-Criteria Assessment (MCA) section 11.

19.3.1 Land Values

Land value changes are primarily used to determine how much developers should be willing to pay for transport improvements. These can make schemes more affordable by reducing the cost to TfL. Once the land value uplift is estimated, as a result of the transport intervention, this can inform negotiations with developers to obtain funding. The expected funding can enter the Financial Case to show that the scheme is more affordable, and should enter the Economic Case by reducing the financial impact on the public sector. The business case spreadsheet automatically treats both private and public sector contributions in the right way.

Private sector contributions, such as those from Developers (even though they may come via a Local Authority Section 106 funding agreement) are netted off the public sector costs and also the social benefits on the top of the benefit to cost ratio as they are a cost to business. The business must get some value out of the contribution but these will manifest themselves as increased land values, increased rents or increased retail sales and these are double counts of the transport benefits estimated in the traditional way.

Land values are also not proved to be a net additional effect. If land value goes up in one area, then that may just mean that land values have not gone up by as much elsewhere. It is also much more difficult to isolate the effect of transport improvements on land values to make the estimation of them reliable and robust.

19.3.2 Number of Homes Access Is Opened Up For

If it is thought that different options can deliver access to support different numbers of homes, then this should be a quantifications supporting Multi-Criteria Assessment and can enter the Appraisal Summary Table (AST) to demonstrate the impact. Market failures leading to an under-supply of homes is accepted as an important strategy area and interventions designed to address this are essential. There is no accepted social benefit value of this however so this must be shown in a quantified but non-monetised way. It is possible to demonstrate potential user benefits of areas to be developed using the WebTAG Dependent Development methodology: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/541209/webtag-tag-unit-a2-3-transport-appraisal-in-the-context-of-dependent-development.pdf

19.3.3 Number of Jobs

In a similar way to the number of homes access is opened up for, the number of jobs access is opened up for is an important quantification that is not monetised. Journey time reductions can express accessibility improvements in areas of high unemployment.

It is also the case that jobs are redistributed as a result of schemes. Improving accessibility to central London for instance will improve the attractiveness of that area compared to outer London, the wider South-East and perhaps the rest of the country. At a National level this is of no interest to Government, however there are economic impacts and productivity effects that are a net additional effect and can be included using the WebTAG methodology. The expected number of jobs to be transferred between areas should be set out to illustrate distributive effects only and not imply that the jobs themselves are additional at the National level.

Economic improvement and job increases as a result of Foreign Direct Investment (FDI) are only worth considering for a very few specific cases. Where this is considered, the effect should be considered as a sensitivity case in the first instance and the evidence provided as to why the scheme will lead to FDI. The evidence base is currently very thin for FDI and the figures are somewhat speculative, so this uncertainty should be acknowledge in any appraisal.

19.4 Tools

19.4.1 Funding Analysis

Overview

The **Funding Analysis** model forecasts the land value appreciation and money that could be generated from **commercial and residential development** in any borough(s) in London. The development is not restricted to transport schemes, and the model can be used whenever a scheme will **increase the number of homes** (residential development) **and/or the number of businesses** (commercial development) in London.

The model estimates the amount of money that can be generated from:

- Mayoral (MCIL) and Community Infrastructure Levies (CIL);
- Stamp duty revenues
- Council tax receipts
- Business rates receipts
- Increases in land value

These sources can in turn contribute to the funding of the scheme and thus some of the money generated can be included as Third party – public sector contributions in the Business Case Model. This will affect the financial impact in the benefit to cost ration and the affordability of the scheme.

The model has been used to forecast the contribution these sources could make to fund an extension of the DLR from the Beckton line across the river to Thamesmead. The model forecasted that a contribution of between 25% and 40% of the total cost of an extension could come from these sources.

Data Requirements

The data requirements below will indicate to the Sponsor developing the case the level of effort and expense likely to use the tool.

Inputs	Possible data source
Borough(s) under consideration	Project lead
Number of net additional housing units	Analysis of development capacity of the area. This may be done by TfL or a consultant
Average sqm(s) per housing unit	Analysis of development capacity of the area. This may be done by TfL or a consultant
Proportion of *affordable housing* units; Shared ownership and Socially rented	This is likely to be defined by the borough or the Mayor
Definition of what affordable housing[4] means (shared ownership and socially rented)	tbc
Average house price(s) of new units that will be built	A specialist in real estate
Increase in property value due to investment as an *annual growth rate*	A specialist in real estate
Start date and end date of increase in property price due to investment	A specialist in real estate
Stock turnover rate (the frequency that houses are	A specialist in real estate. Or the GLA may have data on

[4] currently it is assumed that affordable housing simply means that unit price is 30% of the market price

sold/bought)	this
1992[5] value of new units that will be built	If you know the current house price, the link below can be used to estimate the 1992 value of the house; http://www.nationwide.co.uk/about/house-price-index/house-price-calculator#tab:HousePricecalculator
Additional floor space (sqm) created; Office, Retail and hotel	Analysis of development capacity of the area. This may be done by TfL or a consultant
Rateable value per sqm; Office, Retail and Hotel	A specialist in real estate
Amount of Marketable[6] residential CIL development (sqm) in each Zone[7]	Number of additional marketable[8] housing units * by the average sqm(s) per housing units = Amount of Marketable[9] residential CIL development (sqm)
Amount of CIL development (sqm) in each Zone[10]	Analysis of development capacity of the area. This may be done by TfL or a consultant
Annual delivery of housing; how quickly will the additional net units be built	Data on net completions of house building by borough from the London Development Data base can be used as a guide.
Annual delivery of commercial development, how quickly will the additional commercial space be built	Tbc
How quickly will the new commercial space be occupied by businesses who will then pay business rates	Tbc
Year the investment will become operational/ready to use. And the appraisal period	Project lead should have this information, or the same information as what is assumed in any Economic appraisal should be used. The Green Book[11] suggests using the "the useful life" of the asset as the appraisal period

For using the model contact:

Geoffrey Hobbs, [redacted]

For using the outputs of the model in a business case contact:

Ryan Taylor, [redacted]

19.4.2 Supplementary GVA of Additional Jobs

Overview

The **Supplementary GVA of Additional Jobs** model forecasts the increase in **London** GVA as a result of additional **commercial and residential development** in any borough(s) in London. The development is not restricted to transport schemes, and the model can be used whenever a scheme **will increase the number of homes** (residential development) **and/or the number of businesses** (commercial development) in London.

The GVA estimates calculated should be reported in Multi-Criteria Assessment next to the relevant economic objective. **They should not be included in the initial or adjusted BCR**, but can be included as sensitivity tests. See Webtag A2.1 Wider Economic Impact Appraisal for more details.

[5] This is to estimate the council tax band that these new units will be in. Council tax bands are based on house price valuations in 1992
[6] Marketable development does not include affordable housing
[7] Zones are defined by each borough and the map of zones can be found in the CIL charging schedule for each borough
[8] Marketable development does not include affordable housing
[9] Marketable development does not include affordable housing
[10] Zones are defined by each borough and the map of zones can be found in the CIL charging schedule for each borough
[11] The Green Book - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

It has been used to forecast the increase in GVA for 9 strategic mini tunnels in London. These schemes focused on converting roads in London into mini tunnels. The space created on top of the newly formed tunnels could then be used for commercial and residential development,

Data Requirements

The data requirements below will indicate to the Sponsor developing the case the level of effort and expense likely to use the tool.

Inputs	Possible data source
Borough(s) under consideration	Project lead
Number of net additional housing units	Analysis of development capacity of the area. This may be done by TfL or a consultant
Additional floor space (sqm) created; Office, Retail and Industrial	Analysis of development capacity of the area. This may be done by TfL or a consultant
Additional gross employment created; Office, Retail and Industrial	Analysis of development capacity of the area. This may be done by TfL or a consultant
Annual delivery of housing; how quickly will the additional net units be built	Data on net completions of house building by borough from the London Development Data base can be used as a guide.
Annual delivery of commercial development, how quickly will the additional commercial space be built and the occupied	Tbc
Affected area	This should always be set to Regional
Level of public transport accessibility	Currently the model only works in areas with poor public transport accessibility. PTAL levels can be used to judge this.
Dominant economic sectors for the borough	This can be based on local knowledge of the area, information that boroughs may have or Location Quotients (LQs)[12]. Melvyn Oben has another model that provides LQs by borough
Year the investment will become operational/ready to use. And the appraisal period	Project lead should have this information, or the same information as what is assumed in any Economic appraisal should be used. The Green Book[13] suggests using the "the useful life" of the asset as the appraisal period

For using the model contact:

Geoffrey Hobbs, [redacted]

For using the outputs of the model in a business case contact:

Ryan Taylor, [redacted]

[12] A Location quotient (LQ) is a valuable and universally accepted way of quantifying how concentrated a particular sector is in a region as compared to the nation. A value of 1 means that an industry's share of employee jobs in the region is the same as its share of nationally. A value greater than 1 means that an industry makes up a larger share of employee jobs in the local area than at the national level

[13] The Green Book - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf

20. Financial Benefits

20.1 Overview

For many projects the benefits will be in financial terms rather than as social or economic benefit. If this is the case please refer to the Financial Effects section 3. In this situation a benefit to cost ratio is not appropriate and a Financial Effect will be returned (i.e. just the bottom of the benefit to cost ratio). Together with the payback period, this will indicate the attractiveness of the project.

This section is therefore entirely focused on financial effects that are derived from the social benefits in the preceding sections.

20.2 Calculation of Revenue Effects from Social Benefits

If passengers are given benefits which are not specifically recovered from fare increases then the demand for travel will grow, and revenue will increase. The extent of revenue increase can be calculated by multiplying the passenger benefit by an elasticity factor.

Elasticities are usually calculated by reference to the effects of fare changes. For example, a fares elasticity of -0.28 implies that a 10% increase in fares results in a 2.8% loss in passenger revenue. As the benefits that passengers receive from improvements are measured in monetary terms it is now possible to use the same elasticity (without the minus sign) to indicate the extra revenue that will arise from passenger benefits. So an extension of the above is that a 10% increase in social benefits such as crowding reductions will result in a 2.8% increase in revenue.

Since the public sector subsidises transport services, for appraisal purposes only the overall changes in revenue for all public transport modes should be included. For example, revenue gained by LUL resulting from transfers from bus and rail is subtracted from the total gain. To calculate the "new to public transport" revenue, **conditional** elasticities are used. These are given in the BCDM Data Book and Business Case Model Spreadsheet: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx . The conditional elasticity is used to estimate the change in revenue in the long term since it is assumed that other transport modes will institute a similar degree of improvements.

This elasticity approximation is satisfactory for small changes to services but needs to be supported by further evidence where larger changes are implemented. A cap is placed on the forecast of extra revenue due to a service improvement, such that the implied increase in demand does not exceed 10% of the existing number of passengers who experience the service improvement. Beyond this cap, further increases in forecast revenue due to the improvement will require additional supporting evidence.

A notable example of likely exceedance of the limits of elasticity approximation occurs with LUL congestion relief projects where value derives from avoiding a significant worsening of congestion at a station. In extreme cases congestion delays can be forecast to build up exponentially beyond the point where they can plausibly be modelled. In this Do Nothing scenario, delays should be estimated in two steps. The first step is to model up to a suitable point where the level of delays to passengers still remains plausible. The second step is to extrapolate this worst plausible level of delay to passengers in the remaining part of the peak with the heaviest demand. Following this, the Do Something scenario should best be regarded not as generating extra demand, but avoiding the

loss of passengers who could be deterred by the high levels of delay if no congestion relief measures are implemented. The cap described above will then apply to the proportion of forecast passengers who could be deterred.

For LUL, observation of demand build up following train service frequency changes has revealed that new demand from a project is not generated immediately but builds up over a period of time. The observed build up of demand is as follows:

- 35% in the 1st year of operation
- 75% in the 2nd year
- 90% in the 3rd year
- 100% in the 4th year and thereafter.

These factors must be applied to the revenue generated due to any passenger time savings or ambience improvements. These are coded into the Business Case Model spreadsheet.

No comparable "build-down" following a reduction in passenger benefits should be used. There could be some interval before a service reduction is interpreted as a permanent, rather than a temporary, change; but basically it is "experienced" immediately by existing passengers. By contrast, the attraction of new passengers depends crucially upon them finding out about the change.

Note too that the passenger time (or other) benefits are realised immediately the project is implemented. Thus for a project implemented during Year 0 with a passenger benefit of £80,000 pa, the eventual revenue gain will be £22,400 pa (using an elasticity of 0.28). The entries in the business case spreadsheet (to the nearest £1,000) will be:

	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Revenue	0	8	16	19	22	22
Passenger Social Benefit	0	80	80	80	80	80

It should be noted that after closure of a station or section of line for a prolonged period (say greater than one month), the build up in revenue will be gradual.

Ryan Taylor [redacted]

For Buses, the realisation of capital project revenue generation (including changes in fraud levels) will build up over a number of years of a project's life. The profile varies according to the split of net and gross cost contracts (NCC and GCC) over the years following project implementation. A simple approximation is used in appraisals such that there is no demand increase in Year 1 (the year after implementation) and 100% of the forecast increase from Year 2 onwards.

If a proposed change will have a large impact on revenue in the short term and if the Client has reason to believe that other modes will not change at a comparable rate, they may wish to estimate a revenue impact that assumes transfers from other modes, at least in the short term, to illustrate the effect on gross margin. The maximum potential gain would be calculated using the "**own price**" elasticity which assumes no improvement in other modes. Again, these are given in the

BCDM Data Book and Business Case Model Spreadsheet: http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

The own price elasticity should only be used to calculate the effect on LUL or LB income in the short term and not for appraisals. TfL Business Case Development [redacted]) should be consulted on all occasions when calculations using own price elasticity are considered.

20.3 Revenue Effects In The Benefit To Cost Ratio

The revenue effects outlined above can be included for new trips in the benefit to cost ratio for relatively simple schemes. Typically, the user benefits would be estimated and the elasticities applied to represent the revenue benefit form new users. For these cases, the revenue just nets off the overall lifecycle cost to TfL, so reduces the cost and improves the benefit to cost ratio.

The theory for revenue is that it is a user charge and should be netted off the user benefits (i.e. top of the benefit to cost ratio) as well as the cost. Most of the time this does not need to take place in our appraisals outlined above because the new users would be willing to pay at least the value of the fares to make the journey (or they wouldn't make it) to get the time benefits. So long as new user time benefits are not included in the top of the benefit to cost ratio, it is ok therefore to not put new user revenue in as a disbenefit.

This gets more complicated when new user benefits are also estimated, typically for larger schemes and applying the rule of a half. If the modelling that underpins this work is based on generalised cost (i.e including changes in fares, tolls and road vehicle operating costs rather than generalised time) then it should automatically include revenue / user charge changes. If just a generalised time change is output and entered as a benefit into the benefit to cost ratio, then new user revenue should also be entered as a disbenefits (i.e. a user charge) on the top.

To reiterate: for a simple scheme without separate time benefits for new users, the revenue effect can just enter the bottom of the benefit to cost ratio as a reduction in net financial impact to TfL.

20.4 Financial Impacts On Existing Users

Most scheme business cases should not be modelling changes in fares for existing users. If there are any legitimate fare changes as a result of the scheme (as well as changes in tolls, user charges or private vehicle operating costs) should be reflected as either a benefit or disbenefits to individuals on the top of the benefit to cost ratio and the financial impact of that change on TfL (or other transport agencies) should be put on the bottom.

21. Some Specific Issues of Quantification

21.1 Consumer Surplus where entirely new demand is created

'Consumer Surplus' is the difference between what customers would be willing to pay, and what they actually pay. When a service is improved, the fare does not generally change, and the Consumer Surplus ('passenger benefit') is increased. In TfL appraisals, elasticity is used to represent the relationship between this increase in Consumer Surplus and the extra revenue arising from the increase in demand that is attracted as a result of the improved service.

When an entirely new demand is created, e.g. a large new development is constructed near an Underground line, the above relationship between the increase in Consumer Surplus for existing passengers and the extra revenue from new passengers does not hold. Therefore it is wrong to calculate the Consumer Surplus change in these cases as the revenue increase divided by the elasticity.

In the absence of any contrary evidence, an assumption shall be made that the passengers new to public transport would have been prepared to pay an amount ranging from:

The current fare to *the current fare x 1.5*

The consumer surplus gain shall therefore be estimated as half the fare change multiplied by the new demand, i.e.

0.25 x the revenue arising from the new demand.

(Under this assumption, the number of passengers prepared to pay increasing amounts tapers off up to the maximum, so on average, passengers would only be prepared to pay about 17% more than the existing fare.)

Note that some specific sectors of the market, including people with impaired mobility, may have been prepared to pay a much higher multiple of the existing fare.

21.2 Service Delivery Standards

Service Delivery Standards describe the level and quality of service that LUL is committed to deliver to its customers. The Standards indicate where shortfalls in service quality should be rectified.

It is intended that generic business cases can be demonstrated for most of the Standards, and provided that each proposed project has costs and benefits broadly in line with those assumed in the generic case, no detailed business case will need to be provided.

A user guide is available showing the assumed costs and benefits for each improvement at each location, with guideline values showing at what point increased costs would make each improvement unviable. For any projects falling outside these guidelines, conventional business cases will be required (as they will be for any Standard which does not turn out to have a generic business case).

Customer Service Strategy: Xavier Brice, [redacted]

21.3 Apportioning benefits between two or more projects

When two or more projects contribute jointly the achievement of certain benefits, apportioning may or may not be appropriate. In the first example, suppose project A provides about twice the extra space that a later project B will contribute towards the relief of congestion in a station. Project A might have an excellent benefit:cost ratio, whilst an incremental appraisal of the project B might show a much poorer ratio (though still above the value for money benchmark). However, it is possible to envisage that, if the projects were appraised in the reverse order, project B's benefit:cost ratio would be much improved (since the relief of the heaviest congestion brings the greatest benefits). Under these circumstances, it would be appropriate to use a method which is robust to the order in which the projects are carried out, by apportioning the overall benefits in the ratio 2:1.

In the second example, suppose the attainment of a new peak frequency on an Underground line is completely dependent on two different infrastructure projects: a power supply upgrade, and a new signalling system. Should the total benefits be apportioned? (How would it be done, is it on the basis of cost of each project? How would the other benefits of the projects be taken into account?) Apportioning the benefits would be quite arbitrary, and in this case there is no alternative to a joint appraisal of the two projects.

It is also worth considering a combined programme level business case showing the overall value of the programme that undertakes the analysis to decide which order to undertake the projects (see 2.11).

21.4 Social inclusion (and distributional impacts)

The Treasury's Green Book revision (2003) highlights the need to consider distributional issues – how benefits and disbenefits are apportioned amongst different groups – in appraisals.

In transport appraisals, it may not always be possible to distinguish impacts on different income groups. Nevertheless, some groups, e.g. bus passengers, are known to have lower than average incomes. Another example where different impacts can be distinguished would be where high level modelling enables particular journey time savings to be related to geographical areas whose populations have different levels of deprivation. Where such analysis is available, the appraiser should quantify and draw attention to any differential impacts of a proposal.

Distributional evidence should be presented in the Strategic Assessment Framework (see Section 11) which allows differential impacts to be assessed, not only with respect to the deprivation categories listed in the note below, but also regarding gender, race, etc. Significant distributional impacts should be outlined in the Business Case Narrative.

In particular, any benefits favouring – or disbenefits further disadvantaging – groups which are socially excluded, should be highlighted.

Note. The Government's Index of Multiple Deprivation (IMD) (2015) provides a guide to the extent of various types of deprivation within areas (though does not reveal to what extent individual households are subject to multiple deprivation). The IMD uses indicators under seven broad headings ('domains') which are weighted as follows:

income	22.5%
employment	22.5%
health & disability	13.5%
education, skills & training	13.5%
Housing and services	9.3%
living environment	9.3%
crime	9.3%

Table 2-1: Weightings for Domains of Deprivation

Each ward is given an overall IMD score, which is the sum of its weighted domain scores. A high score or a low rank indicates an area of higher deprivation, where adverse distributional issues should be carefully considered.

The link below provides data for all Local Authorities and wards to determine deprivation levels: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015

21.5 Industrial Relations Impacts

Any change initiative that is being appraised need to include all the potential costs and benefits of that change in the benefit to cost ratio. This includes the potential impact on industrial relations. If there is a high risk of lengthy industrial relations issues, then these may far out weight the potential benefits.

Industrial relations issues can be included in several ways:

- **Certain costs** – an attempt should be made to *estimate* these and include them as a cost. These may not be bourn by the project expected final cost, they could be expenditure by a central department such as HR but they are clearly a cost of the initiative.

- **Project risk** – any project cost that may be affected by industrial relations (i.e. it is uncertain) should be estimated in the *risk register*.

- **Opex costs** (such as wages) and impact on **revenue** as a result of strikes should be estimated and the time impact to passengers estimated. The uncertainty of these impacts should be acknowledged and various *sensitivity tests* used to show the potential impact on value for money/

22. Asset management

22.1 Overview

Asset Management interventions requiring a Business Case are typically 'renewals' (including major refurbishments and replacements) of existing assets. A renewal intervention is required when an asset nears the end of its economic life, when its performance deteriorates and the cost of keeping it in service increases (or the disbenefit increases due to longer periods out of service). These interventions are usually delivered as Delivery Portfolios (annualised programmes), rather than individual projects.

The objective of a Delivery Portfolio is generally to maintain a group of assets in a stable condition profile, with benefits usually associated with the avoidance of cost and risk, rather than the delivery of any new savings or social benefits. For these projects, it is often difficult to justify expenditure using a traditional BCR approach, particularly for long life infrastructure assets where the impacts of not investing may not be felt for many years. In addition, the BCR does not take into account many of the benefits associated with asset management inventions that cannot easily be monetised such as; reputation, customer satisfaction, asset condition, asset risk, sustainability, resource balancing, compliance and synergy opportunities with other projects and programmes.

Although a BCR is still required as a measure of value for money, it is more important to demonstrate the proposed investment **maximises the value** from the assets, particularly where non-monetised benefits are important, or where the BCR is low. Where the optimum solution is not possible (for example due to funding constraints), the long term impact of the decision needs to be understood, including cost, risk, condition and performance.

'Value' can be demonstrated through the following measures:

Whole Life Cost	The **total** discounted present day cost of ownership over the life of an asset, including up front capital cost and all future maintenance, operating and capital costs. Can also include monetised benefits / benefits.
Whole Life Value or Net Present Value (NPV)	The **net** financial and monetised benefit delivered by an intervention / option over the life of an asset, presented as discounted present day value.
Value Index	The total weighted Values Scores, providing a comparative measure of the total Value for each Option. Provides a comparative measure of benefits delivered by different options. (Output from Value Management Assessment – see Chapter 6).
Value for Money Ratio	The Value Index (or Whole Life Value, where applicable) divided by the whole life cost. Provides a comparative measure to compare and prioritise different options.

22.1.1 When is a Business Case Required?

For Delivery Portfolios that are collections of projects grouped together for managerial convenience, an overarching summary business case should be produced.

Separate business cases should also be provided for individual Projects over £2m at Pathway Stage 2, to provide justification for the single option selection.

22.2 REQUIREMENTS

The standard business case template should be used for both Delivery Portfolio's and single asset renewal projects, following guidance within the template on appropriate scaling.

Business cases for asset renewals, including Delivery Portfolio's should consider the following criteria:

Financial	Capital Costs	• Upfront costs of 'renewal' • Future capital costs associated with 'do nothing' or 'deferral'
	Maintenance Costs	• Reduced maintenance following renewal • Increased planned and / or maintenance for 'do nothing' or 'deferral' as asset condition continues to deteriorate. • Risk mitigation costs for 'do nothing' or 'deferral' as asset risk increases.
	Operational Costs	• Reduced operational costs associated with new, modern asset e.g. reduced energy consumption
	Enhanced Capital Allowance	• Recoverable costs for installation of energy efficient systems
	Revenue	• Associated with social benefits / dis-benefits below
Social Benefits[1]	Journey Time	• Dis-benefit associated with non-availability of asset during renewal intervention • Dis-benefit associated with increasing asset risk for 'do nothing' or 'deferral'. • Dis-benefit associated with unplanned maintenance or increased planned maintenance for 'do nothing' or 'deferral'.
	Safety	• Dis-benefit associated with increasing asset risk
	Ambience	• Benefit associated with improved asset condition for 'renewal' option • 'Dis-benefit associated with decreasing asset condition for 'do nothing' or 'deferral'.
	Environmental	• Benefit associated with newer, cleaner asset for 'renewal' option

[1] All monetised social benefits to be calculated according to standard BCDM methodology (see Chapter 4)

An asset management business case should be produced because the usual asset management documents are extensive and difficult to home in on the right information.

The strategic case for investment can be provided through reference to the relevant Asset Strategy, however this should be summarised and made clear in the Strategic Case, i.e. what is the case for doing something and what are the objectives of doing something? What measures will be used to decide options and value for money?

Justification for the Economic Case can be demonstrated by reference to the asset management processes used to prioritise the workbank, or an existing document such as an Asset Management Plan, providing the following points are adequately addressed and summarised into a self standing case;

- Output of analysis to justify the size and composition of the portfolio (i.e. options)

- The condition / risk profile and impact if the funding was reduced (options)
- Capital costs
- Costs and dis-benefits avoided through the intervention(s)
- Whole Life Cost over the life of an asset or portfolio
- Demonstration that the intervention(s) deliver optimal value for money

The preferred option for a Delivery Portfolio is a programme of renewal interventions that deliver optimal whole life value across the asset portfolio, for the available funding. This should be compared to a 'do minimum' base case, which usually requires increased levels of maintenance as the assets continue to deteriorate, often coupled with decreased performance. It is good practice to also include other options, such as reducing or deferring the investment, which further strengthens the case by demonstrating the preferred option is optimal solution.

The diagram below shows an overview of the key asset management activities required to ensure interventions deliver maximise value for money and which should be summarised in the Business Case:

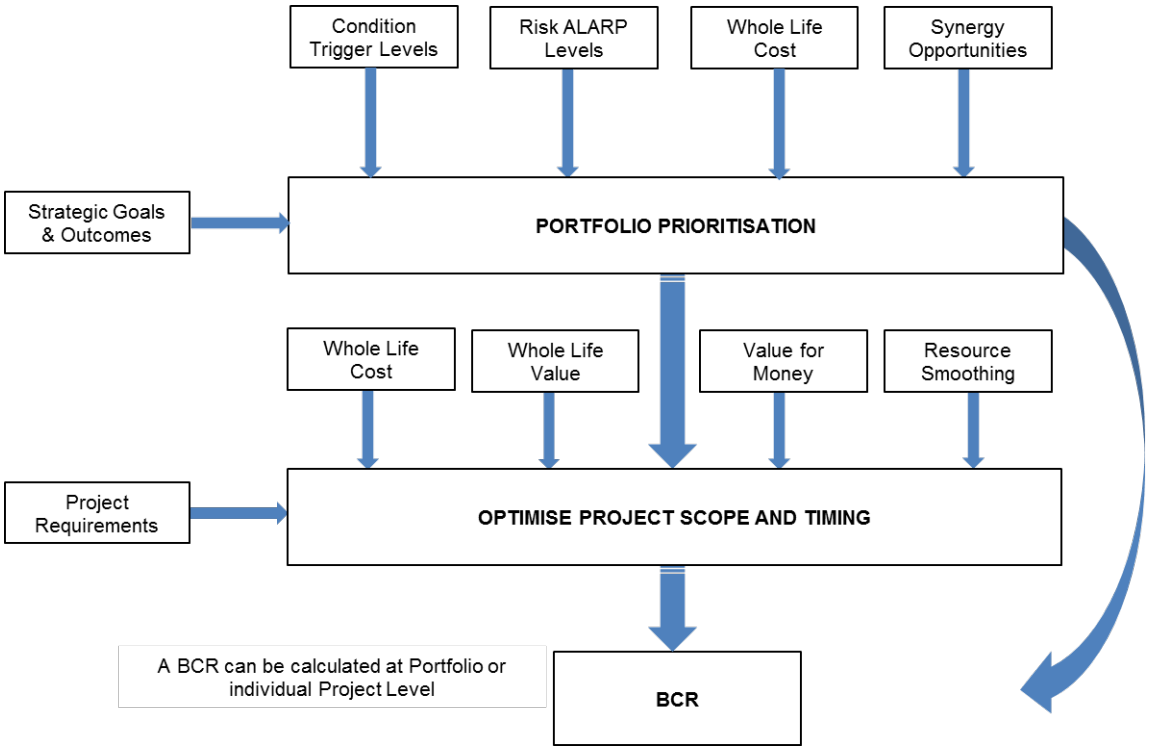


Figure 22.1: Key Asset Management Activities for Demonstrating Value

22.3 Asset strategy

The asset strategy is the long-term plan of activities for managing, developing and maintaining an asset portfolio, or group of similar assets that are required to support TfL's strategic goals and business objectives. The strategy should provide the methodology for balancing the trade off between condition, risk, performance and cost through optimisation of lifecycle activities that will deliver the specified outcomes, whilst taking into account degradation and the effects of changing demand on the asset portfolio.

The output of asset strategy is typically an Asset Management Plan, which clearly explains what the organisation plans to do with its assets with respect to acquisition, maintenance, operation and disposal and what level of service will be delivered as a result of these activities. The plan should reflect the optimisation of lifecycle activities, ensuring that the long-term implications of asset management decision making are understood.

Asset strategies are generally reviewed annually and updated as required to take account of changes to the strategic goals and business objectives, as well as any new innovations in technology and materials, development opportunities, and/or new information about deterioration rates or maintenance costs.

22.4 Lifecycle optimisation

Lifecycle optimisation is the process that balances capital costs, maintenance costs, associated revenue and asset risk, to determine the intervention(s) that represent the lowest whole life cost. In order to undertake this decision-making effectively, an understanding is required of degradation, costs and risks and how these change over time.

Although the 'renew now' option will have a higher upfront cost this is usually offset by lower ongoing maintenance and/or operational costs associated with the introduction of a new modern asset. Conversely, the deferral option will have a lower (or zero) upfront costs, but is likely to have higher maintenance costs that may continue to increase as the asset condition continues to deteriorate. There could also be future capital costs, as asset renewal cannot generally be deferred indefinitely, without costs becoming unsustainable or the asset being removed from service, which may have unacceptable consequences.

A renewal is generally required when an asset is at the end of its economic life i.e. when the operating savings and passenger benefits resulting from the renewal outweigh the financial advantage of deferring the capital expenditure.

Whole life cost is a key input to the prioritisation and optimisation processes, enabling the cost of asset ownership associated with different intervention options to be compared e.g. renew the asset now compared with deferring renewal. The optimal solution is generally the option that delivers the lowest whole life cost.

For optimisation purposes, whole life cost should also include monetised benefits (and dis-benefits, such as those associated with asset risk and periods when assets are removed from service for planned works). Asset risk is converted into safety and journey time dis-benefit as follows;

Functionality Risk	= Likelihood x Consequence Value (LCH's) x Value of Time[1]
Safety Risk	= Likelihood x Consequence Value (Equivalent Fatalities) x Value of Preventing a Fatality[1]

[1] See BCDM Data Book http://intranet.tfl/our-organisation/strategy-and-planning/Developing-business-case.aspx

Once monetised, risks can be balanced against cost, to identify the optimum intervention timing, including the cost of risk mitigation measures, such as additional planned maintenance, inspections or temporary works, which may be uneconomical in the long term.

This trade off between cost and risk to determine the optimal intervention is shown schematically in the diagram below.

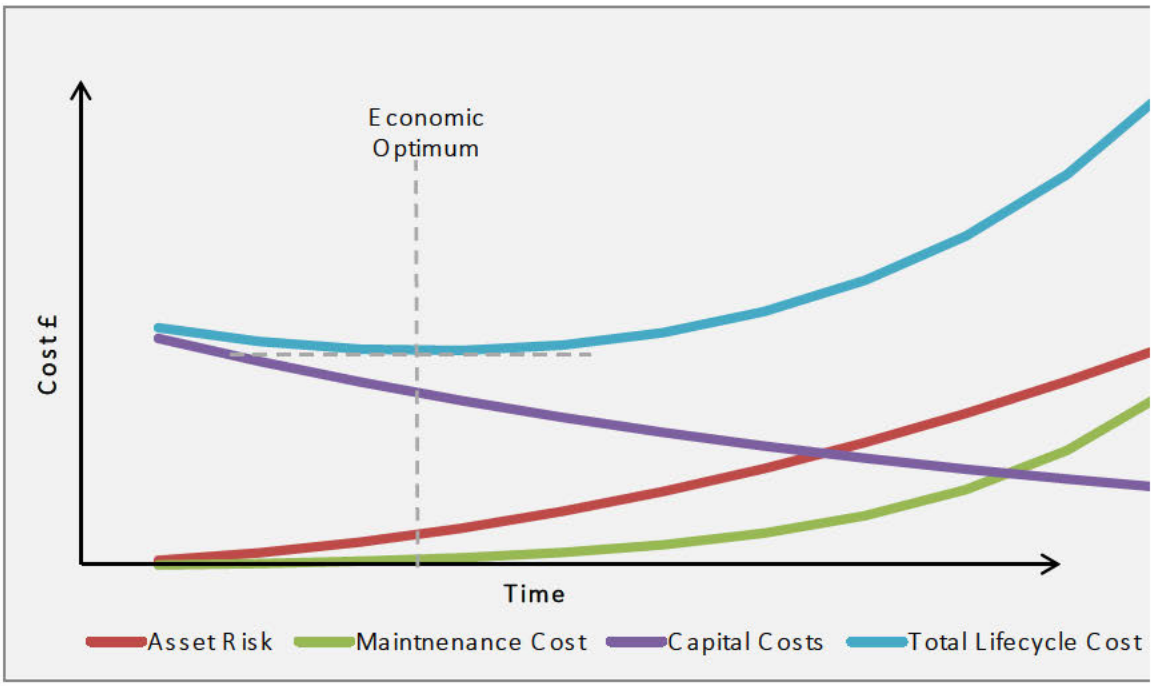


Figure 22.2: Demonstration of Optimal Intervention Timing

22.4.1 Works Coordination

Lifecycle optimisation maximises value from the asset by ensuring optimum interventions are carried out at the optimum time. However to fully maximise value, work programmes also need to be coordinated to take advantage of synergies with other projects and programmes. This will reduce cost and disruption to the network by making use of shared downtime, resources and overheads. Interventions should also be packaged to maximise economies of scale e.g. multiple interventions on the same asset, or similar interventions across multiple assets.

Synergy opportunities are considered by the Asset Managers during the development of the Asset Management Plans. Sponsors should also make themselves aware of further opportunities by speaking with other Sponsors and by checking planned closures;

- *R&U Events and Closures Planning Team – Charles Baker,* [redacted]
- *Surface Works Co-ordinating and Permitting Manager – Helena Kakaouratos,* [redacted]

Once opportunities had been identified, work co-ordination can be carried out using tools such as SALVO, which integrates the different programmes of work and packages activities together to deliver them in the most optimal way.

22.4.2 Long-Life Assets

For a very long lived assets (e.g. a bridge), it can be difficult to justify a renewal through optimisation, as this can often be deferred by many years with suitable risk mitigation in place, making the discounted cost of renewal very low. However, to defer all renewals would result in a bow wave of future interventions, which would be unsustainable in terms of future cost, impact on

performance and resource demand. There could also be loss of reputation and customer satisfaction associated with a deteriorating asset condition, leading to further revenue loss. For these assets, justification may be better provided through Management of Value assessments – see Chapter 12 for further information.

22.5 Decision support tools and techniques

Although the business case model may be sufficient for comparing a limited number of simple options, the optimisation of complex data sets and the comparison of options across large asset portfolio's generally requires the use of more robust decision support tools and techniques. These are summarised in the Table below;

MANAGEMENT OF VALUE	Pro's • Demonstrates alignment to strategic objectives and Project requirements • Prioritises across Asset Portfolio, to select assets that deliver maximum Value • Identifies options at asset / project level that deliver greatest Value Con's • Although Value can be monetised, the output is usually measured as an index, so cannot be used to generate a BCR.
SALVO (Strategic Asset Life-Value Optimisation)	Pro's • Evaluates optimal intervention and timing at individual asset level (and for groups of similar assets) by optimising whole life cost and monetised risk • Optimises intervention timing across programmes of work • Includes sensitivity testing to cope with uncertainty of data • Produces forecasts of future costs and risk Con's • Important strategic benefits may be omitted as only monetised benefits and costs are modelled.
BESPOKE WHOLE LIFE COST MODELS; Track WLC Model L&E WLC Model Civils STRATA Model Surface WLC Assessment Template	Pro's • Evaluates optimal intervention and timing at individual asset level by optimising whole life cost and monetised risk • Optimises intervention timing across asset portfolios • Produces forecasts of future costs and risk Con's • Important strategic benefits may be omitted as only monetised benefits and costs are modelled.
BUSINESS CASE MODEL (Benefit-Cost Ratio)	Pro's • Provides a measure of Value for Money • Evaluates the main options using standard parameters and formulae • Enables Asset Management Projects to be compared directly with other projects and programmes. Con's • May be difficult to justify investment on its own due to lack of new Social Benefits and / or savings generated over the appraisal period. • Time consuming to calculate across large portfolio's.

Different decision support tool / models may therefore be used at different stages of the decision making process, depending on the capability of the model and the complexity of the decision being made.

Life cycle cost and value decisions are only ever as good as the information on which they are based, including asset condition, risk, capital cost of renewals and operating and maintenance costs, both now and as the assets degrade through their life. However, assumptions will often be uncertain due to inadequate data, or variability in asset behaviour and knowledge gaps. Sensitivity testing should be carried out to identify the robustness of result and test the assumptions that have a big effect on the results as even highly uncertain assumptions may be acceptable, if they do not have a significant effect on the results. A tool such as SALVO can be helpful by assessing the value of obtaining better information.

22.5.1 Asset Classification

Due to the large number of assets in some portfolio's, it is helpful to sub-divide assets into smaller groups with common attributes and generally perform in similar ways. This categorisation should take account of material type, construction, deterioration rate and function criticality, so that asset risks and costs are similar for optimisation purposes. Although all the assets within a classification will have the same optimised lifecycle interventions, each asset can be at a different place along the timeline, according to its current age and condition.

22.5.2 Asset Condition and Trigger Values

Once optimised lifecycle interventions have been identified for each asset category, the intervention point can be related to a specified asset condition. An asset will can therefore be considered for renewal once the asset condition reaches a pre-defined 'trigger value'. These trigger values will vary between asset types and are based on a range of criteria including physical condition, faults, defects, and performance.

The approach can be used to narrow down the number of assets at the portfolio prioritisation stage, ensuring only assets at or approaching, its trigger value are considered for renewal.

Appendix A: Models and Simulation Tools

A.1 Introduction

This appendix contains detailed descriptions of modelling tools commonly employed in quantifying benefits for the purpose of the business case. The appendix is arranged in the following sub-sections:

- Summary table of all models described
- The four-stage modelling concept
- The hierarchy of TfL models
- Land use and transport interaction (LUTI) modelling
- Demand modelling
- Strategic public transport modelling
- London Underground operational modelling
- Strategic highway modelling
- Tactical highway modelling
- Micro-simulation modelling
- Bespoke strategic models
- Pedestrian Modelling
- Cycle modelling
- Connectivity assessment tools
- Emissions modelling

A.2 Summary of Commonly Used Models

Name Of model	Ownership	Contact Details and Links	Summary of Model and Purpose	Study area	Examples of Applications
Land Use Transport Interaction Models					
LonLUTI	TfL Planning (Strategic Analysis)	Tej Hunjan, [redacted] Olga Feldman, [redacted]	Land Use Transport Interaction model covering London and the South East and East of England regions. Combines extensive land use data with LTS transport network to provide means of representing land use and transport systems responses.	London and the South Eastern and Eastern Regions.	Development of transport and land use strategies, assessing impact of major transport schemes on land use.
Demand Modelling					
LTS	TfL Planning (Strategic Analysis)	Chris Hyde, [redacted] Tej Hunjan, [redacted]	Strategic Multi-modal model for policy analysis, scheme evaluation for PT and highway schemes and provision of data to other models	Detailed inside M25, plus broad zoning for rest of UK.	Applications include Crossrail, London Plan, MTS, T2025, congestion charging.
LoRDM	TfL Planning (Strategic Analysis)	Ali Inayathusein, [redacted]	A variable demand modelling system designed to produce travel demand forecasts at the sub-regional level in London. Demand responses assessed are: mode shift, trip generation, trip distribution and shift to non-mechanised modes. LoRDM can be used to assess demand responses arising from the impact of both Highway and/or PT schemes.	Designed to link the Sub-Regional Highway and PT models together - so study area is whatever models are linked	Assessing Sub-regional schemes

Name Of model	Ownership	Contact Details and Links	Summary of Model and Purpose	Study area	Examples of Applications
LUTE	TfL DLR	David Arquati, [redacted]	Land use database and trip generation model for Docklands area. GIS database containing site specific development assumptions based on planning applications and local authority/developer information for wider Docklands area to produce trip end inputs to DPTM model	Wider Docklands area (old LDDC plus parts of Lewisham and Greenwich, Barking, Woolwich, Stratford).	DLR network based improvements
Strategic Public Transport Assignment Models					
Railplan	TfL Planning (Strategic Analysis)	Richard Hopkins, [redacted]	Evaluation of PT infrastructure changes, typically based on fixed PT demand matrices. Uses LTS demand matrix for evaluation of public transport projects, can be used to examine detailed impacts within sub-regions.	Detailed inside M25 (more than LTS) but rest of UK covered	Crossrail, Olympic Plans (PT), MTS, T2025, Thameslink, LUL PPP analyses (NACHS).
DPTM	TfL DLR	David Arquati, [redacted]	Evaluation of PT/DLR improvements in Docklands area	London and South East but with great aggregation outside Docklands area and more detail inside	DLR network based improvements, Olympic assessment
MOIRA	Network Rail	Alan Smart [redacted]	Evaluation of impact of changes to NR service patterns, frequencies and run times.	South East, greater detail in London. Outside South East very coarse	Off peak changes to Southeastern network, devolution of West Anglia network to TfL control.
Strategic Highway Models					

Name Of model	Ownership	Contact Details and Links	Summary of Model and Purpose	Study area	Examples of Applications
Sub-regional Highway Assignment Models; (HAMs) CLoHAM, NoLHAM, WeLHAM, SoLHAM, and ELHAM	TfL Planning (Strategic Analysis)	Huy Nguyen, [redacted]	London sub-regional Highway Assignment Model. Available and being used for several studies. There are five models - one for each sub-region of London	Modelled area includes the core area of London sub-region boroughs, within M25 and all UK	Assessment of highway impacts of changes in land use, impacts of strategic highway schemes. Can form basis for more detailed models.
London Underground Operational Models					
Train Service Model (TSM)	TfL LUL	Sandra Weddell, [redacted]	To simulate train service impact on passenger journey time.	Single LUL line (or set of interworking lines)	Evaluation of the benefit of changes to service levels, service patterns, infrastructure or operational arrangements
Journey Time Capability Model (JTC)	LU Transport Planning	Dave Hughes, [redacted]	A spreadsheet model that evaluates the infrastructure provided – track, signalling, rolling stock characteristics etc. – in terms of the service that could be provided with these assets	All lines	Shortlisting potential upgrade options
Station Service Model	LU Transport Planning	Dave Hughes, [redacted]	A spreadsheet model to simulate ticket purchase activities within stations		
Heat Strain Risk Tool (HSRT)	LU Engineering Railway Systems	Tony Lightfoot, [redacted]	A model to provide monetary value to the impacts on passengers arising from changes in temperature.	Deep tube lines	

Name Of model	Ownership	Contact Details and Links	Summary of Model and Purpose	Study area	Examples of Applications
Tunnel Ventilation Model	LU Engineering Railway Systems	Tony Lightfoot, [redacted]	Quantifies the change in temperatures on the deep tube network resulting from service and cooling infrastructure changes.	Deep tube lines	
Railway Engineering Simulator	LU Engineering Railway Systems	Tony Lightfoot, [redacted]	Models the performance of train systems, determining train performance and energy consumption.	All LU lines	
Tactical Highway Modelling					
ONE	TfL Traffic Directorate (TD), Surface Transport	Vladimir Vorotovic, [redacted]	Operational Network Evaluator (ONE) is being used for studying the medium term impact to the highway of operational traffic management and traffic control policy proposals. In addition the model is being used to assess the impact of temporary conditions such as road works, events and major incidents on the network. It is not used to assess long term impacts of permanent schemes. Provides link with more detailed models including VISSIM.	A significant part of central London engulfing most of the CC (WEZ included) area.	ONE operational tests (e.g. WEZ removal, VSU upgrade road works, Oxford St road works tests, State opening of Parliament).
Highway Micro-simulation and Detailed Junction Models					
VISSIM	TfL Surface Transport	Vladimir Vorotovic, [redacted]	To measure performance of networks under different types of traffic control, cycle time and timing plans. Also to measure resilience of network to recover from serious incidents. Design congestion management strategies.	Various throughout London	Hundreds
LINSIG			To optimise cycle time and timing plans for isolated junctions.	Various throughout London	Thousands
TRANSYT-			To optimise the cycle time, offsets and stage lengths of networks of junctions with a view of minimising average delays and stops for general traffic and buses.	Various throughout London	Hundreds
Pedestrian models					

Name Of model	Ownership	Contact Details and Links	Summary of Model and Purpose	Study area	Examples of Applications
Static Toolkit	TfL LUL	Sandra Weddell, [redacted]	Checks for compliance against Station Planning Guidelines	Can be used for any LU station	Evaluating impact of demand changes due to blockades and closures
PEDS			Analysis of Passenger congestion levels internal to LUL stations		
PEDROUTE			Analysis of all LUL station	Individual stations on networks	Assessment of all LUL station designs
LEGION (Stations)			Detailed analysis of pedestrian movements in a range of different environments, including stations, stadia and footways.	Various throughout London	Various including Crossrail, Thameslink, Step Free Access/Congestion Relief schemes
LEGION (Surface)	TfL Traffic Directorate, Surface Transport	Brett Little, [redacted]	Detailed analysis of pedestrian movements on street in a range of different environments, including highway schemes, Interchange Programmes and Event Planning (Olympics).	Various throughout London	Various where pedestrian network is impacted; Highway Improvement Schemes, Interchange Programmes, Olympic Planning
Cycle Modelling					
CLoHAM	TfL Planning (Strategic Analysis)	Ali Inayathusein, [redacted]	An adapted version of the model to examine the impact of changes in cycle usage on highway congestion	Central London	Analyses for the Business Case for the Mayor's Cycling Vision
Connectivity Assessment Tools					

Name Of model	Ownership	Contact Details and Links	Summary of Model and Purpose	Study area	Examples of Applications
PTAL	TfL Planning (Strategic Analysis)	Simon Cooper, [redacted]	Access to the public transport network, providing Public Transport Accessibility Levels	GLA area calculations (100m²) grid and point specific	London Plan and MTS2, GLA Planning applications
CAPITAL			Calculation of detailed PT timings between locations within GLA area for current and Future networks	As Railplan	Crossrail parliamentary evidence, Decisions on Court closure, London Plan work
ATOS			Calculation of travel times for services for each Super Output Area in London	London-wide	London-wide accessibility indices in policy documents
Environmental Emissions Models					
EAT	TfL Planning (Strategic Analysis)	Claire Cheriyan, [redacted] (or refer to Chris Hyde)	Spreadsheet model calculating emissions from road transport, river, aviation and rail	GLA	NOx action plan policy screening, ULEZ, River Crossings business case

A.3 The Four-Stage Modelling Concept

The process of forecasting how travel demand would change in a new scenario follows an approach known as "four-stage modelling". Each "stage" represents a single type of decision that travellers need to make, analysed separately. This does not necessarily mirror the decision making process of any individual, but is a simplification of the complex behavioural phenomena, of the population as a whole translated into a feasible analytical process.

The four-stage approach has evolved over many years, and it may now include additional steps, since some observed responses of travellers to transport interventions were not included originally. The term "four-stage modelling" is still conventionally used to cover the expanded process.

The behavioural responses included in the four-stage approach form a hierarchy, whereby the first stage provides input to the second stage and so on through to the final stage. The process is iterative, with the output of a subsequent phase altering the input to a previous phase. The whole process may therefore be repeated from top to bottom several times because the understanding of behaviour is updated in each iteration, using better estimates obtained in the previous iteration.

The order of the stages in the modelling sequence has mathematical implications that go beyond the scope of this text. As an intuitive explanation it can be said that the earlier stages stand for responses that travellers will only rarely consider changing. If something changes about a traveller's journey, they would more readily reconsider the choice they made in the last stage (e.g. which bus route to use) than the choice made in the first step (e.g. where to live).

The traditional four stages, as well as components added later to this convention, are important to consider when preparing a business case. These components include:

i. Trip Generation – How many trips will be made?

Population forecasts, economic forecasts and land use patterns are needed as inputs to this stage in the traditional four-stage approach. Trip rates (i.e. number of trips made per person) are derived from historical information such as surveys and census data. The calculations are made separately for a number of different trip purposes (such as commuting, business and leisure). The output of this stage is known as 'trips ends', i.e. the estimated number of trips that start or end in a particular geographical area. An agreed split of the overall study area into such geographical areas is referred to the "zoning system", and each individual area is a "zone".

ii. Mode Split or Mode Choice – How will people travel?

Traditionally this was the third stage in the four-stage hierarchy, but more recent evidence supports the decision to place it as the second tier of decision making. This stage uses parameters that represent user preferences in the relevant area to split the trip ends between different travel modes – primarily between trips made by car and trips made by public transport. Some mode choice models further split public transport demand into specific public transport modes such as rail, underground and bus. Recently there has been progress in also incorporating walking and cycling into mode split models, but this is an area of modelling which is still under development. The choice between modes in any mode choice model takes into account the travel time to make a journey by each of the available modes, weighted to reflect the relevant inconvenience of each element of the journey such as waiting time, transfer time and in-vehicle time. Other variables that affect mode choice are out-of-pocket costs including fares, the availability of a car for use, and

other factors representing real or perceived bias towards or against certain modes (such as the level of privacy, comfort and flexibility when travelling).

iii. Trip Distribution – Where will the trips go?

Travel and traffic analysis requires full information on trip origins and destinations. Trip generation and mode split are often analysed at the trip end level, i.e. as the totals for all the origins and all the destinations separately. At the trip distribution stage, trip ends for origins and destinations are linked together, to produce a full Origin to Destination (O-D) matrix. Traditionally this was done before the mode choice stage, hence it was the second stage in the modelling hierarchy, whereas now it is more common, based on recent behavioural evidence, to model trip distribution as the third stage. Trip distribution calculations normally employ a 'gravity' process, whereby the trip ends (i.e. total trips to/from each zone) are broken down, using information on distance or travel time, into a full matrix for each trip purpose, describing the estimated number of trips from each zone to each other zone.

iv. Time Choice – When will people travel?

People may choose when to travel based on the time when they need to undertake an activity (e.g. get to work). But depending on the purpose of their journey and other specific circumstances, they may be able or willing to reschedule their journey in order to make it quicker, more comfortable or cheaper. Some tools can estimate this time shifting mechanism, which is particularly critical for pricing, charging or tolling schemes, where the price varies between the peak period and other periods. Time choice was not included in the traditional four-stage modelling approach. It is becoming more common as peak crowding and congestion become significant issues. Time choice is still not a common functionality, and potential enhancements for specific studies need to be considered if time shifting is likely to have a significant impact on their business case.

v. Assignment or Route Choice – What routes will be used?

Assignment models take the demand matrices from the previous step and work out how those trips would use the network available to them. Separate route choice models are available for London's highway network (looking at driving routes) and for its public transport network (looking at the way passengers choose where to board, transfer and alight). TfL Planning also has an initial version of a highway model suitable for looking at route choices on cycling trips. All assignment models are iterative, since the number of people choosing each route affects travel times, levels of crowding and congestion, and these in turn influence people's routing decisions. The simulation of these decisions runs in a loop until an equilibrium position is reached.

A.4 The Hierarchy of TfL Models

The four stage process is undertaken with strategic level models which cover large geographical areas. However, for many investment proposals within TfL a more localised but in depth understanding is required to appropriately quantify benefits (for example, more detailed localised analysis of the performance of signal settings in a junction or of crowding levels within a station). A range of tools has been developed across the business drawing on specialised technical knowledge of assets and the interaction between these and the people who make use of them. As the appraisal process continues to evolve and develop, these models will become ever more critical to informing management decision making.

Most commonly, the operational and localised models make use of standardised output from the four stage process, and therefore the implicit assumption is that travel behaviour decisions forecast through the four stage process are not changed by the investment proposal. Therefore a "hierarchy" exists in terms of the scope of the models and the way they are being used.

When planning how to appraise an investment, all these types of models should be considered, but not necessarily used. This is to be judged based on the likely credibility of forecasts from a model in each specific context.

A.5 Land Use and Transport Interaction (LUTI) Modelling

As explained in the Section 3 of the main text, the traditional approach to transport modelling is based on a four-stage process of trip generation, trip distribution, modal split and assignment. The traditional approach does not examine whether changes in travel demand trigger wider impacts over time, including people and businesses choosing to relocate, and the changes in prices and land uses associated with such choices. LUTI models are used to estimate such long-term impacts in studies or projects where they are seen as relevant. Changes in land use lead to changes in trip generation and subsequently in all other modelled choices; therefore, when a LUTI model is used on top of the four-stage hierarchical process, it is positioned at the top of the model hierarchy, above trip generation.

LONLUTI

Overview: LonLUTI (London's LUTI model) forecasts urban, economic and transport change across the Greater South-East region, taking particular account of planning and transport interventions within London and immediately around it. The model is an application of the DELTA model, developed by the David Simmonds Consultancy. It forms an integrated package that combines DELTA with a version of the LTS transport demand model (see below). LonLUTI can produce a detailed set of forecasts of how the region will change over time given a set of economic and demographic scenario inputs combined with planning and transport policy information.

Input: Land use details, economic and socio-demographic data, and a transport network.

Output: Population, households, employment by type; car ownership and car availability proportions; floorspace stock, vacant floorspace, rent, unused permissible development by floorspace type; origin and destination accessibility measures by household type, purpose and car availability level; workers employed by activity and socio-economic level; travel-to-work data by socio-economic level and car availability; transport data (from LTS) including cost of travel by purpose, main mode and car availability.

Area coverage: LonLUTI covers the whole of the Greater South-East, i.e. London, the South-East and the East of England.

Transport modes: Same as LTS (public transport and highway).

Journey/activity purposes: There are 40 household types (10 household types split by 4 socio-economic levels); 40 income groups; 4 person types; 20 employment types; 11 floorspace types, 7 travel purposes in the demand model; 2 highway assignment purposes.

Time periods represented: 24 hours in the demand model; 3 time periods (AM peak, Inter Peak, PM peak) in the assignment as in LTS. An average weekday is represented (with no seasonality), and an average hour is represented in each time period.

Base year: 2007; the model is currently being rebased to 2011.

Future years: All years between 2007 an 2041, based on transport model outputs for 2007, 2011, 2016, 2021, 2026, and 2031.

Software: Pshell (LTS), Fortran (DELTA).

Operation: Run and maintained by TfL and the David Simmonds Consultancy.

When to use the model: LonLUTI provides a powerful tool for examining and consequences of alternative transport and planning decisions for London. LonLUTI can consider the impacts of planning decisions on the distribution of economic activity, and the mutual feedback between economic, spatial and transport activity. It can form a critical input in projects where there is interest in estimating wider economic benefits as recommended by WebTAG.

Examples of model application: Assessment of Crossrail 2, River Crossings programme, Northern Line Extension, London Underground Deep Tube Programme.

Model limitations: The model cannot represent changes at a detailed level (for example, Output Area level). The model is not suitable for testing schemes outside Greater South East or close to the boundary.

Group Planning, Strategic Analysis: Tej Hunjan, [redacted] Olga Feldman [redacted]

A.6 Demand Modelling

LTS

Overview: LTS (originally named after the London Transportation Study) is the foundation for all strategic modelling carried out within TfL. It is a strategic multi-modal simulator of London's transport system, and it extends to cover all of the UK. Its principal relevance to TfL is in creating a complete picture of current and future year public transport and highway travel demand. LTS features the traditional four-stage modelling with trip generation, mode split, trip distribution and assignment modules. The model requires a representation of the public and private transport networks, which allow travel times, fares and other user costs to be calculated. Based on comparable travel times and consideration of car availability, the model determines what proportion of the total demand would travel by each mode. Demand changes for walking and cycling are also estimated. Trip ends, distribution and modal split were calibrated against observed data, including the London Travel Demand Survey and previously London Area Travel Survey, to ensure the demand results are realistic.

Input: LTS requires forecasts of population and employment by geographical area covering the whole of the UK, and more detail coverage within the GLA area. These are based on historical census information for the modelled base year (2007), and primarily on the London Plan for future levels. The current London Plan sets out a fully integrated economic, environmental, transport and social framework for the development of the capital to 2031, and is produced by the GLA together with national forecasts provided by DfT. LTS also requires information on the overall changes in income, GDP, public transport services and routes, new roads and other highway restraint measures.

Output: LTS produces forecasts of the number of trips that would be made (trip generation), from where to where (trip distribution), the modes of transport chosen, highway flows and speeds, public transport boarding/alighting figures, and public transport route loadings.

Area coverage: Detailed inside M25, plus broad zoning for the rest of the UK.

Transport modes: Private vehicles (car driver/passenger), other motorised vehicles (Taxis and Goods Vehicles), public transport (National Rail, LUL, DLR, London Bus network, and Tramlink), and a combined walk/cycle mode.

Journey/activity purposes: Split between home-based and non home-based purposes, blue and white collar work, car availability levels and person types.

Time periods represented: AM peak period (07:00-10:00), Inter-peak (10:00-16:00), and PM peak period (16:00-19:00).

Base year: originally built for 1991. Recalibration and validation for highway and public transport demand was undertaken using 2001 data and later updated to 2007. The work to re-base the model to 2011 using the 2011 Census data and other recent observed data is currently underway.

Future years: 2016, 2021, 2026, 203.

Software: Originally Unix-based TRIPS models with specialised features. LTS is currently being migrated to the CUBE/Voyager software, and the new version will be available in 2014.

Operation: Currently the capabilities to run LTS are limited to MVA Consultancy, Jacobs, and Mott MacDonald, who can produce and develop models scenarios and runs. Access to the model should be based on agreement with TfL Planning (Strategic Analysis).

When to use the model: The model should be used when considering major changes in transport infrastructure or land uses. Users may find it easier to use other models to test their infrastructure options before carrying out changes in LTS, because LTS usage can be time-consuming and resource-hungry. It is also advisable to limit the number of scenarios being tested.

Examples of model application: Supporting the production of the Mayor's Transport Strategy, assessing the impact of the Central London Congestion Charging Scheme, assessing the impact of introducing Crossrail.

Model limitations: LTS produces highway assignment results as part of its four-stage loop, but these are not generally used as an independent highway model, as the LTS highway assignment is not sufficiently detailed for some types of analysis. The relatively coarseness of LTS's highway network has a certain impact on all model stages through the iterative process. This was a key incentive for the development of LoRDM (described below).

Group Planning, Strategic Analysis: Chris Hyde [redacted] Tej Hunjan, [redacted]

LoRDM

Overview: The London Regional Demand Model (LoRDM) is a version of LTS, recently created to assess projects in East London, with a general intention to later use a similar approach throughout London. Most functions within LoRDM are similar to those of LTS, but the assignment models used in LoRDM include a more detailed network representation. Railplan is used for public transport route choices and ELHAM (described later in this chapter) replaces LTS's own highway assignment for highway route choices. LoRDM also incorporates some enhancements to the way assignment outputs are transferred between the assignment model and the rest of the demand model.

Input: Mostly the same as LTS. In addition, since LoRDM combines elements of LTS, Railplan and CUBE, conversion tables are required between the zoning systems used in these different components.

Output: Outputs from the demand model include demand matrices for highway and public transport that will be fed back into ELHAM and Railplan model respectively. For outputs from Railplan and ELHAM, see the relevant sections below.

Area coverage: Currently the model covers East London (as ELHAM) in greater detail, and the whole of the UK at a minimal level of detail. Versions of LoRDM covering other parts of London are likely to be created in the future and prioritised based on project needs.

Transport modes: Same as LTS.

Journey/activity purposes: Seven demand journey purposes; one highway assignment journey purpose in general but split into four separate user classes (three non-business purposes associated with three income groups and one purposes representing business travel).

Time periods represented: 24 hours in the demand model; three time periods in the assignment.

Base year: 2009; the model is being rebased to 2011.

Future years: 2021, 2031.

Software: CUBE, SATURN.

Operation: The model can be operated by the URS consultancy or by members of Strategic Analysis in TfL Planning.

When to use the model: LoRDM in its current form is primarily suitable for testing highway schemes in East London. Testing is underway to confirm its suitability for testing public transport schemes in the same area. Development of versions for other versions for the rest of London is currently being scoped.

Examples of model application: The River Crossings programme for East London.

Model limitations: LoRDM is a complex package, and a high level of expertise is required to assess how suitable it is for specific applications. Consultation with the model Custodians is recommended. Model run times are generally very high.

Group Planning, Strategic Analysis: Ali Inayathusein, [redacted]

LUTE

Overview: Land use database and trip generation model for Docklands area. GIS database containing site specific development assumptions based on planning applications and local authority/developer information for wider Docklands area to produce trip end inputs to DPTM model (note: this model will be discussed in a later section).

Input: Planning applications, masterplans, likelihood of developments being built, dates of opening, PTALs, estimated levels of car ownership, trip rate assumptions.

Output: Public transport trip ends for DPTM model within Docklands. Project is underway to also generate trip ends for Railplan sensitivity tests. The model can also generate highway trip ends although these have not been tested for some time.

Area coverage: Wider Docklands area (former London Docklands Development Corporation area plus parts of Lewisham, Greenwich, Barking, Woolwich and Stratford).

Transport modes: Forecasts trip ends for public transport and highway demand.

Journey/activity purposes: Land use split between office, retail, housing, trip ends forecast for work and non-work.

Time periods represented: AM and PM peak hours; all day.

Base year: 2007.

Future years: All years up to 2031 (with ability to extend beyond this time period if development assumptions are available).

Software: Custom written on SQL server. It is also possible to replicate many of the trip end calculations in a macro-enabled spreadsheet.

Operation: Maintained by SKM for Rail & Underground Transport Planning. Access on agreement with R&U.

When to use the model: To test the impacts of different development assumptions anywhere in the greater Docklands area.

Examples of model application: DLR revenue forecasting, development impact tests (e.g. new Royal Docks developments)

Model limitations: The model is unsuitable for the following: Trip distribution (this is not included in the model – LTS trip distribution would be used instead).

David Arquati [redacted]

A.7 Strategic Public Transport Modelling

RAILPLAN

Overview: Railplan is TfL's public transport assignment model. The geographic coverage extends to all of the UK but is detailed within the M25, and it includes all public transport modes (including National Rail). Railplan can be used either on its own, to predict the impacts of network changes, or as part of a full demand model (LTS or LORDM). The network coded in Railplan also includes walk routes, which can be used either to access the public transport network or as an alternative route.

Input: Demand matrices, predominantly derived from LTS. The Railplan zoning system divides London into 4000 zones, so conversion from the coarser LTS system is needed. Inputs also include all public transport routes in London and a definition of the walk network. For each public transport route, the speeds, stopping patterns, frequencies and capacities are defined.

Output: Demand and travel time on each route, route section, stop or station. These are typically subdivided by mode and by travelling conditions (crowded / uncrowded). A range of output graphics is available, such as plots of links where the greatest crowding relief occurs following the tested intervention, or origins/ destinations of trips which experience the greatest travel time changes. Outputs from Railplan are often used as inputs to operational models or station models (described later).

Area coverage: Detailed inside M25 but also covers the rest of the UK.

Transport modes: All public transport modes in London. Buses include those run by TfL and other operators within the M25 boundaries.

Journey/activity purposes: As in LTS.

Time periods represented: Morning peak, inter-peak and evening peak, compatible with LTS.

Base year: Currently 2007, in line with LTS. The re-base to 2011 is underway which will be compatible with the CUBE-based version of LTS.

Future years: As in LTS.

Software: EMME3, which will be upgraded to EMME4 in the foreseeable future.

Operation: Railplan can be operated by trained staff in TfL Planning, London Underground, London Rail or Crossrail. There is also a panel of accredited consultants which are trained to use Railplan and available to do so for external clients (e.g. Boroughs or developers). Model use by external bodies requires a license, which is available from StrategicModelling@tfl.gov.uk. Understanding of the modelling assumptions and knowledge of how to interpret the results are critical.

When to use the model: The model is suitable to test the impact of various interventions on the level of public transport, in or around Greater London.

Examples of model application: Public transport scheme assessments, such as Crossrail, Crossrail2 or Thameslink; the Olympics transport plan; testing line closure impacts.

Model limitations: Railplan predicts routing choices and their impacts, but not the demand itself; this is taken from LTS or LORDM. In addition, before every application of Railplan it is important to examine whether the zone structure in the study area is appropriate for the needs of the study. As a strategic model, Railplan does not exhibit a high level of local detail, and this too needs to be considered in the context of each specific application.

Custodian: Group Planning, Strategic Analysis. Contact Tej Hunjan [redacted] or Richard Hopkins [redacted]

Docklands Public Transport Model (DPTM)

Overview: The Docklands Public Transport Model (DPTM) is a variant of Railplan that is focused on the Docklands development areas. It was originally developed to support planning and appraisal for the early development of London Docklands, and in that area has a zone system that is quite different from LTS. Demand matrices are supplemented by a local land use model which generates trips relating to the development areas (LUTE).

Input: LTS demand matrices, with trip ends in the Docklands area replaced by LUTE assumptions. Bus networks based on local bus timetables, LUL from LUL definitions, National Rail (current day) taken from Timetable, DLR from franchised base service plans.

Output: As Railplan

Area coverage: London and South East but with great aggregation outside Docklands area and more detail inside. Zone structure is designed around Docklands development sites.

Transport modes: All public transport modes

Journey/activity purposes: Not disaggregated

Time periods represented: AM peak only

Base year: 2007

Future years: All years 2009-2019 then 2021, 2026, 2031

Software: EMME

Operation: Maintained by SKM for Rail & Underground Transport Planning. Access available through agreement with R&U.

When to use the model: To test the impact of changing development assumptions in the wider Docklands area; to test changes to DLR service patterns; to look at network improvements within the area covered, using a Docklands development scenario.

Examples of model application: DLR revenue forecasting, development impact tests (e.g. new Royal Docks developments), service pattern tests and business cases

Model limitations: Not suitable for use outside the wider Docklands area covered by LUTE

David Arquati, [redacted]

MOIRA

Overview: Moira is an Elasticities-based model that forecasts the impact of changes to service frequencies, patterns and run times on the National Rail network using generalised time. The generalised time formulation used includes measures of in vehicle and waiting time as well as interchange penalties and is based on National Rail modelling practice.

The model also stores annualised data covering total journeys, revenue and passenger miles for all stations in the London area and many outside London in the South East. This data is taken directly from the National Rail ticketing system (Lennon). The model also stores the same data for interstation links.

Input: The model uses a revenue and demand matrix taken directly from the National Rail ticketing system. It also uses an electronic version of the National Rail timetable to calculate generalised travel times; users alter this timetable to model the specification of their project.

Output: The main outputs are the changes in overall travel time and revenue arising from whatever amendments are made to the services. Changes to journey volumes and passenger miles are also output. All outputs are available at various levels of disaggregation. The base matrix can also be interrogated to get information on passenger journeys, revenue and passenger miles for the nodes and links included on the network as well as user defined groups of services.

Area coverage: The model incorporates a detailed representation of the rail network in the London area including all stations. The rail network outside London in the South East is also represented in a reasonable amount of detail with some stations being grouped together. The representation of the rail network outside the South East is very coarse with only major stations being included.

Transport modes: The model covers National Rail only, including London Overground.

Journey purposes: The model contains no information on Journey Purpose. It can output data by ticket type; this can be mapped to journey purpose categories if required.

Time periods represented: Moira can model service changes that occur at any time throughout the week.

Base year: Demand and revenue matrices are available for all financial years from 2000-01 to 2012-13 inclusive, so modelling can be undertaken during any of these years. Timetables are also available for most of this period.

Future years: The model contains no future year demand and revenue matrices. It has no future year timetables either.

Software: The model runs in a Windows environment and can be downloaded directly from a CD.

Operation: The model is not available on TfL's computer network. It is run on a standalone basis using a laptop or desktop computer equipped with the Windows operating system..

When to use the model: The model is best used for forecasting the impact of short term off peak service changes on the National Rail network. It is also provides a useful and detailed repository of demand and revenue data.

Examples of model application: The model has been used to forecast the impact of off peak service changes on the Southeastern and West Anglia networks. It has also been used to provide a mixture of revenue, journey and operational data to support the devolution of control over the West Anglia network to TfL.

Model limitations: Moira can only model the National Rail network and contains no representation of other modes. The demand used in the model is based on records held within the National Rail ticketing systems and often understates the true level of demand in the London area. Model outputs can be corrected to allow for this.

The profiles used to segment demand by time period in the model are out of date and understate the level of demand during off peak periods, particularly weekends. Again model outputs can be corrected to allow for this.

Moira's central London zoning system does not include the Canary Wharf development.

Moira cannot model the impact of on train crowding or changes to fares.

Development team, S&SD Transport Planning: Alan Smart, [redacted]

A.8 Strategic Highway Modelling

HAMs

Overview: TfL developed a suite of Highway Assignment Models (HAMs) to be used for strategic planning work. There are five HAMs, each one covering one of London's five sub-regions (Central, North, East, South, and West). Accordingly, they are named CLoHAM, NoLHAM, ELHAM, SoLHAM and WeLHAM. All 5 HAMs are linked to each other; the information is stored centrally in a single dataset, LOHAM (London Highway Assignment Model). LOHAM is not used as a model per se but as a mechanism for ensuring that network coding anywhere in London follows a consistent approach. Updates to any of the HAMs are fed back to LOHAM to retain this consistency.

Input: The representation of London's road network includes the lengths of the each road link, capacities and junction information and signal timings where relevant. Demand matrices are taken from either LTS or LORDM when the HAMs are used within a full demand model. Alternatively, for small-scale studies which assume no change in trip generation, distribution and mode split, a base matrix is available for each HAM. Matrices were developed using a gravity model with roadside interview data. Future year demand is created by applying the demand growth generated by LTS to the HAM base year.

Output: Road network conditions for the modelled scenarios, which include traffic flows, delays on all modelled roads and junctions, volume-over-capacity ratio, average speeds over a specified area (e.g. borough), journey times on specified routes. It is also possible to extract demand matrices for any user-defined area, to be used in detailed junctions and micro-simulation modelling.

Area coverage: All HAMs cover the whole of the UK, while each one of them is particularly detailed within the respective London sub-region. The area that each HAM focuses on (for example, Central London in CLoHAM) is analysed in the model using full simulation of all junctions, whereas the rest of the network is analysed using a coarser "buffer" approach. Each London Borough is within the core area of one specific HAM. For example, ELHAM has a detailed representation of the highways within East London core boroughs (i.e. Havering, Barking and Dagenham, Redbridge, Waltham Forest, Hackney, Newham, Tower Hamlet, Greenwich, Lewisham, Bexley). ELHAM is less detailed in the rest of area inside the M25, and much less detailed in the rest of the UK. The LOHAM zoning system contains almost 6000 traffic zones in total.

Transport modes: cars (including minicabs), taxis (black cab), light goods vehicles (LGVs), other goods vehicles (OGVs) and buses. The demand for buses is not modelled in detail.

Journey/activity purposes: There is no split by journey purpose. Different user classes are defined for the different modes listed above.

Time periods represented: AM peak hour (08:00-09:00), inter-peak hour (average hour of 10:00-16:00), and PM peak hour (17:00-18:00).

Base year: The current base year for all the HAMs is 2009. The HAMs are currently being rebased to 2012 based on more recent data.

Future years: Same as LTS.

Software: SATURN.

Operation: The HAMs can be operated by trained staff in TfL Planning. There is also a panel of accredited consultants which are trained to use the HAMs and available to do so for external clients (e.g. Boroughs or developers). Model use by external bodies requires a license, which is available from [redacted] Understanding of the modelling assumptions and knowledge of how to interpret the results are critical.

When to use the model: The HAMs are used for a wide range of applications, since almost any major strategic planning process has highway impacts. This includes highway upgrade schemes, new tunnels and bridges, public transport schemes and major developments.

Examples of model application: The models have been used in various Opportunity Area Development Framework (OAPF) studies to assess the impact of the development on the highway traffic. They have also been used in various traffic management studies, such as introducing two-way systems on Piccadilly and Tottenham Court Road.

Model limitations: The HAMS loads the demand for highway travel onto a representation of London's highway network. The demand itself needs to be estimated outside the HAMs, normally with LTS or LORDM, or as a separate exercise using data sources such as TRICS and TRAVL. Before using the HAMs, there is also a need to consider whether the level of model detail is appropriate for the specific study. Often clients are interested in a level of detail which is too high to be forecast reliably (for example, in a way that looks at junction performance in detail or seeks outputs for minor streets). In some cases it is possible to enhance the network in the study area to adjust it for the needs of the specific study.

Group Planning, Strategic Analysis: Huy Nguyen [redacted]

A.9 London Underground Operational Modelling

TSM

Overview: The Train Service Model (TSM) simulates railway operations on individual Underground lines with fixed passenger demand. It is used to evaluate how the service would respond to both infrastructure and train service changes, and to quantify the journey time benefits that can be achieved through such changes.

The TSM simulates the running of the railway for a given schedule and level of demand, modelling the interaction between individual trains and the boarding / alighting passengers, and the consequent impacts on the timetabled service over the modelled period. Each LUL line has a separate TSM model, with the exception of the Sub-Surface Railway, (District, Metropolitan, Hammersmith & City, and Circle), and the Piccadilly line, all of which are contained within one model due to the level of interaction between these lines. It can also be used to analyse the impact of non-timetabled events – such as a train taken out of service.

Input: Most of the features of the railway that define its capacity concern the time required for passengers or trains to perform certain tasks. As such, the TSM is populated with information about the time taken for certain 'events' to complete (e.g. the time for a train to run from one station to the next).

Output: A wide range of information can be extracted from the TSM, including customer journey time, passenger hours (crowded/uncrowded), in vehicle time, platform wait time, etc.

Area coverage: Single LUL line (or a set of interworking lines)

Transport modes: LUL

Journey/activity purposes: N/A

Time periods represented: Variable

Base year: Variable

Future years: Variable

Software:

Operation: Contact custodians

When to use the model: Evaluation of the benefit of changes to service levels, service patterns, infrastructure or operational arrangements

Examples of model application:

Model limitations:

LU Transport Planning: Sandra Weddell, [redacted]

JTC

Overview: The Journey Time Capability (JTC) model is a spreadsheet tool for calculating the passenger benefit of changes to runtime and capacity inputs for LU lines. It evaluates the performance of the infrastructure that is provided – inter station runtimes, signalling performance, rolling stock characteristics etc. – in terms of the passenger service that could be provided with these assets. As the JTC model is spreadsheet based it is quick to run. Data fields describing the characteristics of the assets can be readily changed. The model can provide immediate estimates of the passenger benefits from enhancements to the line or rolling stock which can then be used for developing business cases. It is a useful tool for comparing alternative upgrade proposals and providing preliminary estimates of benefits. It can therefore form part of the method for narrowing down a wide range of options to a shortlist for full appraisal.

Input: The JTC models contain core data – largely derived from the TSM – on passenger demand, expected platform wait times and peak crowding levels all for a planned level of service. User input data – that can be modified – consists of rolling stock capacity parameters, inter station runtimes, station reoccupation times, and platform layouts.

Output: The key model output generated is a single figure – the Journey Time Capability - for each LU line (for the sub-surface network values are produced for 'sub-surface north' and 'sub-surface south'). The JTC value represents the weighted average Journey Time for a passenger using the line. This figure can be annualised for all passengers on the line and thus annual benefits for alternative options determined.

The Journey Time output data can be disaggregated by time period (peak/non-peak) and by component (on train time, crowding weighting, and weighted platform wait time). The model also calculates achievable train frequencies for all stations and termini (plus junctions on the sub-surface network) and displays these as a constraints table.

Area coverage: Models exist for each of the LU lines; a single model covers the sub-surface lines.

Transport modes: LUL

Journey/activity purposes: N/A

Time periods represented: The model calculates output for 'peak' and 'non-peak' periods. These values are aggregated into an average output value.

Base year: The base years of JTC models are determined by the TSM inputs to the models. By default these are forecasts of the year 2014, though for some lines alternative forecast years have also been developed.

Future years: N/A

Software: MS-Excel

Operation: User input data cells in the spreadsheet may be modified and changes to the output (JTC, its components and/or headway constraints) observed.

When to use the model: As a comparator to narrow down a list of options for a fuller evaluation (e.g. through TSM); as a benefits calculator for smaller scale enhancements; and as a tracker that can provide early indications over whether planned benefits of line upgrades are likely to be achieved at project completion.

Examples of model application: Development of the passenger Journey Time benefits for the Central and Waterloo and City Line upgrades business cases as part of the New Tube for London project;

Calculation of benefits from enhanced braking systems and operation on the Northern and Jubilee Lines;

Analysis of predicted performance from the planned sub-surface ATC implementation

Model limitations: The model requires a pre-determined planned service pattern to have been tested in TSM. It is able to determine the impacts of small shortfalls in this service pattern, but not wholesale changes. Margins are used to align the model with observed service levels but the model is not able to predict the impact of changes to reliability.

LU Transport Planning: Dave Hughes, [redacted]

Station Service Model

Overview: This is a spreadsheet model to simulate ticket purchase activities within stations.

Input: The model is based on static spreadsheets which contain data about the facilities available and demand levels, and is essentially a queue simulator. With training, the model is straightforward to use.

Output: Passenger queuing times and staff costs.

Area coverage: Many individual locations

Transport modes: LU Ticket Halls

Journey/activity purposes: Not segregated

Time periods represented: Variable – depending on demand info.

Base year: Location specific

Future years: Location specific

Software: MS- Excel

Operation: Contact the custodian.

When to use the model: To assess how changes in ticket hall facilities will affect queue lengths.

LU Transport Planning: Dave Hughes, [redacted]

Heat Strain Risk Tool (HSRT)

Overview: The Heat Strain Risk Model (HSRT) has been developed to give a monetary value to the impacts on passengers arising from changes in temperature on the deep tube network. These impacts are in terms of both thermal comfort (based on willingness to pay data and customer priority surveys) and safety – risk of heat related illness (based on crowding levels and the probability of stalled train events).

Input: The HSRT takes baseline temperatures for the network - seasonal, station platforms and train - and allows changes in temperature from such factors as line upgrades or cooling infrastructure to be analysed. (The changes in temperature are derived separately, normally from Tunnel Ventilation Models). Travel time and passenger numbers are also needed, and the safety calculations require crowding levels and the probability of stalled train events of differing durations.

Output: The calculation is repeated each year for a forty year appraisal period allowing changes in passenger numbers, line upgrades and external climate to be accounted for. Outputs can be provided by link and then grouped per station, line and network.

Area coverage: Deep tube lines

Transport modes: LUL

Journey/activity purposes: Not split by journey purpose

Time periods represented: 40 year, annual calculation of financial benefits

Base year: Default: 2009 (Modified subject to programme requirements)

Future years: 40 years from base year, changes in passenger numbers, train service and climate can be specified.

Software: Custom – Bespoke

Operation: Contact Tony Lightfoot

When to use the model: To evaluate investments that impact on thermal environment of the LU network

Examples of model application: Evaluation of financial thermal benefits of: Cooling infrastructure (such as ventilation fans, Platform Air Handling Units), traction power energy saving initiatives, increased service levels/train performance.

Model limitations: The model applies to the deep tube lines only, SSR is excluded.

LU Engineering Railway Systems: Tony Lightfoot, [redacted]

Tunnel Ventilation Modelling (TVM)

Overview: The Tunnel Ventilation Modelling (TVM) has been developed to quantify the change in thermal environment on the deep tube network for the implementation of line upgrades and cooling infrastructure. The models also allow for assessment of the impact of climate change on the thermal environment and allow understanding of air velocities around stations and in tunnels.

Input: The TVM takes inputs for the station and tunnel geometries, cooling infrastructure, trains, service levels and external conditions. Speed limits and passenger numbers are also needed. The models have been benchmarked against existing platform temperature data.

Output: The models output air velocities and air temperatures for station areas and tunnels during the summer evening peak hours, when the network is warmest. The models take into account the longer term impact on the surrounding ground conditions of line upgrades and climate

changes. The models can predict the impact on ventilation fan performance due to piston effects of trains. The temperature outputs feed directly into the HSRT models to quantify the financial thermal benefits.

Area coverage: Deep tube lines

Transport modes: LUL

Journey/activity purposes: Not split by journey purpose

Time periods represented: Summer Evening Peak Hour (now and future)

Base year: Default: 2009 (Modified subject to line requirements)

Future years: 2030's, 2050's or 2080's climate data used depending on line upgrade implementation dates

Software: SES (Subway Environment Simulation)

Operation: Contact Tony Lightfoot

When to use the model: To evaluate the thermal and aerodynamic impact of changes to the LU deep tube network

Examples of model application: Evaluation of thermal impact of: Line upgrades, increased service levels/train performance, Cooling infrastructure (such as ventilation fans, Platform Air Handling Units), traction power energy saving initiatives, Air velocity impact assessments for public areas of stations.

Model limitations: The models are split by line. Seasonal variations in thermal conditions must be evaluated post simulation.

LU Engineering Railway Systems: Tony Lightfoot [redacted]

Railway Engineering Simulator (RES)

Overview: The Railway Engineering Simulator (RES) is a network simulator. The simulator models the performance of train systems, determining train performance and energy consumption. The model is used to understand train performance, assess train system capacity and to estimate energy consumption. The model also considers the traction power supply system, it can be used to estimate traction power supply system loading levels. The model therefore quantifies changes that can be monetised, and also provides inputs to other models which can calculate the monetisable impact on passenger journey times.

Input: RES requires infrastructure data, track capability, gradients, and track lengths. Signalling data and train parameters are required. The model also requires timetable (or service level data) and passenger loading data.

Output: The models outputs train performance giving inter-station run times and reoccupation times, this can be used to determine train system capacity. The model also outputs energy consumption levels and power infrastructure loading levels. This can be used to determine energy costs of scenarios as well as determining if additional power infrastructure capacity is required.

Area coverage: All lines

Transport modes: LUL

Journey/activity purposes: Not split by journey purpose

Time periods represented: All

Base year: Modified subject to requirements

Future years: Dependant on Requirements

Software: RES (Railway Engineering Simulator)

Operation: Contact Martyn Chymera

When to use the model: Any time there are changes to rolling stock performance, track layouts/capability, signalling systems or service levels (timetable).

Examples of model application: Evaluate the run time improvements of enhancements (to rolling stock, track or signalling); Determine capacity constraints and the impact of changes (to track, signalling, dwell times). To determine the loading of the traction power supply system following a timetable change (particularly service level uplift); Assess the effectiveness of energy efficiency initiatives

Model limitations: The models are line specific.

LU Engineering Railway Systems: Tony Lightfoot [redacted]

A.10 Tactical Highway Modelling

ONE

Overview: ONE (Operational Network Evaluator) is used for studying the impact of operational traffic management and traffic control proposals on the performance of London's highways. It is also used to assess the impact of temporary conditions such as road works, events and major incidents on the network. It is not used to assess long term impacts of permanent schemes. The model is used in parallel with micro-simulation models and is structured in a way that facilitates this link between the models.

Input: Central London road network; travel demand from the 2001 Census, updated using planning data from LTS, extrapolated to 2008, and then uplifted based on observed data to 2012.

Output: Road network conditions for the modelled scenarios, which include traffic flows, delays on all modelled roads and junctions, volume-over-capacity ratio, average speeds over a specified area (e.g. borough), journey times on specified routes. It is also possible to extract demand matrices for any user-defined area, to be used in detailed junctions and micro-simulation modelling.

Area coverage: Central London. ONE is gradually being expanded to cover the whole of London.

Journey/activity purposes: Can be split by congestion charge payers / non payers, and by in-work / non-work trips.

Time periods represented: AM peak hour (08:00 - 09:00) and PM peak hour (17:00 - 18:00).

Base year: 2012

Future years: 2015

Software: VISUM.

Operation: In-house. Contact Traffic Operations.

When to use the model: To understand operational impacts and optimise a holistic strategy for management of events.

Examples of model application: ONE applications included testing the Western Extension Zone removal, Victoria Station Upgrade road works, Oxford Street road works, 2012 Olympics, Tour de France, Westfield developments at both White City and Stratford.

Model limitations: Coverage is limited to an extended central area. Peak hour only.

Network Performance, Traffic Operations, Surface Transport: Vladimir Vorotovic, [redacted]

A.11 Highway Microsimulation Modelling

VISSIM Models

Overview: VISSIM is a complex and powerful tool, capable of modelling several groups of linked junctions and can complement analyses provided by traditional traffic optimisation and design tools such as TRANSYT and LinSig. VISSIM is particularly useful where over-saturated conditions and exit-blocking occur, or where queues interact with other facilities. VISSIM models can account for dynamic changes in network infrastructure occur during the modelling period – due to the use of SCOOT signal control, demand-dependent signal settings or bus priority at signals. It also has visualisation features and is therefore used where it is beneficial to visually demonstrate the operation of a scheme, for use in a stakeholder consultation or Public Inquiry.

Input: Representation of the network area, including signal timings, bus frequencies, location of bus stops, cycle lanes and pedestrian crossings. Traffic demand, composition, desired speed range, signal timing plan information, route choice and proportions, bus frequency, location of bus stops, locations of pedestrian crossings.

Output: All aspects of network performance, in aggregate or for individual links or even vehicles. The model produces visual dynamic representation of the operation of the modelled network including 3-D visualisations suitable for promoting concepts to non-specialist audiences. Other outputs are multitude of network performance statistics, from aggregate (average/total delay per vehicle type, number of stops, average speed) to disaggregate, link by link or even vehicle by vehicle.

Area coverage: Various locations throughout London, including all 23 TLRN corridors

Transport modes: All highways, including cycles and freight

Journey/activity purposes: not differentiated by journey purpose, but results can be split by vehicle type.

Time periods represented: generally am, pm and interpeak, but any period can be modelled if the demand is known.

Base year: location specific – TLRN corridor models are 2010, due to be updated to 2014

Future years: location specific – TLRN corridor models are 2015

Software: VISSIM (may include other proprietary packages in the future)

Operation: In-house. Contact Traffic Operations.

When to use the model: To measure performance of networks under different types of traffic control, cycle time and timing plans. The model an also be used to examine the resilience of network to recover from serious incidents. Design congestion management strategies.

Examples of model application: TLRN corridor models; Testing of Cycle Superhighways proposals; Testing of Elephant and Castle layout changes

Model limitations: Data hungry, requires significant resource both in terms of time and skill / experience. Doesn't model cyclists very well

Network Performance, Traffic Operations, Surface Transport: Vladimir Vorotovic [redacted]

LINSIG

Overview: LinSig is a detailed junction design tool which can be used to assess the performance of a signalised junction. It combines geometric layout, traffic and controller modelling to accurately reflect the way the junction operates. LinSig is best used for the design and assessment of isolated signalised junctions. It is a useful tool in optimising the signal timings for a changed junction layout – either to maximise capacity or to minimise total delay. Historically LinSig was only appropriate for single junctions, but the software capability has expanded to deal with small interconnected networks.

Input: Required input information includes the geometry of the layout, method of control, signal timing plans and traffic flow by turning movement.

Output: is highly customisable and can display data by road link or by junction as a whole, tabular or graphical, flows, capacity, stops and delays and queue build up.

Area coverage: 842 individual sites on the TLRN, and over 2000 others across London

Transport modes: All highway vehicle classifications including cyclists

Journey/activity purposes: not disaggregated

Time periods represented: generally am, pm and interpeak, but any period can be modelled if the demand is known.

Base year: Varies by locations

Future years: Varies by location

Software: Linsig3

Operation: In-house. Contact Traffic Operations.

When to use the model: Optimising signalised junction designs

Examples: Every signal modification or upgrade must be tested on LinSig.

Model limitations: Within TfL, LINSIG is not used for larger networks. It is more appropriate when the junction design is well advanced as detailed geometry is required. There is potential for unrealistic representation of driver behaviour when queues are moving off.

Network Performance, Traffic Operations, Surface Transport: Vladimir Vorotovic [redacted]

TRANSYT

Overview: TRANSYT is used to produce timing plans for a network of signal-controlled junctions and is particularly useful where benefits accrue if sequential junctions' signal timings are linked to minimise delays. It is used for developing optimum signal settings for representative traffic conditions, and therefore can forecast timings for a proposed change to the network. Transyt is now used effectively interchangeably with LinSig as both have similar capabilities.

Input: TRANSYT models require average traffic data to be collected (or projected) and analysed for each modelled period, in addition to data describing the physical layout of the network.

Output: TRANSYT can deliver a variety of outputs. It is possible to define specific routes through a TRANSYT network to examine performance statistics for a particular pathway or vehicle type, or for the modelled area / demand as a whole. Outputs can include travel times, queuing time etc. Coloured graphs can also be produced – e.g. of queue build up per cycle.

Area coverage: Various locations

Transport modes: All highway vehicle classifications including cyclists

Journey/activity purposes: not disaggregated

Time periods represented: generally am, pm and interpeak, but any period can be modelled if the demand is known.

Base year: Varies by locations

Future years: Varies by location

Software: TRANSYT

Operation: In-house. Contact Traffic Operations.

When to use the model: Optimising signalised junction designs

Model limitations: TRANSYT does not model the spatial geometry of the junction and individual vehicles and therefore approximates actual traffic behaviour. This is adequate for business cases. However, TRANSYT has limited ability to automatically simulate the effect of a queue building up to the extent where it blocks back to an upstream junction – and would not be the preferred tool where this is a consideration.

Network Performance, Traffic Operations, Surface Transport: Vladimir Vorotovic [redacted]

A.12 Bespoke strategic models

CEM

Overview: CEM is a Charging Evaluation Model, developed especially to test alternative user charging strategies for the East London River Crossings programme. CEM includes a very simple representation of the road network in parts of East London where an existing tunnel, bridge or ferry cross the Thames, or where potential infrastructure for crossing the Thames is being considered. CEM is a stand-alone tool, but interpretation of the results needs to be done jointly based on outputs from CEM and ELHAM (described earlier).

Input: CEM was built entirely based on data extracted from ELHAM, to retain consistency with the ELHAM assumptions which have a key role in the East London River Crossings programme. Both the demand and the network in CEM are simplified versions of those used in ELHAM, aggregated to a very coarse zoning system. CEM attempts to retain some overall consistency (on average) with travel times calculated in ELHAM through the use of speed-flow relationships that were calibrated from ELHAM outputs. Regarding the inputs for individual scenario runs of CEM, the model was created so that the user can define a detailed charging strategy for a whole day, specifying charging parameters in a higher level of detail than what is straightforward to do in ELHAM.

Output: Traffic flows, times and charging revenues on a pre-defined set of routes. Various reports can be created to analyse the revenue profile.

Area coverage: The model focuses on traffic that crosses the Thames in East London, either based on current data or in future hypothetical situations. Traffic which is unlikely to consider crossing the Thames in this area is considered as background traffic only.

Transport modes: Road-based traffic.

Journey/activity purposes: There is no split by journey purpose, but local traffic is defined as a separate demand segment, in order to be able to test potential discounts to residents of the area adjacent to the schemes being tested.

Time periods represented: Each model run covers a full charging strategy option for the entire day. The charged can vary by time period, but they need to be fully specified for the whole day.

Base year: 2009.

Future years: These are yet to be defined.

Software: Excel.

Operation: The model was specified by Strategic Analysis in TfL Planning; developed by AECOM; and run primarily by TfL's Finance team. All these can operate the model, including specifying and running new scenarios.

When to use the model: CEM was developed in order to test a large number of user charging strategies, which ELHAM would not be the right tool for. ELHAM runtimes are high, and are mainly spent examining traffic routing throughout East London, with limited sensitivity to the willingness of users to pay a charge. CEM focuses explicitly on the decision whether to choose a route with or without a charge when crossing the Thames. This is done without much network detail, and the interactions between vehicles are not looked at. The limited detail means that running the model takes only a few seconds, hence examining a very large number of scenarios is straightforward. The user-defined scenarios can incorporate various aspects of the charging strategy.

Model limitations: CEM is run as a stand-alone tool, but interpretation of the results should be done after examining results from both CEM and ELHAM jointly. Results will not be the same, but the modelled response to tested scenarios using both models can be used to logically infer which outcomes are more likely and where high uncertainty remains.

Strategic Analysis: Ali Inayathusein

A.13 Pedestrian Modelling

Static Toolkit

Overview: The Static toolkit is a spreadsheet based analytical tool that rapidly applies Station Planning Standards to the proposed design. It works within Excel. Each element in the model (Passageway, Staircase, Escalator, Gate line etc.) is treated separately and they are joined together for presentation purposes. It has a very fast run time and depending on the complexity of the station the development time is very short (days). It is best used for quick analysis of initial proposals for potential design, ensuring that any options that make it through to the shortlist address potential high level station design concerns.

Input: Each element of the station is defined by its space characteristics and hence its capacity (using the formula from the Station Planning Standards). Any demand can be input but it is usually from RODS or forecasts for peak 15 min periods, and any assumptions about routing options are applied. Train service, in the form of TPH is also an input.

Use/Output: It provides Level of Service (LoS) and Utilisation plots, in the form of block diagrams of station layouts with demand coded in relation to supply, for each element. It also provides an indication of whether they pass or fail Standards in the scenario under consideration. Free Flow Journey Time Analysis is also a feature of this tool.

Area Coverage: About 25 stations are currently covered, but development time for new ones is very short.

Transport Modes: Pedestrian activity with stations

Journey/activity purposes: Pedestrian activity with stations

Time periods represented: Can cover any, but usually calculated for 15 min peak.

Base year: Any, usually the latest RODS.

Future years: Any where demand is available

Software: Ms-Excel

Operation: Only by trained users. Short training courses available.

When to use the model: For quick analysis of design options, to weed out high level failures, or of future year demand, to highlight areas of concern, or of different routing strategies within a station to see what works within Station Planning Guidelines. Can act as a first stage, before taking a proposal through to more dynamic modelling

Examples of model application: To quickly review the impact of demand changes as a result of ESTL track blockades on selected stations. To identify which parts of what stations would fail to cope with demand that is revised as a result of partial line closures.

Limitations: It does not assess delays, queuing and social cost benefits. It does not involve dynamic modelling and the impact of individuals' movement on other individuals. Also, as station elements are assessed independently of one another, high levels of congestion in one station element does not feed back into the assessment of adjoining elements.

Station Capacity Analysis Team: Sandra Weddell [redacted]

PEDS

Overview: PEDS is a statistical model of the entire network. It covers all stations but it has a coarse detail in station layout and it does not model the link between stations. It has a very fast run time and depending on the size of the project the development time is very short (days). It assesses delay and congestion in all stations in the LU network and it can analyse line-level changes and station-level changes. It handles multiple closure scenarios and supports analysis of performance measures, but does not assess queuing time. It is a useful first indicator of the station impacts of more strategic (line or network wide) interventions.

Input: Coarse station elements (in block form), train service, demand (Railplan), train service information.

Output: It assesses delay and congestion in all stations in the LU & DLR network and it can analyse line-level changes and station-level changes. It handles multiple closure scenarios and supports analysis of performance measures, but does not assess queuing time. It is a useful first indicator of the station impacts of more strategic (line or network wide) interventions.

Area coverage: Whole LU network and DLR stations

Transport modes: Pedestrian mode only

Journey/activity purposes: Demand is not currently separated by journey purpose

Time periods represented: Usually AM and/or PM peaks (3 hrs), divided into 15 min periods.

Base year: Usually based on most applicable Railplan/RODS base

Future years: Any year can be simulated if input info is available – usually Railplan dependant.

Software: Bespoke PEDS software, based on a FORTRAN algorithm in a Windows based interface.

Operation: Trained users only.

When to use the model: Initial indication of the impact of line level and strategic station changes.

Model limitations: Detail is course and further investigation at a station level (with other tools) is likely to be required for a scheme appraisal.

Examples of model application: Assessment of station impacts of line upgrades. Prioritisation of station upgrades in relation to a future network wide demand scenario. As an input to NACHS, for calculating lost customer hours

Station Capacity Analysis Team: Sandra Weddell [redacted]

PEDROUTE

Overview: Pedroute was developed as a bespoke model for London Underground to model the impacts of crowding within stations and quantify the passenger experience based on Fruin's Levels of Service.

Input: CADs, demand data (including boarding/alighting data), station operational arrangements, train service frequencies.

Use/output: Social cost/benefit, congestion levels (average delay - on a block by block basis), and comparison against station standards.

Journey/activity purposes: Pedestrian activity with stations

Time periods represented: 15 min periods, usually in AM and/or PM peaks.

Base year: Usually based on most applicable Railplan/RODS base

Future years: Usually based on Railplan: so 2016, 2021, 2026, 2031/ 2041

Software: Bespoke software

Operation: Trained user via secure access dongle.

When to use the model: In the absence of a more detailed Legion model, and/or when a quicker, albeit less detailed response is required

Examples of model application: To review future station operations given passenger capacity and/or demand changes.

Limitations: Results are confined to blocks within a station, and careful consideration of 'service level' outputs is required.

Station Capacity Analysis Team: Sandra Weddell, [redacted]

LEGION

Overview: Legion is one of the commercially available software packages which assign individual pedestrian movement within the confines of a modelled environment. It shows the precise individual routes that passengers take through a station based on a vast array of data to develop accurate computational algorithms, calibrated and validated from observations. In particular, passenger movement is influenced not only by origin and desired destination but also by the constantly changing immediate space availability. Given the micro-level, agent based, simulation

modelling provided, Legion models can require a long development time (possibly months). About 50 stations are currently covered by existing Legion models.

Input: Station CADs (existing and planned) as well as actual station operational plans, and signage are the building blocks of supply. The latest RODS, additional ad-hoc surveys to validate overall numbers and define routing choices, Railplan, (or in some instances LTS to produce revised Railplan forecasts) are the contributors to inputs on the demand side. Detailed train service timetabling and train capacities are also inputs. For future year demand, trends, assumptions, and Railplan may be used in varying combinations.

Use/output: Legion can provide detailed graphical outputs, such as density (heat) maps, utilisation maps and 2D and 3D videos. It can also provide detailed numerical output used to calculate journey time, social cost, passenger flow numbers and rates, and platforms clearing times. Future scenarios are compared against one-another, and against a validated current, or a future year, base case.

As with the other tools, weekday AM peak (07.00 – 10.00) and PM peak (16.00 – 19.00), are the usual modelled periods, although others can be (subject to input data/assumptions). The model works on a second by second basis, but reporting is usually agglomerated into 15 min periods, or the busiest 15 mins in each peak.

Journey/activity purposes: Pedestrian activity, usually within stations.

Time periods represented: Usually AM and/or PM peaks, with 15 min outputs. Displays can be created on a second by second basis.

Base year: Usually based on most applicable Railplan/RODS base

Future years: Often based on Railplan: so 2016, 2021, 2026, 2031/ 2041, but any forecast can be used.

Software: Legion – bespoke software

Operation: By trained users and on specific desktops with software loaded and licensed.

When to use the model: For detailed review of station passenger capacity and/or demand changes, supporting operational routing arrangements during disruption to supply, design of capacity elements, and measuring benefits for input into business cases.

Limitations: If a model doesn't already exist, complex stations can take several weeks to prepare and months between inception and completed reporting. Some existing Legion models are a little old, or only cover part of a station. Forecasting future demand numbers carries a lot of uncertainty. These would be agreed with the client and include some sensitivity testing.

Sometimes, options being looked at may not complete a model run due to excessive congestion, and tweaking with further model runs may be required to find the weak-point. Sometimes modelling results will highlight areas where design does not resolve some, or all, of the issues. Other analysis may be required to quantify the disbenefit, and the design may subsequently need to be revised and tested again. As far as possible, it would be wise to eradicate any obvious design flaws before intensive modelling takes place. Hence the benefit, in some cases, of a hierarchical approach to modelling tools, using simpler approaches to quickly assess the viability of multiple design options and then move to more detailed modelling of a refined design.

Examples of model application: Design of, and business case development of, major station enhancements: e.g. Victoria, Bank, Holborn, Camden, Elephant & Castle, Paddington

Advice and review of station operating strategy during interruption to elements of capacity, for example escalator or lift works: Baker St., South Kensington, Embankment, Victoria, Finsbury Park, Euston, Kings Cross, and Covent Garden.

LUL: Station Capacity Analysis Team: Sandra Weddell, [redacted]

Surface: Brett Little, [redacted]

A.14 Cycle Modelling

CLOHAM for cycling

Overview: CLOHAM is the Central London Highway Assignment Model, which was described earlier under "strategic highway models". In 2013, a special version of CLOHAM was created to examine the impact of the Mayor's Cycling Vision on highway congestion in Central London. This version is similar to version 2 of CLOHAM but it also includes a cycle matrix and cycle network. These are used to estimate cycling routes and cycle flows, which are then used as background flows in the main highway assignment. This is meant to ensure that the road space taken by cyclists is taken into consideration when assessing the levels of congestion, car routes and travel times, as well as the impact on buses.

Input: Version 2 of CLOHAM, as well as cycling counts, other cycle surveys to determine model parameters, and information on parts of the Central London network that are suitable for cycling.

Output: See earlier section about the HAMs. Outputs of particular interest from the scenario analysis were estimates of the impact of the increate in cycling demand on car and bus traffic in terms of speeds, delays and flows.

Area coverage: Central London.

Transport modes: Road-based modes including cycling.

Journey/activity purposes: See earlier section about the HAMs.

Time periods represented: See earlier section about the HAMs.

Base year: See earlier section about the HAMs.

Future years: See earlier section about the HAMs.

Software: SATURN.

Operation: The model can be operated by Strategic Analysis in TfL Planning of by consultants Steer Davies Gleave.

When to use the model: When assessing the impacts of cycling interventions in Central London.

Examples of model application: The model supported the business case for the Mayor's Cycling Vision.

Model limitations: A list of model limitations was documented and is available upon request. It is critical to note that the model does not estimate changes in cycling demand, only the highway impacts of cycling demand that needs to be estimated outside the model.

Planning – Strategic Analysis: Ali Inayathusein [redacted]

A.15 Connectivity Assessment Tools

PTAL

Overview: PTAL measures the level how easy it is to reach public transport service from anywhere in London. The acronym PTAL (Public Transport Accessibility Levels) may be somewhat confusing,

since PTAL does not look at physical accessibility (i.e. step-free or disabled access) but at the walking distance to nearest stops and stations, and the frequency of service available from these stops or stations. For any given point in London, the walk time to stops/stations is combined with typical wait times at these locations to give an index, ranging from 1 (poor) to 6 (excellent). A web-based PTAL calculator is available at http://www.webptals.org.uk/. Note that this website will be abolished in late 2014; see the section about WebCAT below.

Input: The calculation of PTAL is based on a detailed walk network; a grid of points (every 100 metres) covering the whole of London; a GIS layer defining all points where public transport services can be boarded; and information about service frequencies at these points, which is updated regularly. It is possible to replace the frequencies and access points with alternative values for future scenarios, to show how PTALs will change in those scenarios.

Output: PTALs, from 1 to 6, for all points in the grid. This is often presented as a map.

Area coverage: Any point in London.

Transport modes: Rail, bus, underground, tram and DLR. Note that boat services, coach services and taxis are not included.

Journey/activity purposes: No split by purpose.

Time periods represented: The calculation is based on the morning peak only.

Base year: 2013.

Future years: Future year PTALs can be produced for any future year is a respective Railplan run has been prepared.

Software: In-house base year calculations use MapInfo, Routefinder and Excel. In-house future year calculations require the same as the base year, with Railplan outputs produced in Emme. Base year calculations only are also available on the website with no particular software necessary.

Operation: The website is available for anyone to use. The in-house tools are run by Strategic Analysis in TfL Planning.

When to use the model: PTALs are useful to present a picture of levels of connectivity in different parts of London and to demonstrate where the need for better connectivity is higher. It is not recommended to use PTAL as a single measure of connectivity. There is no single measure that complies all the information on the ease of travelling to a defined location, and it is therefore recommended to present a balanced picture by presenting several measures jointly.

Examples of model application: PTALs are used by boroughs and the GLA to support decisions regarding housing densities, parking provision and investment in transport infrastructure.

Model limitations: PTALs are based on a simple calculation combining walk time and service wait time. When looking at PTALs for w given location, it is important to note that they do not consider whether public transport services from that location go to a destination that many travellers would be interested in. They also do not consider how long it would take to get to the destination, only the wait time for a public transport service at the origin,

Group Planning, Strategic Analysis: Simon Cooper [redacted]

CAPITAL

Overview: CAPITAL is a Calculator of Public Transport Accessibility in London. As with PTAL, the word accessibility in the title is not consistent with TfL's definition of accessibility (which focuses on step-free access and related physical arrangements, not related to the CAPITAL measure).

CAPITAL, like PTAL, measures how well places are connected to each other using London's transport system. Unlike PTAL, which uses a relatively simplified formula, CAPITAL is based the entire journey time from the origin to the destination. It is therefore more appropriate than PTAL if only one measure of connectivity is presented. CAPITAL analysis is normally presented as a map, and can be simply seen as an effective way of mapping the outputs of our strategic models. The CAPITAL acronym is inaccurate also because we use the CAPITAL concept for either public transport or highway connectivity, as defined by the user.

Input: CAPITAL levels for public transport require outputs from Railplan for whichever network scenario the user is interested in. In addition, the CAPITAL process examines the walk to and from the boarding/alighting locations in more detail than Railplan, for which a detailed walk network is needed in a GIS format. The calculation is based on a grid of 25,000 points throughout London, corresponding to Census Output Areas. CAPITAL levels of highway travel require inputs from the HAMs, and there is no walk time calculation involved.

Output: Typical maps produced with CAPITAL show travel time bands from a user-selected location to all other locations in London, with the change in colour indicating an area that requires a longer journey. Alternatively it is possible to present maps of travel times from all locations to the nearest school, hospital, town centre and a range of other services.

Area coverage: London-wide or narrower, as defined by the user.

Transport modes: All modes covered by either Railplan or the HAMs.

Journey/activity purposes: Not split by purpose.

Time periods represented: The analysis can be undertaken for any time period modelled in Railplan or the HAMs.

Base year: Any year modelled in Railplan or the HAMs.

Future years: Any year modelled in Railplan or the HAMs.

Software: MS Access, MapInfo RouteFinder and Emme or SATURN.

Operation: The tool can only be run in Strategic Analysis in TfL Planning. For alternative, see under WebCAT below.

When to use the model: CAPITAL is effective for presenting outputs from strategic models (Railplan, HAMs, LTS or LORDM) in a graphical and intuitive way, and to link them to other planning information such as the location of town centres, colleges, medical services and so on.

Examples of model application: NHS study of service reconfiguration; a range of Opportunity Area Planning Framework studies; regeneration study as part of the East London River Crossings programme; and many others.

Model limitations: Travel times are calculated for each pair of origin and destination in London. If for example we use the typical split of London into 4000 zones, there are 16 million such pairs, and they cannot be plotted on a single map, let alone the differences in travel times between scenarios. To keep the outputs simple and intuitive, it is advised to define specific points of interest and focus each map on travel times from one point to everywhere else. It is also critical to note that CAPITAL maps will only show impacts which Railplan or the HAMs can model. There are many impacts which are not modelled; seek advice from the Strategic Analysis team for each specific application.

Group Planning, Strategic Analysis: Simon Cooper [redacted]

ATOS

Overview: ATOS stands for Access to Opportunities and Services. It is an application of the aforementioned CAPITAL measure for public transport. ATOS is a combined measure of travel times from a user-defined location to a basket of services in the area surrounding that location. To define the ATOS measure, a specific basket of services was defined, which includes GP surgeries, primary schools, secondary schools, further education colleges, food shopping, open spaces and workplaces. Travel times for each service are banded into five categories, A to E, which are normalised to the typical travel times for each type of service separately. As a result, level A or one type of service (e.g. surgeries) does not necessarily represent the same travel times as level A of another service (e.g. food shopping) since people generally travel longer and less often for different services.

Input: Same as CAPITAL input, as well as a listing of all relevant services as defined in the ATOS basket.

Output: A map of ATOS levels either for a specific service or for the whole basket.

Area coverage: London-wide.

Transport modes: Public transport modes as in Railplan.

Journey/activity purposes: The analysis can be undertaken for a given list of services (which represent different activities, e.g. shopping, visiting a doctor, education and so on).

Time periods represented: As in Railplan.

Base year: As in Railplan.

Future years: Future year scenarios can be used but future year service configurations (e.g. school locations) may not be known.

Software: Same as CAPITAL.

Operation: Same as CAPITAL.

When to use the model: Same as CAPITAL.

Examples of model application: Same as CAPITAL.

Model limitations: The dense level of services in London means that most can be reached in a reasonable amount of time; for example, from most parts of London it is possible to access some of the nearest GP surgeries and primary schools on foot, even in case where residents choose to do otherwise. Users often have considerations for not using a specific service which are not included in this tool, such as personal preferences, quality, capacity, the need to register, and so on. For this reason, ATOS will often not show an improvement when a transport scheme is introduced, because without these specific circumstances, the levels seems near-ideal even without investment.

Group Planning, Strategic Analysis: Simon Cooper [redacted]

WEBCAT

Overview: WebCAT is a website which has been developed to replace the PTAL website. WebCAT allows mapping PTALs as well as other measures of connectivity, similar to CAPITAL or ATOS, which are not available on the current website.

Input: WebCAT users are able to generate connectivity maps for a given set of scenarios, including a base scenario, a standard future scenario (including committed schemes such as Crossrail), and possibly other planning scenarios which will have reached a stage where they can be shared widely.

Output: Maps of connectivity levels for a user-defined area of London.

Area coverage: Anywhere in London.

Transport modes: Same as Railplan and the HAMs.

Journey/activity purposes: Much of the information is not split by purpose, but it is hoped to allow travel time queries for specific types of services, similar to the concept of the ATOS measure described earlier.

Time periods represented: Any period which is covered in Railplan or the HAMs, if it has been uploaded to the WebCAT database.

Base year: Any year covered in Railplan or the HAMs, if it has been uploaded to the WebCAT database

Future year: Any year covered in Railplan or the HAMs, if it has been uploaded to the WebCAT database

Software: Internet-based. The background information is to be created using Railplan and the HAMs.

Operation: The website will be password-protected. Some information will be available to the public following free registration. Other information will be available to accredited users only.

When to use the model: It is hoped that the introduction of WebCAT will encourage planners to maximise the use of evidence on the transport system to support planning applications and planning processes.

Model limitations: Information that would be available on WebCAT is based on transport models, and has all the limitations of these models. For example, queries on a specific location would actually refer to the modelled traffic zone where the location is, and not the specific location. The information will not be applicable at a high level of detail but as a high-level, "zoom out" guidance.

Group Planning, Strategic Analysis: Simon Cooper [redacted]

A.16 Emissions Modelling

EAT

Overview: The Emissions Assessment Tool (EAT) is a spreadsheet tool for calculating emissions from road transport, river, aviation and rail. The detail below relates mainly to the road transport component, since this is the component that most applications to date have focused on.

Input: The tool requires estimates of the vehicle fleet composition and the total mileage travelled. These are standard outputs of the HAMs, described earlier, at a detailed level of individual road segments. Alternative sources of such estimates are LTS, at a borough level, or the London Atmospheric Emissions Inventory (LAEI). The HAM or LTS runs need to correspond to the scenarios we wish to test with EAT.

Output: Total tonnage of NO_x, CO_2, PM_{10} (exhaust, brake & tyre, abrasion, all) and $PM_{2.5}$ (exhaust, brake & tyre, abrasion, all) for each year specified, for the reference case and for each policy. The output is available by borough and by road link.

Area coverage: Greater London area.

Transport modes: Car, LGV, Rigid HGV, Articulated HGV, Bus & Coach, and Taxi.

Journey/activity purposes: No split by purpose.

Time periods represented: Figures are only reported annually.

Base year: Depends on the input data. Fleet composition data only goes back to 2008.

Future years: Depends on the input data. Fleet composition data only goes up to 2035 but can be adapted for future years if required.

Software: Excel with VBA

Operation: Operated by members of the monitoring team in Strategic Analysis – TfL Planning.

When to use the model: 1) for the assessment of environmental policies at the early stages of policy development 2) to understand the emissions impact of a scheme that has been tested in the HAMs or LTS.

Examples of model application: NO_x Action Plan policy screening; Ultra Low Emission Zone (ULEZ) option screening; River Crossings business case; Roads Task Force scenario testing.

Model limitations: In addition to the limitations explained in the "overview" paragraph above, note also that the model is limited to emissions outputs, and does not calculate concentrations. It is not suitable for final stage emissions or air quality assessment. Also note that to report total tonnages, LAEI inputs should be used. If inputs are based on HAMs or LTS, the model should only be used to calculate the percentage change in emission.

Strategic Analysis – TfL Planning:
Claire Cheriyan [redacted]
Lucy Parkin, [redacted]

Appendix B: Contact Details

(In order of appearance)

Bookmark code	Function	Contact Details
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ContactDetail02	Risk Functional Lead	Ibar Murphy,
ContactDetails03	Group Treasury	FX Hotline,
ContactDetails04	Sustainability Assessments	Helen Woolston
ContactDetails05	Commercial Finance	Julian Ware,
ContactDetails06	Surface Outcomes and SAF support within Surface	Tanya Durlen,
ContactDetails07	SAF use within Rail and London Underground	Kirsty Baker,
ContactDetails08	SAF technical support	Ben Warwick,
ContactDetails09	SAF Methodology	Ali Inayathusein,
ContactDetails10	LoRDM	Ali Inayathusein,
ContactDetails11	HAM	Huy Nguyen,
ContactDetails12	Health Assessments in SAF	Lucy Saunders,
ContactDetails13	Strategic Driver workshops and benefits mapping	Ben Ganney,
ContactDetails14	Underground Demand	Sarah Scott,
ContactDetails15		
ContactDetails16	LU Transport Planning	Howard Wong,
ContactDetails17	Bus Demand	Alex Phillips,
ContactDetails18	Road Space Management Data	Andy Emmonds,
ContactDetails19	One Model (Cyling Data)	Andy Emmonds,
ContactDetails20	CYDER	Ali Inayathusein,
ContactDetails21		
ContactDetails22	Customer Experience Analytics Managers	Customer Experience Analytics Managers,
ContactDetails23	LUL Simulation Modelling: NACHS, TSM	Sandra Weddell,
ContactDetails24	Equality and Inclusion	Lawrence Thurbin,

ContactDetails25	WebCAT Team	WebCAT team,
ContactDetails26	QRA, LUL Safety Appraisals	Nicola Perrins,
ContactDetails27	Surface Safety	Sandra Cowland Michael Pilch,
ContactDetails28	Road Safety Audit Team	Andrew Coventry, Mark Borrett, Anya Bownes, Shane Martin,
ContactDetails29	Design Team in Road Space Management	Samuel Barnes,
ContactDetails30	Risk in Appraisal Methodology	Simon Motley,
ContactDetails31	Valuing Urban Realm Toolkit	Robin Buckle,
ContactDetails32	PERS	Spencer Clark,
ContactDetails33	EIA (Group Planning)	Neil Kedar,
ContactDetails34	Noise Specialist	Jon Colclough
ContactDetails35	Air Quality	Lucy Parkin,
ContactDetails36	LU RES Model	Martyn Chymera,
ContactDetails37	LU Energy and Carbon assumptions	James Ingram,
ContactDetails38	LEGGI and related Emissions Assessment Tool.	Claire Cheriyan,
ContactDetails39	Service Delivery Standards (Customer Service Strategy)	Xavier Brice,
ContactDetails40	LonLUTI (Group Planning)	Tej Hunjan, Olga Feldman,
ContactDetails41	LTS (Group Planning)	Chris Hyde, Tej Hunjan,
ContactDetails42	LUTE, DPTM (DLR)	David Arquati,
ContactDetails43	RailPlan	Richard Hopkins,
ContactDetails44	MOIRA (NR)	Alan Smart,
ContactDetails45	JTC, SSM (LU)	Dave Hughes,
ContactDetails46	HSRT, TVM, RES (LU)	Tony Lightfoot,

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ContactDetails48	VISSIM/LINSIG/TRANSYT	Vladimir Vorotovic, [redacted]
ContactDetails49	Pedestrian Modelling (LU)	Sandra Weddell, [redacted]
ContactDetails50	Pedestrian Modelling (Surface)	
ContactDetails51	CLoHAM	Ali Inayathusein, [redacted]
ContactDetails52	Connectivity (PTAL/CAPITAL)	Simon Cooper [redacted]
ContactDetails53	Works Co-ordination and Permitting Manager	Helena Kakaouratos, [redacted]
ContactDetails54	R&U Events and Closure Planning	Charles Baker, [redacted]
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