RISK AND UNCERTAINTY
Introduction

The requirement for public sector projects to take account of risk and uncertainty is outlined in HM Treasury Guidance[1]. Advice from tie's technical consultants at STAG 1 and Outline Business Case stage indicated that cost uncertainty amounted to an additional 24% over and above the base estimate. This included estimates of 10% for specified contingency estimate and 14% for optimism bias. Since that stage, the Edinburgh Tram Network project has accounted for risk and uncertainty by reporting the P90 output from quantitative risk analysis. Although not strictly correct in mathematical terms, this provides a useful check against reported risk and OB figures.

The ETN project is approaching the stage where the Final Business Case is being concluded and this paper has been written in order to allow project personnel to understand and make a decision on the figures to be reported within the FBC.

Estimating Terminology

Where there is uncertainty, estimates include for four basic elements, namely base cost, contingency, quantified risk and optimism bias. The definition of each element varies from person-to-person and project-to-project. It is however, important that the definition of each element is clear in order that costs are not double counted resulting in a higher than necessary figure being reported.

In the ETN project, base cost includes the estimators' best professional opinion of the project costs given the specified scope for the estimate. This has been produced through single point estimating for each item in the estimate.

The term contingency has been recognised as ambiguous for some time. The understanding of the term affects how contingency is managed. Contingency is normally accounted for through three-point estimating or by simply applying a percentage based on the estimators experience to each item of the estimate. What the three-point estimating or percentage includes depends upon the requirements of the project. It may include for cost variance, reserve allowance, risk or under estimation amongst other things. In the case of ETN, the base estimate is understood to exclude all contingency.

Risk has been identified over and above the base estimate and includes items that have a less than 100% probability of occurrence. The quantitative risk register contains discrete (one-point) uniform (two-point) or triangular (three-point) costs associated with specified risks together with their likelihood of occurrence. The register has been analysed using Monte Carlo analysis in order to produce a range of values relating to the cost at risk for various confidence levels. Thus far the ETN project, with the approval of Transport Scotland, has reported at P90 confidence levels to include for optimism bias. Where risks develop a likelihood of 100% probability of occurrence, they are closed and transferred to the base estimate. The development of the risk register has excluded items that are covered by the change process.

Contingency can be included within risk as items specified within the risk register. This is not the case for ETN and consequently there is no contingency specified within the project.

The Optimism Bias (OB) phenomenon exists on projects world wide both in the private and public sectors. It is the tendency for project appraisers to be overly optimistic and is caused by a combination of how the decision making process is organised and the strategic behaviours of actors involved in the planning and decision making processes. It largely results from:-

- Poor definition of the scope and objectives of projects in the business case, due to poor identification of stakeholder requirements, resulting in the omission of costs during project costs;
- Overestimation of the project benefits or underestimation of costs possibly due to enthusiasm for the project, and;

[1] HM Treasury (2003) *The Green Book: Appraisal and Evaluation in Central Government*, TSO, London

- Overestimation of the ability of project managers to manage project delivery and treatment of risks.

Work by various authors' shows that OB applies to specific risk areas and that the level of OB reduces throughout the course of business case development and project delivery as the areas are addressed or project cost becomes more certain. The risks covered by OB cannot be quantified and valued individually – their value is calculated empirically based on data from previous projects, and often they are the unknown unknowns.

Risk and Optimism Bias is also applied to time within programmes.

Risk Calculation and Reporting

There are two main aspects to the figures that are reported from risk analysis. The first is the risk position and the second is the position on the probability curve resulting from Monte Carlo analysis.

Inputs to the risk register, whether cost or time, can be at three positions. These are the inherent or untreated risk (known as the uncontrolled position), current risk position and the residual or treated risk (known as the controlled position). Monte Carlo analysis can be run on the three sets of input to produce 3 output curves – worst, current and best case. At outline business case stage, when little or no specified risk mitigation has taken place and risk analysis is normally only semi-quantitative, it is prudent to report the uncontrolled position. The controlled position can also be reported perhaps as a target but this can raise expectation to a high level. Furthermore, additional risks will be identified as the business case progresses and although some risks will reduce in magnitude, the initially reported uncontrolled position is unlikely to be achieved. At Final Business Case stage, the uncontrolled position is irrelevant as much has already been done to treat risk. The risk position reported is a matter of investor attitude and the ETN project is reporting the current position, rather than the fully controlled position, in order to provide confidence in the risk figure.

Monte Carlo analysis is used to ascertain a range of costs and/or times that should be applied over and above the base estimate/programme to report a likely overall outcome. The outcome is selected from a probability curve made up from the various iterations that have been run. Normally an organisation will select one of the three "average" outputs, i.e. the mode (most commonly occurring value but rarely used in risk management), median (P50) or mean (expected value), for project management purposes and a higher value for investment confidence/reserve purposes. Selection of the position on the probability curve reflects the level of confidence that risk will be managed. It is a matter of organisational policy as to which values are selected and in the case of ETN, the P50 and P90 positions are used.

Optimism Bias and Reporting

Although a risk in itself, OB is a mathematically different concept to risk. Risk is essentially a bottom up activity based on figures building upwards from the base estimate. OB is a top down activity based on empirical evidence from previous projects and comprises "unknown unknowns" from outside the risk register. Their causes are also different, risk being a validated method of calculating the possibility of known occurrences and OB is largely a human behaviour related issue only in part related to specified risk management. Therefore, it is not valid to include OB as part of the curve produced by Monte Carlo analysis.

Thus far the ETN project has included for OB by reporting risk at P90 levels and although this is perhaps a valid check that project budget is not being overrun du to risk, it does not normally provide the full picture.

The concept of OB is relatively new, the landmark work being developed in 2002 as a result of a study by Mott MacDonald[2] on behalf of HM Treasury. The paper presents compelling empirical evidence that public sector projects typically overrun in terms of cost and time and investigates and present reasons for overrun occurrence. Subsequent work, although limited in quantity, supports the concept of OB.

[2] Mott MacDonald – HM Treasury (2002) *Review of Large Public Procurement in the UK*.

To ascertain the level of OB for a project, headline areas which have been established as the cause of OB are considered in terms of the extent of their treatment so far – a "mitigation factor" is established. The MM paper provides upper bound values (in %age terms) based on empirical data for particular types of project and the mitigation factors are applied to this upper bound level. The ETN project is considered a Standard Civil Engineering project which has an upper bound level of 44% and lower bound level of 3%. Where the risk register has identified risk that applies to the designated areas, this can be applied within the mitigation factor determination process also. Thus, technically speaking, an item that started out as an unknown unknown in OB has transferred to specified risk or into the base estimate as project requirements become more certain. The total consideration of each area is taken into account to produce an overall figure for OB. This figure is reported as a percentage.

Application of Risk and OB Figures

The guidance for determination of the OB percentage figure is very detailed. However, the application of this figure to the base estimate is less than clear. Therefore, based on information gleaned from the guidance and mathematical argument, the recommended equation to calculate project outturn cost is as follows:-

Scheme cost = (Base Cost * (1+OB)) + Contingency + Risk + Cost of Risk Management

The selection of risk level and the application of OB is ultimately a matter of investor policy.

Commonly the level of risk applied is P50 or expected value for management purposes and P80 for investment purposes i.e. the reserve held by the investor for a project is simply the P80-P50 figure. OB is also often regarded as part of the reserve.

OB is sometimes applied to the base cost, contingency and specified risk resulting in a higher figure than if it were simply applied to the base cost. Essentially this method of application means that "unknown unknowns" have been applied to each element of the estimate. Given the estimate element definitions above, this is perhaps not a valid approach.

Current Outturn Cost Outputs

To demonstrate the difference that the various approaches make, indicative costs are shown in Table 1 below. All of these items exclude the cost of risk management as this has not yet been established for ETN.

Item	P90 – ETN Current Method	P80 – Upper Reserve Method	P50 – Lower Reserve Method	Mean Upper Reserve Method
Base Estimate	£533,189,654	£533,189,654	£533,189,654	£533,189,654
OB @ 5.6%		£29,858,621	£29,858,621	£29,858,621
P90	£59,025,000			
P80		£51,390,000		
P50			£36,800,000	
Mean				£38,950,000
TOTAL	**£592,214,654**	**£614,438,275**	**£599,848,275**	**£601,998,275**
Reserve excluding OB			Reserve P80-P50 Method £14,590,000	Reserve P80-Mean Method £12,440,000
Reserve including OB			£44,175,621	£42,025,621

Table 1. Indicative Costs

Investor behaviour is often such that they will allow a project to manage up to the designated lower reserve level and then an additional funding application process applies for use of the reserves.