Managing Cost Risk & Uncertainty In Infrastructure Projects

Leading Practice and Improvement: Report from the Infrastructure Risk Group 2013

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Foreword

Risk and contingency management offers major financial benefits for the next generation of multi-£billion infrastructure projects.

Infrastructure UK, a unit within the UK Treasury that works on long-term infrastructure priorities, has undertaken a review of the cost of infrastructure projects in the UK and how this cost can be reduced.

One workstream within this has focused on the best risk and contingency management in UK infrastructure projects; the research investigated how to share and improve this leading practice. It is felt that this offers major financial benefits for the next generation of multi-£billion infrastructure projects.

This report is aimed at those who can help make this happen; directors, senior managers and experienced risk managers. This research has been undertaken by an industry group with representation from major infrastructure owner operators. This report presents this group's output. It describes the challenges we are aiming to tackle, the research we undertook, as well as our recommendations. This is backed up with a package of supporting material, including a compendium of leading tools, examples of leading practice and the plans for future improvement.

This report has been prepared independently based on the material collated. The recommendations have been formally approved by the group; organisations will choose to adopt them in a way which suits their organisational context. While it has been reviewed by individual members of the group, and their comments have been considered, it does not represent the policy of the contributing organisations.

I am very grateful for the contributions made by all the group members, especially those who participated in the behavioural workshops or contributed case studies. In addition, all sources are referred to in footnotes.

Miles Ashley,
Programme Director of Crossrail & Stations, London Underground
Leader of the Infrastructure Risk Group

irm
Leading the risk profession

The Institute of Risk Management is pleased to support the publication of this much needed piece of research and guidance by the Infrastructure Risk Group. In a fast developing field like risk management, we believe passionately in the value of sharing practical knowledge and experience across industry and we commend the work of this group in addressing a matter of great public interest.

Carolyn Williams, MIRM, Technical Director, Institute of Risk Management

Summary

9 Key Recommendations

Behavioural factors significantly influence risk and contingency management

The group's research looked at the management of cost risk and uncertainty throughout the project lifecycle. The incentive is to significantly reduce the cost of projects by curbing unnecessary spend, especially of the contingencies allocated for cost uncertainty.

The group found extensive good practice across the UK, despite the inherent difficulties in understanding risk exposure at each project stage. What stood out was the range of behavioural factors influencing risk and contingency management. Examples include:

- Project teams, contracting supply chains, and project sponsors deliberately underestimating ('gaming') their risk estimates in order to secure work;
- Torturous risk fund release processes influencing projects to hold excessive local contingencies;
- Organisational requirements for projects to return unused risk monies before project completion is actually discouraging mitigation of risk by project teams, i.e. smaller contingencies were felt to be more likely to be exceeded by new risks occurring (with negative career impact for project managers); anything that led to a smaller contingency was therefore resisted. This included mitigation activity that would have led to reduced risks needing less provision, and a requirement to return the 'savings' to the organisation.

As a result of their research the group has nine recommendations:

Cost and risk estimation

1. Present risk exposure as a range, to promote more informed decisions and communications (particularly at strategic-level);
2. Leading organisations to underpin early-stage risk allowances with both reference-class forecasting, and risk analysis, rather than Optimism Bias-based uplifts;
3. Consider cost and risk estimates side-by-side, for completeness and to combat double-counting.

Active risk mitigation and management

4. Incentivise risk mitigation, to ensure risk actually gets managed in the face of other behavioural influences (c.f. London 2012 Olympics delivery programme, and London Underground's Ring-Fenced Risk Model);
5. Adopt informed and rapid contingency draw-down processes (e.g. as for the Olympics);
6. Different organisations to cooperate on risk and contingency management of interfacing programmes, to enhance mitigation and avoid duplicating contingencies.

IRG will lead development of project risk management practice.

Enabling and Supporting Activity

7. Use a common vocabulary and develop a generic risk profile;
8. Set up a UK-wide body to collect and share data;
9. Establish a UK forum to share good practice.
    - The existing industry group that carried out this research should be formally established as the guardians of leading UK practice in project risk and contingency management to support recommendations 8 and 9. This group will be known as the Infrastructure Risk Group.

These recommendations are supported by a more in-depth explanation of the associated risk management disciplines, a compilation of useful generic tools and approaches based on the findings of a set of case studies contributed by Group members, and a glossary which has been developed to ensure clear and consistent usage in this report as well as initiating Recommendation 7.

Next Steps

In line with IRG's recommended role as guardians of leading project risk management, further steps are needed to support further development and deployment. The relevant activities will include continuing to collect case studies and project histories and, in particular, implementing 'critical friend' reviews. These are a type of peer review which will investigate the existing practices in regard to risk and contingency management on a project or programme and make recommendations for improving them in the light of the information which has been collected as part of this exercise.

This report should be read in conjunction with the forthcoming HM Treasury Green Book Supplement[1] providing additional early stage guidance on appraisal in the light of our research.

1. Current version is *Determining risk and uncertainty in the early cost estimates of (infrastructure) projects and programmes. Consultation document on Supplementary Green Book guidance.* January 2013.

“There is an opportunity to improve control of £billions that would otherwise be committed.”

Managing Cost Risk & Uncertainty In Infrastructure Projects

Contents:

“Risk analysis helps us to track uncertainty and provides a range of possible final costs.”

Part A
Review and Recommendations

1 Context

Moving from a range to a single number risk allowance is a matter of judgement.

Risk management is there to manage risks. This is, perhaps, self-evident, but the IUK research observed how prominent the financial aspects of estimating risk are, and how much less attention was given to actually managing risks. This was despite the evident quality of risk management practice looked at by IUK. It suggests that the mitigation of risks could receive significantly more focus, a simple step that could offer major financial benefits for the next generation of infrastructure projects. With this rider in mind, the following text introduces some of the practical challenges around the financial estimation of risk.

When we begin to initiate and develop a project we do not know with certainty what it will cost. This uncertainty starts large and reduces as the solution to the business requirements is developed, the design is crystallised, contractors are selected and the project is built. Risk analysis helps us to track the uncertainty through these stages by providing a range of possible final costs.

Optimism bias can lead to gaming behaviour.

But a range of costs is generally incompatible with the management disciplines we have to exercise though the project lifecycle. We use a single value of cost to compare with the benefits when we carry out a value for money appraisal. We need a single figure for the annualised budget of the project. We need a single number for the money we authorise the project manager to spend to deal with the risks that materialise during construction. So we create financial risk allowances to deal with these issues.

To move from a range of possible final costs to single number risk allowances is a matter of judgement. The risk analysis is inherently subjective to some extent and there is no acknowledged single way to move from the estimate risk exposure to the risk allowances.

This opens up the possibility of both random variations in performance and gaming by the various parties involved.

As an example, some 10 years ago the Government became frustrated with the extent of cost overruns on projects. They attributed this to over-optimism on the part of project sponsors. To counter this they implemented a system of uplifts based on high-level project characteristics which became known as optimism bias. This was incorporated into the Green Book guidance on appraisal. While this development may have improved the quality of project appraisals it has become apparent that it may be increasing the cost of projects: in broad terms the optimism bias uplift may become enshrined in the eventual budget, becoming a project contingency, and spent, even in situations where it is not needed. There is therefore a potential opportunity to better control £billions that may be over-invested in this way. Helping to resolve this is a major target of this report.

To take another example, consider the position of a contractor bidding for the main construction contract of an infrastructure project. Being in a competition creates gaming by definition. The contractor must not bid so high that the work is lost. But a low bid may result in crippling losses. Maybe the answer is to bid low in the hope of recovering profit through claims, thus building a difficult relationship into the project from Day 1. From the point of view of the client organisation, risk and uncertainty around the project physical costs has been transformed into a spectrum of commercial and relationship risks. How are these best planned for and dealt with?

There is an opportunity to improve control of £billions that would otherwise be committed using optimism bias methodologies.

The IUK Risk and Contingency project contains two strands. The first is broad in scope, identifying current good practice in risk and contingency management, whilst making recommendations for its enhancement. This report deals with this strand. The other centres early stage contingency appraisal, and is part of HM Treasury's Green Book guidance for central Government departments.

This report is produced by the industry group, who are mainly professional risk managers, and is directed at senior managers and project managers in all organisations who sponsor and deliver infrastructure development in the following sectors:

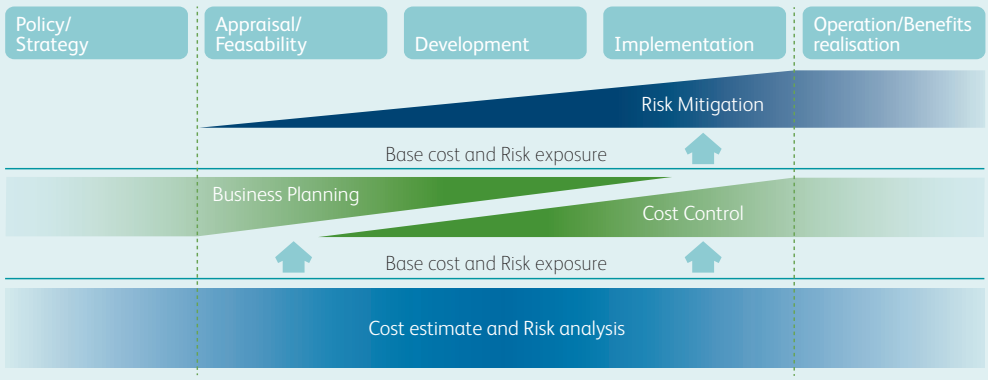
- transport
- water, waste water, flood risk and coastal erosion
- energy
- solid waste management communications.

The importance of sponsors being closely involved in dealing with cost risk and uncertainty is a running theme in this report. To deal with this, our intended audience includes Government officials and other managers who will not normally engage with the details of risk. Accordingly this is not a risk management manual and this report is produced by, not directed at risk managers. Risk managers may nonetheless find it helpful.

Scope and Contents

The scope of this report is illustrated in Figure 1. At the top are the usual project lifecycle stages. Management of risk begins, in some form, from the earliest stages of Appraisal/ Feasibility. The management decision making processes move from business planning to cost control as the project becomes better defined. Cost estimation and risk analysis are sustained throughout the scheme.

Fig 1: Business processes supported by cost and risk estimation



1 Context (cont.)

Our focus is on cost risk and uncertainty in project delivery.

Our primary focus is the three middle stages of the project lifecycle, as indicated by the dotted lines. However we recognise that the other processes are important. Specifically:

- Policy/ Strategy
  The context of Figure 1 shows that project development flows out of business strategy and the resulting requirements. This was a key feature of our research workshops (see Chapter 5). But our primary interest begins when the concepts which meet the requirements have been identified.
- Operations
  The topics of whole life costing, operational costs, benefit realisation and decommissioning are important for business planning and project delivery; they need to be considered as an inherent part of project appraisal. Indeed savings on capital costs can lead to additional operational costs.

This report is purely concerned with cost risk and uncertainty in project delivery, that is, anything which can have an impact on the cost of the project. Safety and environmental risk have not been considered. It is taken for granted that the project will be safe and meet environmental requirements – or any other compliance matter. Neither is this report concerned with schedule risk, commercial risk, legal, risk, reputational risk or any other type of risk *per se* except to the extent that they contribute to cost. In this respect it is worth noting that schedule risk is fundamental to cost risk for many organisations. Figure 3 (Chapter 4) also illustrates the point that eliminating programme uncertainty is the next priority once outline scope has been determined.

Furthermore this is not a manual of risk analysis or risk management. It is assumed that organisations undertaking infrastructure procurement in the hundreds of millions of pounds bracket, or more, will take steps to attain an appropriate level of risk management maturity, for example Level 3 in the OGC project risk management framework: a centrally-defined, consistent risk process used across all projects.

We found there was an expectation that this report would provide guidance on how to analyse the risk of inflation, that funding might not be available, and that specific taxes might apply, and so on. As this is not intended to be a risk analysis manual we do not cover specific risks here. However an important principle of the approaches we recommend is to engage closely with each important issue so as to understand what it can mean for the specific project.

> The issue is straightforward in principle: how do we approach the financial management of projects with an uncertain final cost. But in practice organisations find this challenging.

It is important to be clear whether the cost risk and uncertainty is expressed in real costs, outturn costs or, indeed, present values. Different conventions will apply in different circumstances and there is no single answer. One respondent considered that it is important to take real costs as the starting point and then systematically consider potential inflation as well as other ways in which the external environment may change such as change of law.

The issue is straightforward in principle: how do we approach the financial management of projects with an uncertain final cost. But in practice it is difficult. The subjectivity means there is no unique solution; the gaming means that concepts have become muddied. Consequently we think that a clear and systematic use of language can help lift the veil of obscurity covering this topic.

This means the Glossary (Chapter 7) is a key element of the report. It is here that we set out the definitions which we use throughout the remainder of the report. It is also here that we note alternative language in common use and comment on its relationship with our preferred set. In addition to this, we concluded that it was necessary to describe at a high level some fundamental elements of risk management; risk analysis and cost control to dispel some unstated assumptions and provide a common set of concepts (Chapter 4).

The Green Book Supplement[2] is a parallel document to this report. Its scope is the early stages of project development and the use of risk exposure information in decision making. We have adopted consistent terminology across the two documents.

2. *Determining risk and uncertainty in the early cost estimates of (infrastructure) projects and programmes.*

2 Exploring the Challenges

Behavioural factors are important.

Improving the risk performance cycle.

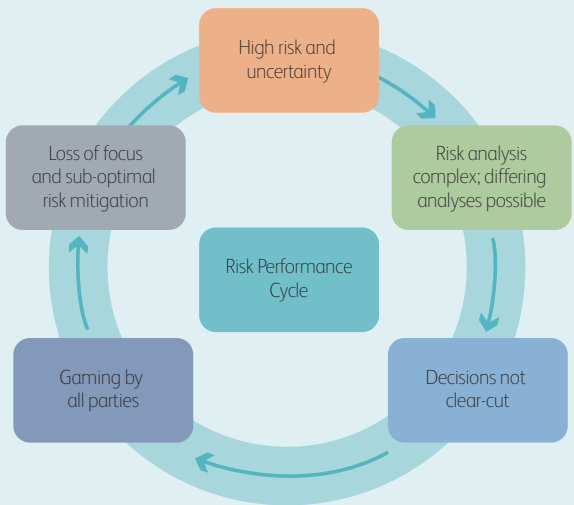
We undertook a programme of research to explore the various approaches and tools which are used within leading organisations to manage cost risk and contingency. Following discussions, initial research began to reveal the importance of behavioural factors. As a result 'behavioural simulation workshops' (described in Chapter 5, alongside the other tools) were undertaken to investigate this.

Our research showed that there are many factors which contribute to the overall challenge of managing cost risk and uncertainty, especially the uncertainty at early stages in a project, and range of behavioural factors. This potentially creates a cycle of diminished risk performance as sketched out in Figure 2.

High risk and uncertainty means that the risk analysis is challenging; different analysts could characterise the risk exposure in different (and equally-correct) ways. As a result decisions may be less clear-cut than is desirable. This leaves the door open to gaming for stakeholders to achieve their desired objectives, all of which in turn leads to a lack of focus on real risk management: putting actions in place to reduce risk and uncertainty and implementing them. And the uncertainty remains higher than it should be which may result in unnecessary expenditure. This report is about improving the risk performance cycle, and its associated processes/behaviours.

But first it is worth listing the specific challenges in each box of the circle.

Fig 2: The risk performance cycle arising from high uncertainty



So there are risk analysis challenges …

… difficult decisions …

… and gaming is a further complication.

Challenges for Risk Analysis

- There is no such thing as an 'accurate' risk analysis, at least in this context; risk analysis is subject to judgement and subjectivity, both in the risk model and in the data which quantifies it.
- There is no established toolkit for early-stage risk analysis:
  - there is no established process for progressing the risk analysis from generic uplifts, to project-specific cost analysis and then on to a recognition of commercial/contractual-structures;
  - there is a tendency to overstate the effectiveness of mitigation, leading to excessive or unjustified assumptions of risk reduction.
- The optimism bias concept is often misunderstood and is too readily accepted as the best available figure, contrary to explicit Green Book instructions. In addition:
  - optimism bias does not account for the principles adopted in developing the base costs;
  - building on this, there may be double-counting: recognition of risk may be included in the base cost and risk allowances;
  - so that to the extent that optimism bias (or any other approach based on past performance) depends on poor performance, project costs will tend to be overestimated.
- Inconsistent terminology has caused confusion, including the tendency to mistake specific statistical properties of the risk exposure with the management provisions for risk.

Challenges for Decision-Taking

- Large uplifts at the early stages encourage more to be spent than is necessary to achieve the business requirements; the project may become over-specified, or the contingency may be frittered away.
- Alternatively projects may be de-scoped – failing to achieve the business requirements – if the final cost is fixed too early.

Typical 'Gaming' Behaviours

- Project sponsors will tend to adopt assumptions which favour a project, which might be gaming (also known as 'strategic misrepresentation'), or might be genuine optimism.
- Financial managers will tend to exert pressure to reduce risk contingencies irrespective of actual risk levels to address more short-term financial needs.
- Project managers will tend to overstate risk so as to secure and maintain large contingencies, for example to avoid the ignominy and career impacts of overspending.
- Contractors may price unrealistically in order to win work and then use commercial means to maintain their profits.
- Project managers may resist any activity that leads to reduced contingencies. This may include mitigation activity that could lead to reduced risk levels needing less contingency.

2 Exploring the Challenges (cont.)

Organisations may lack risk management maturity.

And this creates cultural challenges.

- Financial managers may exert pressure for reporting forecasts to be smooth and budget-compliant when – by definition – they will vary with time as the project progresses.

All such gaming opportunities are increased for **complex projects**, undermining transparency and control where the risk is already more difficult to appreciate and manage.

Impacts on Risk Mitigation

- The focus on analysis emotive debate around risk budgets can significantly detract from identifying and implementing effective controls, that is, good risk mitigation.
- Co-dependent projects (e.g. different organisations side-by-side at the same location) may not manage risks and contingencies effectively overall, for example there may be contingencies for the same risk within both organisations.
- Opportunities for leaner project delivery may not be sought or may be overlooked.
- Contingency draw down processes may not be fit for purpose – cumbersome and torturous, for example, leading to unauthorised local contingencies being created.

Cultural Challenges

- Organisations may lack the necessary degree of risk maturity or an appropriate risk culture to implement the risk analysis and governance activities that are necessary.
- The risk management practitioner community is often comparatively inexperienced and junior considering the scale of financial decision-making involved (multi-£billion contingencies). This may be because the discipline is not seen as sufficiently important by senior managers, and, as a result, may not get the attention or priority it requires.
- Early-stage single-figure cost estimates, if they are made public, can be used inappropriately as a yardstick for subsequent project performance.
- And as a final, logic-defying point we were told that firm, fixed end dates (such as the Olympics) act as a major spur to project decision-making and commitment, thereby diminishing risk levels encountered by the project.

Whilst the underlying challenge is posed by behavioural factors in the face of uncertainty, it is apparent that this is inflated by lack of a common language, lack of common understanding and lack of shared toolkit.

> “Consider cost and risk estimates side-by-side, for completeness and to combat double-counting.”

3 Recommendations

Face up to uncertainty and use ranges of final cost.

Use risk analysis combined with reference-class forecasting from an early stage.

Following considerable discussion we make the following recommendations to rise to these challenges. For each recommendation there is a summary in the title followed by the full recommendation, the reasoning and finally some examples of where the item has been successfully implemented. Once more we emphasise that these recommendations are not intended to be prescriptive and indeed can be addressed in different ways by different organisations.

Recommendation 1

Present risk exposure as a range, to promote more informed decisions and communications (particularly at strategic-level)

Adopt **ranges** to explain early-stage project uncertainty rather than **single-figure** estimates such as an AFC (Anticipated Final Cost).

This reflects the point that the cost risk and uncertainty is highest during the early stages of projects. This leads to a tendency for overly high single numbers to be quoted when senior figures have to provide authoritative early forecasts of costs e.g. to Parliament.

We consider this has a very large financial impact in the UK, and the use of ranges for forecasting will reduce this inflationary trend.

This approach is adopted by the Highways Agency where the case study shows that during the early stages P10s and P90s are kept in view. As also noted in the case studies, Crossrail routinely works with percentiles whilst stating its AFCs.

Recommendation 2

Leading organisations should underpin early-stage risk allowances with both reference-class forecasting, and risk analysis, rather than optimism bias-based uplifts

Early-stage cost estimates should be calculated by adopting the results of specific risk analyses and cross checking with reference class forecasting instead of using the current optimism bias approach.

This will encourage interrogation and mitigation of the risks driving risk allowances and eventually project contingencies. It will lead to the earlier identification of specific risks, avoiding fear of the unknown being priced into optimism bias uplifts, thereby reducing the eventual need for contingency funding. This will also encourage the mitigation of significant risks, again leading to major cost savings. This reflects evolved risk management good practice used by leading UK infrastructure organisations.

For example, the Highways Agency case study shows how an organisation can use specific risk analyses to support the appraisal of projects with no generic uplifts. Network Rail move from a generic uplift to reference class forecasting and on to project specific analyses.

Look at cost and risk estimates together.

Maintain attention on mitigating risk.

Recommendation 3

Consider cost and risk estimates side-by-side, for completeness and to combat double-counting

The process for both cost and risk estimation should be undertaken in an integrated approach, for example, both being combined into a single forecasting model.

Both the IUK and the Scottish Futures Trust research[3] highlighted the need for an integrated approach to cost and risk estimation. This is designed to prevent risk allowances being duplicated in the project base cost and vice versa. It is important to understand that the risk needs to be developed in light of the base cost. The most straightforward way to achieve this discipline is an integrated model on which the cost and risk estimators work closely together (see Chapter 5).

For example, the Highways Agency case study combines the risk analysis directly into the cost estimation format so that duplication can be checked. Network Rail create their early stage cost estimates using reference class forecasting, meaning that the effect of risk has already been included and the need for further risk allowances can then be carefully considered.

Recommendation 4

Incentivise risk mitigation, to ensure risk actually gets managed in the face of other behavioural influences (c.f. 2012 Olympics delivery programme, and London Underground's Ring-Fenced Risk Model)

Risks should be actively mitigated and opportunities positively pursued through the use of incentive schemes such as London Underground's ring-fenced risk model (see Chapter 5). This encourages projects to deliver risk mitigation targets, but goes on to ensure that the teams are not penalised by withdrawing these reductions from contingency funding. The 2012 Olympics benefited from a similar incentive derived from delivery organisations retaining the savings from mitigation and risk reduction.

Mitigating risk and exploiting opportunities lie at the heart of risk management and reducing risk exposure. This simple point is often obscured by the plethora of complicated process surrounding risk. A step change in this area may produce major reductions in the cost of project delivery. Our research highlighted the crucial significance of behaviours in projects, with personal incentives being identified as the most effective method overall to tackle this issue.

3. *Review of project cost and budget estimation: report on findings*, Scottish Futures Trust, September 2011.

3 Recommendations (cont.)

Where projects interface, organisations should manage risk together.

Contingency draw down must be efficient and effective.

Recommendation 5

Adopt informed and rapid contingency draw-down processes (e.g. as for the Olympics)

Contingency monies within organisational hierarchies should be sufficient, transparent and accessible, with clear guidance on risk analysis and the allocation of funding, and with rapid but controlled contingency draw down.

Our research indicates that insufficient contingency leads to undesirable behaviours at all levels as teams seek to protect their position. This includes hiding contingencies in project base costs, contractors adopting claims-based strategies, and 'gaming' behaviours to inflate contingencies. Tortuous contingency draw down processes also lead to delays in authorising the use of contingencies after risks have materialised.

Very clear guidance on the level of mitigation allowed for within risk quantification is essential to prevent such gaming behaviours. E.g. a post-mitigated risk position can vary by many £millions depending the proportion of mitigation assumed to be effective. Strategic awareness of this issue at senior levels and implementation of appropriately balanced control systems are also essential to prevent problems.

The creation of adequate contingency funding is promoted by the use of different levels of contingency, for example at programme level as well as project level. This recognises that a lower provision is required to protect a whole programme of projects to a given level of confidence than would be required to protect each project individually to the same level of confidence. This is the so-called portfolio effect. Furthermore there are benefits to be gained from managing some systemic risks across the programme.

Recommendation 6

Different organisations to cooperate on risk and contingency management of interfacing programmes, to enhance mitigation and avoid duplicating contingencies

Different capital delivery organisations should work together to achieve active management across parallel, interfacing programmes using joint risk registers and jointly agreed risk mitigation. External organisations (e.g. HMT) may be able to play a successful role in facilitating this on a case-by-case basis.

This recommendation reflects the frequently recurring scenario of separate public sector capital delivery organisations running construction programmes side by side (e.g. in the same urban developments), whilst separately holding hundreds of millions of pounds against risks caused by the other. If joint mitigation approaches could be set up and made to work, these problems could be reduced with major benefits to the taxpayer and customers.

Despite numerous opportunities for this we have found only one example of where this has been successfully deployed. A dedicated risk team has bridged the risk processes in Crossrail and London Underground where each poses a significant risk to the other.

Collect information to support risk analysis.

Use a common language and, if possible, common risk structures.

Recommendation 7

Use a common vocabulary and develop a generic risk profile

A common vocabulary of technical terms should be agreed across all organisations and a generic risk profile knowledge-share database of recurring risk items should be developed to facilitate consistent risk analysis.

The lack of a common vocabulary hindered all aspects of the research. It was very difficult to achieve clear and consistent communication about risk and the way it should be dealt with a various stages of project development. We have been careful in this document to use simple language in accordance with natural use as far as possible – see the Glossary in Chapter 7.

Similarly we have experienced significant difficulty in understanding the relationship between the differing ways of understanding risk exposure and generating risk allowances. Being able to comprehend these in a consistent manner offers the prospect of much easier and credible risk analysis; see the high level discussion of key processes in Chapter 4.

Recommendation 8

Set up a UK-wide body to collect and share data

Establish a system of robust, consistent and accurate data collection and sharing in the UK.

Together with the previous recommendation, this will enhance the objectivity and effectiveness of risk analysis.

With respect to project data we note the information which has been collected by the Saïd Business School at Oxford which can support reference class forecasting alongside bottom-up risk analysis.[4] Setting out a route to making more, and more relevant, project data available is a key element of our future programme described in Chapter 6.

For example the Network Rail reference class forecasting technique gathers data on projects and provides risk-inclusive cost estimates based on the broad characteristics of the projects.

4. For a critique of the issues involved see *Quality Control and Due Diligence in Project Management: Getting Decisions Right by Taking the Outside View*, Bent Flyvbjerg, International Journal of Project Management, in press, available online 8 November 2012.

3 Recommendations (cont.)

IRG will lead development of risk management practice for infrastructure projects.

Recommendation 9

Set up a UK forum to share good practice:

a) The existing Industry Group should be renamed as the Infrastructure Risk Group (IRG), and formally established as the guardians of leading UK practice in project risk

Establish a forum of infrastructure organisations to share good practice and peer review and support developing programmes; the earlier and more thoroughly good practice is shared, the more effectively projects will be developed and implemented.

This report makes a start on this collation and IRG will continue this, acting as the guardian of leading practice, and supporting its improvement. The deployment of the best available tools will be encouraged by 'critical friend' reviews which will be carried out by IRG teams on significant projects. These reviews will seek to test whether good practice is being adopted, suggest how this could be improved and also to identify improved approaches which could be used by other infrastructure clients.

Part B
Guidance and Improvement

4 The Project Lifecycle and Risk

Risk mitigation is a key lever in controlling/ reducing project costs.

Effective risk mitigation can eliminate £billions of risk exposure.

The explanations which follow are meant to serve as management briefings. Like the rest of this report, they are intended to provide the necessary overview for senior managers, decision makers and policy formers. They are not designed to be specialist texts for risk managers.

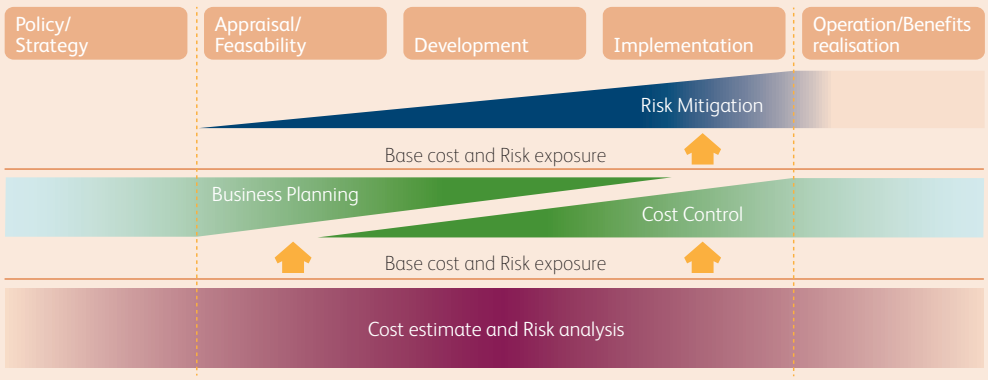
Overall, we stress that risk mitigation is a major lever for controlling and reducing project costs. The follow text expands on this, alongside risk management maturity (this has been a recurring theme, essential to the effective management of cost risk and uncertainty in organisations commissioning infrastructure projects). We discuss the principles of risk analysis before turning to cost control. We recognise that business planning and appraisal are largely covered by the Green Book.

This report is about highlighting and enhancing existing good practice. The case studies in Chapter 8 provide many examples.

But to put them in an appropriate context so that informed decisions can be made about which to adopt it is necessary to do two things. One is to extract the core ideas from the good practice examples. If this were not done there would be a risk that a specific tool – a piece of software or a decision support criterion – would be picked up and used in a way which was not appropriate to the organisation. So in the next chapter we list the underpinning ideas of what works in leading organisations as a set of useful tools.

But even before this, it is necessary to understand better the context in which these tools are deployed (Figure 1, reproduced below). The principles underpinning this are the key to a proper understanding of the purpose of the tools. Cost risk and uncertainty is a familiar phenomenon, but its complexity, and the challenges it poses mean that in spite of this familiarity there are many ways of thinking about it and many terminologies are used to describe the key elements.

Fig 1: Business processes supported by cost and risk estimation



Different organisations may adopt different approaches, depending on their characteristics and risk maturity.

The OGC P3M3 format provides a convenient way to assess risk maturity.

This in turn has resulted in many common unstated assumptions – common but not necessarily shared. The extent of this emerged only while previous drafts of this report were discussed.

The purpose of this chapter is to build on the Glossary's common terminology to clarify these assumptions, build a picture which sheds light on the challenges and recommendations listed in Part A, whilst providing a framework for the following tools.

Risk Mitigation

As previously mentioned, risk management is there to manage risks. However, ensuring that formal risk management translates to practical mitigations at all levels of programme organisations is challenging. Driving accountability, sustaining intensity of activity, and implementing a culture of mitigation is demanding, technically-challenging professional work requiring significant top management support and commitment. Done well, it can eliminate £billions of risk exposure. Done poorly, or with limited focus, the result is an infrequently-reviewed, administrative process and a missed opportunity to prevent project overruns.

We saw much good mitigation practice as part of the IUK research, with engaged senior management teams benefiting from practical mitigating actions across projects. We stress the need to continue and intensify such activity, at all levels of delivery organisations, thereby developing the next generation of leading practice. Ultimately we recognise the crucial importance of this aspect of risk and contingency management, and the potential for significant savings that it offers.

Risk Management Maturity and Risk Culture

We have emphasised that the most important feature of risk management is that it stimulates action to reduce risk. It is of paramount importance that a proactive approach is taken to identifying mitigating actions and implementing them. The ability of an organisation do this depends on its risk maturity and its risk culture.

The idea of assessing risk management maturity has been around for some years. Numerous variants have been developed which seek to characterise increasingly good practice in the various activities which make up the accepted risk management process as set out in standards.

One of these is the OGC P3M3 process which provides assessment tools at the portfolio programme and project levels. Any organisation sponsoring projects at costs of hundreds of millions of pounds and more is likely to face significant cost risk and uncertainty. As a result leading organisations find it well worth the investment in developing a high level of risk management maturity. In fact we recommend that any such organisation should seek to achieve at least Level 3 maturity on the OGC scale: "project and programme risk management is based on a centrally defined process addressing the organisation's policy for the management of risks and is used consistently."

However the risk maturity concept leaves some important matters unaddressed or glossed over, some practical and some cultural.

4 The Project Lifecycle and Risk (cont.)

Risk professionals must be suitably skilled, experienced, and operating at senior level.

Risk culture is important to create the right conversations and make the right decisions.

From the practical point of view, it is apparent that risk management does not enjoy a high status in some organisations. It is seen as a technical subject, an administrative activity frequently delegated to specialists, an approach with contrasts with the multi £billion scale of UK contingencies. As a result, risk professionals are often junior, inexperienced, and ineffectively deployed. This is not helped by the lack of defined qualifications and career prospects for these professionals. Indeed, the role of the risk manager, and how it is distinguished from that of the risk analyst are also sometimes misunderstood. Part of our future programme involves better characterisation of the roles and the appropriate qualifications.

Turning to the cultural dimension, it is increasingly recognised that good risk management is not just a matter of process, however mature. It is essential that these processes are supported by the right organisational environment which goes beyond the essential level of risk management maturity that we recommend for a programme of large infrastructure projects. For example, some organisations find it challenging to maintain the necessarily mature level of risk conversations so that contingency is drawn down or released when appropriate. And it is important that the overall process surrounding does not detract from actually managing risk. All of these are cultural issues.

The Olympic case study emphasises the importance of transparency, openness, mature and informed discussion, good working relationships, full understanding of project and programme management issues, willingness to learn, unwillingness to compromise on the quality of information, rigour and, above all, excellent people. These set a cultural standard within which risk and contingency management can work well.

Risk Analysis

Figure 3 provides an overview of the cost estimation process. This is divided into two streams: the estimation of base cost and risk analysis. There are two components to the risk analysis: a risk model and quantification data.

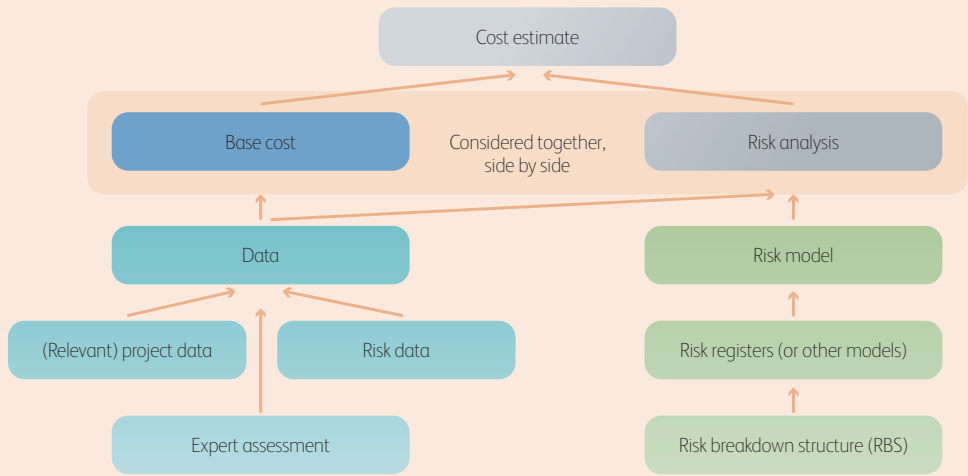
The risk model is some form of representation of the possible ways the project might evolve. This can be a risk register, a list of uncertain events and parameters. One starting point for a risk model might be a risk breakdown structure. By analogy with a work breakdown structure used in project planning, this is a hierarchical list of risk areas working down to specific risks. Generic risk breakdown structures are very useful to initiate the risk model for individual projects and are discussed in more detail in Chapter 9.

When the risk model has been created it needs to be quantified. This requires data. The data typically comes from three sources:

- experience with similar projects or activities; the degree of similarity is crucial to the approach and subject to judgement
- experience of similar risks materialising
- expert assessment based on broader, more diffuse experience.

Cost estimation integrates base costs and risk assessments.

Fig 3: Building up the cost estimate



The data may be hard or soft, but it must be relevant.

In practice there may be mixed approaches where informed adjustments are made to data available from the relevant projects.

The Industry Group expressed a clear preference for risk estimation based on hard data – the first two bullets. This is considered to be more objective and certainly more auditable. The 'outside' data-based view is strongly recommended by Flyvbjerg[5] in his review of forecasts. It is worth a warning, though, that the past is not always a good guide to the future. Circumstances may change, new techniques be developed, or different risks may become material. It is important that data is always reviewed for relevance.

Figure 3 also makes clear that data feeds into the base cost estimates, especially the information on similar projects. Figure 3 reinforces Recommendation 3, that it is important to consider base cost estimates side by side with those of risk exposure. The purpose of this is to make sure there is no double counting.

This is shown in Figure 4 which illustrates how the three main elements evolve from an 'immature' state to a detailed mature assessment.

5. *Flyvberg Op cit.*

4 The Project Lifecycle and Risk (cont.)

'Mature' cost estimates require that the design is fundamentally complete. This means all major design decisions are finalised, with remaining design work being detailed in nature.

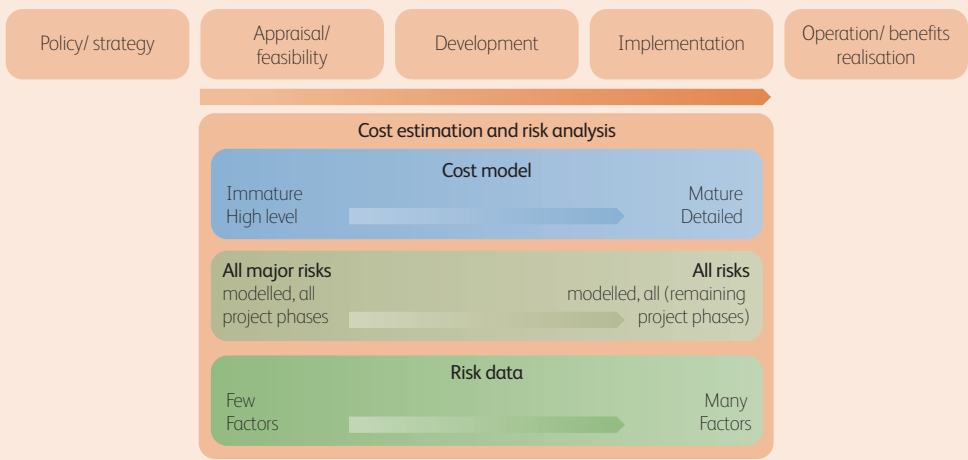
A cost estimate transition from immature to mature occurs when:

- The project design is sufficiently understood and detailed for the base cost to be **fundamentally complete**.

This will mean that options selection is complete, and major design decisions will have been finalised and incorporated into the design. Substantial more design work may still remain, but this is likely to be much more detailed, specific activity.

For example, a new. underground metro station with a fundamentally complete design would have chosen its ticket hall location through option selection, whilst finalising tunnel lengths and scheme size. Completed designs around lift shafts and other structures would also be fundamentally complete. Further design work will still be required, with examples including; choice of concrete reinforcements, fixtures materials, detailed systems integration and software reviews.

Fig 4: Cost and risk estimation from early project stages



The anticipated Green Book Supplement also emphasises that leading organisations will prepare bottom-up risk analyses as early as possible. The risk analyses will be required to be cross-checked with reference-class forecasting (using data from comparable projects). This replaces the optimism bias approach which has historically been followed.

This will mean risk analyses being prepared ahead of the design being fundamentally complete and cost maturity being reached. This will lead to significant risks being mitigated substantially earlier in the project, and considerable cost savings. Given the timing of the analysis, it will not be possible to model **all** project risks, as large numbers of detail-level risks will only become evident later in the project (e.g. during construction). However, it will be possible to model **all major** project risks before a mature cost estimate is prepared. This will involve early estimation of major risks from the later project stages.

Worked Example:

In the metro station example above, it would not be possible to identify all the systems integration risks around CCTV software- this level of detail will simply not be available until much later in construction. Despite this, experience of previous, similar systems integration risks on earlier projects will exist, even if such projects have different elements etc. Correspondingly, it should be possible to estimate major systems integration risks ahead of design maturity.

There are three powerful conclusions from this:

- every important risk item needs to be carefully considered and analysed to ensure that the way it will play out is understood and quantified in the best possible way
- performance data from previous projects is one important input to this
- thus it is also important to collect such data, including on an organisation and project specific basis.

As the estimate develops the risk breakdown structure will become more detailed and evolve into a customised risk register. The quantifying data will be much more risk-specific and this in turn will drive organisations to set up more detailed data banks.

These criteria should mean that the organisation feels comfortable with budgetary commitment to the project and project managers are willing to commit to an AFC. Thus the Green Book identifies a key commitment point with associated budgets which can be subjected to cost control going forward.

At each stage it is essential that the risk model and the data are carefully reviewed and checked to ensure it all makes sense and that it is fit to support the decision- taking process. We believe that it is also essential that project sponsors be involved in this to gain a better understanding of the risk issues and how they have been tackled. This helps to avoid the quantified analysis being treated as a 'black box', providing answers which are taken as scientifically-generated, incontrovertible truths.

4 The Project Lifecycle and Risk (cont.)

Contingency is that part of the budget retained to deal with uncertainties and risks.

Contingencies are set with reference to the risk exposure.

The next chapter provides more details of the principles underlying the following tools which leading organisations have found useful in developing cost and risk estimates:

- generic risk breakdown structures to assist setting up the early stage risk model and progressing it through to implementation
- examples of risk modelling at an early stage of a project
- integrated cost and risk estimation tools to assist in looking at cost and risk estimates side by side
- schedule risk analysis to assist in understanding the programme vulnerabilities of the project
- project performance compilation to assist reference class forecasting
- Standardised risk assessment guidelines to assist consistency, especially in analysing the impact of mitigation measures.

Cost Control

At the right hand side of Figure 5, as the cost estimates mature and commitment grows, the emphasis moves to cost control. Again, this is complicated by the risk exposure. The solution is to hold contingency, but to be able to discuss this meaningfully it is necessary first to clarify this much-misunderstood concept a little. The discussion which follows is simplified as required to draw out the relevant points expressed in this report. The language may not fit in the context of a specific organisation.

Figure 5 is a simple illustration of how we gain financial control over projects. Expenditure to a certain level is authorised and delegated to managers. This level will recognise the existence of risk and make some allowance for this: the contingency. The actual amount will vary depending on the organisational style. Going forward, the expenditure is compared with budgets (including the contingency budget) and decisions are taken on risk mitigation and reallocation of authorised expenditure in the light of the information available.

In more detail, individual budgets are assumed to break down into:

- costs allocated to specific activities – in this context the base cost
- cost not allocated to specific activities – contingency.

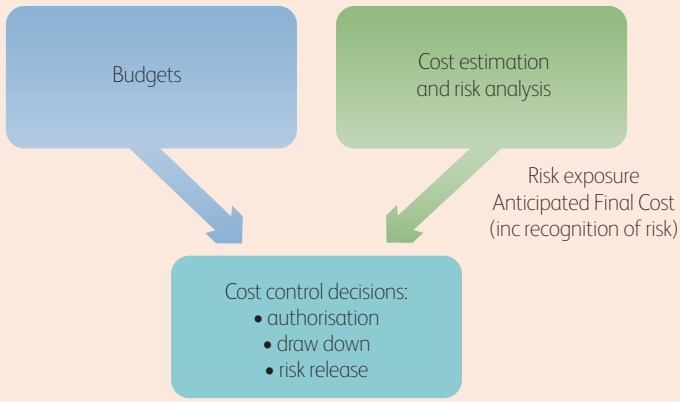
Contingency is there to deal with situations where the costs allocated to specific activities turn out to be wrong: that is, risk materialises or uncertainties crystallise.

There are a number of comments which can be made:

- estimates of risk exposure and AFC are independent forecasts; they are not there to demonstrate that budgets, or other financially driven criteria, can be met
- contingencies may be allocated to specific risks or groups of risks (for example on the basis of the party best placed to mitigate the risk)
- it is not always easy to relate the need for contingency to a specific risk having materialised

There are many ways in which contingencies can be set and managed.

Fig 5: The cost control process



- the fact that a risk that has materialised is not in the risk register does not mean that there is no need for a contingency draw down (though the accounting treatment could differ, for example, it might be taken as an immediate profit hit)
- contingencies may be allocated to specific projects, but that does not necessarily imply that they can be controlled by the project manager, not does it mean the contingency forms part of the project manager's budget; the project manager may have to apply upwards for all contingency allocation to specific activities
- contingencies may be pooled across projects or a programme to benefit from portfolio effects
- since the final cost is uncertain, there is always a balance between inefficient over-provision and crisis-provoking under-provision across the whole organisation

It is worth pointing out that larger organisations can afford to run with leaner contingencies, not only because of portfolio effects within individual programmes, but also because the occasional overspend will not cause a financial crisis. Government is the most relevant example of this, but in a context in which overspends could create a reputational crisis.

4 The Project Lifecycle and Risk (cont.)

Good practice may dictate the optimal way of dealing with these questions, but it is important to be clear that there is no single answer. For example, a mature risk organisation may be quite happy to allow managers a high level of discretion, confident that contingencies not required will be quickly released for alternative uses and the managers will be confident that justified requests to have it back will be looked on fairly and without damage to the manager's personal prospects.

As another example, there is no overarching requirement to set contingency at a specific level. Some organisations budget at P50 (the Highways Agency, London Underground, Heathrow). In principle this means that around 50% of projects would come back for more funds, which would be excessive. (It is interesting to explore why this does not happen in practice – see the Highways Agency case study.) In other organisations it might be considered more efficient to allow a contingency at a higher level to reduce the need for re-authorising expenditure. For example, Network Rail allows P80 contingencies.

Furthermore, organisational policies requiring projects to return unused risk monies before completion actually discouraged mitigation of risk. Smaller contingencies were felt vulnerable to overspend due to the impact of new risks (with negative career impact for project managers); consequently anything that led to a smaller contingency was resisted. This included mitigation activity that would have led to reduced risks, and a requirement to return the 'savings' to the organisation.

However these matters are treated, it is important that a project is not held up or cast into uncertainty by the discussions which surround these decisions. Effective contingency management is therefore an essential tool for efficient infrastructure delivery and we set out the process elements of this in the next chapter. However there is more than process to managing risk and contingency well and this leads on to risk management and its maturity and culture – understanding the characteristics of organisations which manage risk well.

> “Risk mature organisations can afford to run with leaner contingencies.”

5 Useful Tools and Approaches

The case studies in Chapter 8 reveal a number of techniques which are employed by leading organisations to deal with cost risk and uncertainty through the project process. In most cases it would not be appropriate to adopt uncritically a tool or technique used by another organisation. So, in this section we have collected together some of the good practice methods, and described them in terms of the principles involved. Each organisation must make independent decisions about how to implement this. This is tied to the organisational context, the business process, and project stage of development. Accordingly, this listing of tools is suggested, based on what has helped others.

Risk Mitigation

Most project and programme organisations have mitigations in place to control risks. However, a number of factors are essential to drive intensive mitigation of risk:

- **Top Management attention and review.** It is critical that risk mitigations receive regular interrogation and support from top managers, ideally in formal review settings. This is necessary to ensure the pre-requisite project team focus on mitigation, and to develop the culture of mitigation that is needed.
  - Furthermore, the style of such reviews is important. Risk Management can appear a technical, financially complex area of project delivery. Accordingly it is unsurprising that senior managers from non-risk backgrounds might ask technical, financial questions. This will however encourage risk practitioners to focus on the technical and financial aspects of risk, rather than the practical delivery of risk mitigations. This will ensure that risk mitigation does not receive the drive and leadership to realise its potential. Clear dashboard-based reporting of mitigation data can go some way toward helping.
- **Risk Manager Review.** Regular, diarised risk mitigation reviews are integral to developing a culture of mitigation. N.B. these differ from risk workshops designed to check for new risks/ modify risk estimates. Risk mitigation reviews should encompass SMART actions to reduce risks, and practitioners should be seeking to utilise the problem-solving potential of project teams to produce innovative risk reductions. All too often mitigation actions serve only to prevent risks from worsening, rather than aggressively seeking to eliminate risks altogether.

Top management attention is crucial to drive risk mitigation.

- **Risk Mitigation Targets.**
  In order to drive focus on the steps above, risk mitigation targets can be used, for project managers and risk managers. As an example London Underground's Stations Programme has developed a system of risk mitigation targets. Project managers are annually instructed to reduce the expected value of their risk by a defined amount. To do this they must implement visible mitigation actions and they can claim the benefit only when the action has been completed, its effectiveness has been demonstrated.

  - In addition, the same team has investigated the benefit of an approach termed **the Ring-Fenced Risk Model**. This centres on their observation that project managers were reluctant to reduce their risk levels after mitigation through concerns it would lead to their contingencies being cut. This mindset could also inhibit aggressive, intensive further mitigation. To offset this, a protocol allowing project managers to retain full contingency (until project completion) was developed (the Ring-Fenced Risk Model). Simultaneously, this would be combined with aggressively-targeted risk mitigation. Cf. parallels with the Olympic delivery experience outlined in Case Study 4.

Value Management and Opportunities

It is a truism that risk management is not just about downside, but also about finding and exploiting opportunities. This is important throughout the project lifecycle right through detailed design and construction and the value management / value engineering discipline ensures it takes place. In fact we suspect that it is this that enables more than 50 % of the projects given P50 contingencies to live within their budgets.

This of itself makes value management and opportunity exploitation an important tool to be deployed.

But some organisations, for example Network Rail, have found that they can create a virtuous circle from combining this cost reduction technique with contingency management. As noted in the case study, Network Rail uses a reserve account for each project to track contingency which is not expected to be drawn down. Increasing the reserved funds can be motivating for project managers as a demonstration of the cost reductions they are achieving. This in turn motivates them to find and exploit opportunities.

5 Useful Tools and Approaches (cont.)

Risk analysis requires a risk model and data.

Organisational Context

All organisations want to deliver maximum value for minimum cost and minimum risk with projects that are managed with adequate contingency, but with early release of unnecessary funds. But the priority accorded to different aspects of this will depend on the organisational context which may include:

- **public or private sector**
  whether the objective is to deliver policy with value for money (and the Green Book must be complied with) or achieve an adequate return on capital and whether the primary interests to be met are political – reputational pressure – or those of shareholders – financial pressure
- **regulation**
  in practice most private sector infrastructure owners are subject to regulation and the regulator is a major influencer of the way investment programmes are shaped, modelled and delivered
- **other powerful stakeholders**
  such as customers or users will also seek to ensure that unnecessary expenditure is minimised
- **size, complexity and novelty of programme**
  organisations with large capital programmes, which also generally implies the high levels of complexity which make risk analysis and management more challenging, can afford to invest in their risk, estimation and decision making capability whilst smaller ones, or those with one-off projects should look for comparability with other organisations
- **governance**
  related to the previous point, a governance structure which groups projects into programmes allows them to benefit across a range of areas - risk management and mitigation, financial management, delivery and synergies between projects - as well as from portfolio effects in their contingency management by setting contingencies at different management levels
- **repeatability of programme**
  those organisations which develop a stream of similar projects are better placed to collect relevant data, understand their risk profile, and nurture a preferred supply chain; organisations with one-off or innovative projects need to recognise that uncertainty is correspondingly higher and that relevant data will be harder to come by.

Risk management standards and guidance emphasise the importance of understanding the organisational context before designing the risk management framework and the risk processes within it. We have already noted the importance of achieving the appropriate risk culture and level of risk maturity. This also applies to infrastructure projects and understanding the factors listed, along with others, will help in appropriate tool selection.

A generic risk breakdown structure supports comprehensive risk identification.

Early-stage risk modelling encourages up-front thinking about risk.

Risk Analysis

An important aid to defining the model is a risk breakdown structure. This may coincide with the cost breakdown structure, the work breakdown structure, the location ('geographic breakdown structure'), the technical trade, and so on. In general more than one can be used and this often creates some confusion if it is expected that risk can be broken down against one or more of these. However it is usual to create risk registers based on type of risk and our first tool is to develop a generic risk breakdown structure.

Recommendation 3 arises because it is helpful to integrate the risk analysis process better with cost estimation. As well as seeking to eliminate double counting, this enables the major cost uncertainties to be assessed alongside the significant risks. This leads to the second risk analysis tool we propose.

A risk model may contain much more structural information than just a list of risks. For example a schedule risk model will contain the logic links between the activities. The identification of dependencies between risks is a key element of the construction of a risk model and they will affect the range of final cost resulting from the risk exposure. The main tool for dealing with this is the skill and knowledge of the risk analyst. But schedule risk analysis is increasingly recognised as an important tool and we have added it to the list.

Data collection is a key element of risk analysis and we noted that the Green Book Supplement is likely to specifically recommend reference class forecasting in parallel with risk analysis, (that is, the collection and analysis of project performance- such as the Mott MacDonald study carried out to support optimism bias).

Finally, care is needed in assessing the impact of planned risk mitigation measures. It is sometimes considered that the residual risk after mitigation is zero, or that it will have an unrealistically low probability of occurrence. This is subject to gaming and therefore it is helpful for organisations to introduce standardised protocols for this. This is the fifth and final risk analysis tool.

Generic Risk Breakdown Structure

Chapter 9 describes the challenges of developing a suitable risk breakdown structure for a specific project. There are many lists of risk available in publications and we outline some in Chapter 9. These are intended to:

- provide a set of prompts for identifying risks and uncertainties
- serve as a structure for developing risk models
- serve as a structure for collecting information about past and ongoing projects.

Early-Stage Risk Modelling

The following example also provides some suggestions as to how best define and modal such risks at an early stage of a project (e.g. at Feasibility). It should be stressed that this was a tailored approach, developed to meet the needs of a specific scheme- other projects will have differing needs and their modelling solutions should be developed to reflect these needs.

5 Useful Tools and Approaches (cont.)

Integrated cost and risk estimation tools promote a standard and comprehensive approach to uncertainty.

Early-Stage Risks: robust, reliable modelling is possible

The Main Board of a large power-generation organisation faced a Feasibility-phase decision on whether to proceed with a major hydro-electric power project. This required detailed understanding of specific risks at a very early point in the scheme; the necessity was for early-stage AFC clarity and completion confidence.

DS+A Ltd consultancy set out to identify and estimate these early-stage risks. The project required early clarity on differing and uncertain construction sequencing in an environmentally sensitive corridor as well as a large-scale application of specialized technology at a remote, extreme-weather site. Productivity variations and the general difficulty of the work were reflected in an integrated risk model and risk register that was used to forecast the cost and time exposures of the project. To achieve credibility of the results and hence assurance of the decisions to finance and sanction the project, the risk modelling included the following:

- **Excessive rain and high wind risks:** modelling based on statistical inference from local weather data. This was used to predict the likely lost working days and hence adjust the quantity of planned work in the discrete construction stages.
- **Construction productivity variations;** Productivity Chain Models based on Markov Models to forecast variable production durations.
- **Potential impact of indecision and of failures to improve processes;** Unresolved Options and Multiple Failure Models based on bespoke risk distributions (in this case binomial and Poissan distributions).
- **Financial consequences of extensions of time:** Integrated Cost and Time Risk Modelling based on analyses of time-dependent costs within the scheme.
- **Effectiveness of risk mitigations:** evidence-based analyses of strategies for the reduction of risk exposure.

This rigour then allowed the Board to understand what its Feasibility-phase exposure to risk would be, as well as necessary contingency provisions.

Integrated Cost and Risk Estimation Tools

The concept is that a standardised cost estimation spreadsheet is extended to allow the uncertainty in the main cost lines to be recorded (typically as a 3-point quantification). This should be accompanied by clear evidence for the ranges applied. It is then further extended to allow the main risks to be added (without double counting).

Network Rail employs such a tool during their early stage risk analysis. At Heathrow this is used throughout the early stages but with a very deliberate cutover to a risk register later. By contrast the Highways Agency uses their implementation throughout the project.

Events on previous projects and knowledge of their cost provide information about what might happen on future projects.

QSRA is an increasingly used technique to understand risk to delivery timescales.

Schedule Risk Analysis

Figure 6 illustrated the importance of defining a time-based programme for the delivery of the project. The final cost of the project (as well the realisation of benefits) depends crucially on maintaining this schedule. Therefore several leading organisations have found it useful to create models of the schedule risk to evaluate this.

Such models generally work by taking a project programme defined in planning software and then applying risks whilst allowing the logic built into the programme to predict the resulting completion date or other key milestones. Not all projects can be modelled very well this way, for example if they can be easily rescheduled to deal with risks materialising, however where the logic links are immutable useful results can be obtained.

Network Rail, London Underground, Heathrow and Crossrail are all organisations which find such modelling, often referred to as QSRA – quantified schedule risk analysis, useful.

However their experience shows that this is not as straightforward a tool to deploy as expected. Most project programmes are not suitable for doing this 'out of the box.' as they usually contain logical constraints which lead to unrealistic behaviour. And considerable skill is required to do an effective job of setting up the risks, incorporate suitable correlation, and so on. This is an advanced tool, again requiring experienced, well-qualified practitioners.

Project Performance Compilation

This tool aims to build on the experience of similar projects and create a database of actual project costs indexed by key characteristics of the project such as type, size and complexity. The data can then be used to create estimates for other projects based on the relevant characteristics and quantities. Adjustments may be made for unrepresentative outliers.

It provides a very important 'outside' view on forecasts as documented by Flyvbjerg.[6] This counters any bias created by the 'planning fallacy' which tends to ignore the lessons of past experience. An example is the reference class forecasting approach used by Network Rail – see the case study.

Such tools are mainly developed to provide support to estimators. This means that the base costs prepared by them will account for those risks which have materialised. It is therefore important to recognise the potential for double counting. This can be countered by common risk and estimation teams, or least a high level of dialogue between the two. This will have to tackle the question of the relevance of the data to the project at hand.

Moving beyond trying to understand past performance simply in terms of project characteristics, the Highways Agency is aiming to collect data on individual risks. This is easier for organisations where projects and contractual strategies are more standardised.

We hope to develop more support for both types of data collection in our future programme, see Chapter 6.

6. *Flyvberg Op.cit.*

5 Useful Tools and Approaches (cont.)

Organisations will deal with risk more efficiently where these is a common approach.

Business planning is an iterative assessment of options to meet the business requirement.

Standardised Assessment Guidelines

In situations where there is less standardisation, or before data on projects has been collected, it is necessary to provide more specific guidance to risk assessors on what risks to consider, how to assess them, and how to estimate the impact of mitigation measures. This leads to more consistency and realism, and makes best use of hard-won experience – all of which can help reduce gaming.

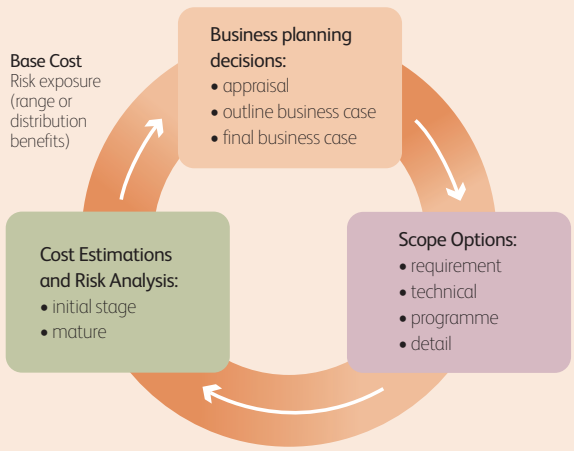
Such an approach is taken by London Underground in its Engineers Best Estimate approach. Network Rail has also developed a body of knowledge to assist assessors in working with cost estimators to provide the overall AFCs.

Business Planning

Figure 6 illustrates the business planning process and specifically how the decision to proceed at each stage depends on the estimated cost and risk which in turn depends on the options available. As the decision process moves from the early stage to letting contracts the detail increases, but the principles remain the same.

This report recommends that the risk information which informs the decision should essentially represent a range of possible final costs. Whilst a single number will be used to develop a cost benefit ratio or return on investment figure, and whilst future portfolio expenditure forecast will normally comprise single numbers, the range will help inform the robustness of the associated decision. Can we be confident that one option is superior to another? Are we sure that value for money will be achieved?

Fig 6: The business planning-management cycle



Business planning and associated communications will be improved if a range of potential final costs is considered.

A qualitative commentary on the risk profile helps to understand the risk exposure in the round.

Stress testing is essential to understand how robust the decision is.

In general the single figure to feed into the decision criteria and forecasts will be a central value – e.g. the P50. At the early stages perhaps a 'most likely' value from a 3-point estimate. But it is important to use the range to provide a feel for the full range of uncertainty and to communicate this to stakeholders.

As a result of this we identify two tools associated with business planning:

- Qualitative risk reporting to pick up on the dimensions of the risk profile which are not apparent from the raw analysis;
- Stress testing to explore the robustness of decisions.

Qualitative Risk Reporting

It is often difficult to understand the full profile of the risk exposure by reading risk registers or looking at the results of quantitative risk analyses alone. One potential source of additional information is a more descriptive and higher level commentary on the risk exposure. We term this qualitative risk reporting.

Such a commentary can give a more rounded view of the different aspects of risk exposure such as safety, environmental, security and reputational impacts. It can also provide a strategic perspective which complements the detail provided by the more analytical tools. One model is the descriptions of the risk exposure which are found in company reports, prospectuses, information memoranda for deals and so on where this approach is well-established and subject to quite stringent standards.

The Highways Agency has recognised the potential for this and is aiming to develop such a tool, termed the Qualitative Risk Assessment, to sit alongside the risk management plans and risk registers created by its delivery partners. Their tool remains in development but is expected to provide useful perspectives in the future for option selection and decision making.

Stress Testing

The Green Book notes that, 'sensitivity analysis is fundamental to appraisal.' What this means is that different scenarios should be considered and switching values should be investigated. (The switching value of a parameter is the value at which the decision would be reversed, for example, the cost at which the benefits would no longer be worthwhile). As another example, financial institutions are 'stress tested' to confirm the adequacy of their reserves.

Ranges of final cost are the key to stress testing. During the early stages of business planning the ranges may arise from broad assumptions on the most important cost items. For example Heathrow insists that ranges are provides for each cost line and that the numbers which underpin these ranges are explained and be rooted in past performance. Later in the project development process confidence intervals from full risk analysis may be available.

5 Useful Tools and Approaches (cont.)

Contingency management is best implemented in association with change control.

It is important to remember two important principles:

- stress testing is an essential part of decision making
- but, as one of our respondents memorably remarked, "don't give them the stress test money;" in other words, as we have emphasised throughout this report, the risk allowances and exposure ranges used for business planning should not be the starting point for setting contingencies and authorising expenditure.

Cost Control

Integrated Change Control and Contingency Management

Approving the draw down of contingency represents a project change. This is true whether the draw down is to meet a change of scope or to recognise that a risk has materialised. Change control is a key project process so to integrate it with contingency management ensures that contingencies are effectively dealt with without creating a significant additional process burden.

The Olympic case study demonstrates a change control process which:

- is based on systems which are integrated to provide a single source of truth
- is fully informed on project and programme spends, risk materialisation, etc
- is fully informed on budgets and spends, for example via a contingency dashboard
- recognises the benefits of holding contingencies at multiple levels, (including at a high level) to deal with portfolio effects and systemic risks
- involves people who understand the issues associated with the nature of risk and uncertainty (instead of maintaining a single-minded pursuit of unrealistic financial targets, for example)
- exists in a culture in which project managers are not unreasonably blamed, dismissed, or otherwise treated as scapegoats when unavoidable risks materialise.

Finally, many aspects of the Olympics change control process are documented on the learning legacy website (see the case study). This overall system therefore a good example of effective systems for cost control which can be relatively easily adopted by other organisations.

It is worth emphasising, though, that effective contingency management will not be guaranteed by suitable processes alone. As some of these bullet points make clear, it is **essential to have the right people having the right conversations** in support. This is underlined by other aspects of the Olympic case study, and, for example, by the recent Institute for Government report[7] into the Olympics.

7. *Making the Games: what government can learn from London 2012*, Emma Norris, Jill Rutter and Jonny Medland, January 2013. Available from www.instituteforgovernment.org.uk.

Behavioural simulation workshops can help identify gaming behaviour

Management Assessment

In order to gather information for this report The Industry Group held some strategic engagement sessions with a selection of delivery organisations, HMT and Scottish Futures Trust. These sessions suggested a focus on optimism bias, gaming and other behavioural influences. To explore these influences further a number of 'behavioural simulation workshops' were held and the output of these enabled the problem statement and recommendations of this report to be developed.

In future this will be built on to support the 'critical friend', review which is expected to be deployed to improve project and programme handling of cost risk and uncertainty.

As such, behavioural simulation workshops form a useful addition to this Chapter, though not strictly speaking a tool for risk and contingency management in itself.

Behavioural Simulation Workshops

The workshop is held to explore practices within a specific delivery organisation. Senior managers of the selected organisation contribute to a detailed discussion of their approach to risk, contingency and delivery for major projects and programmes (typically over £500m). This was tracked through three stages (essentially as outlined in Chapter 1) of Feasibility, Design and Implementation.

A large chart was used to plot the interconnections between risk, contingency and other project elements. For example the relationship between project behaviour and risk governance could be explored in a holistic way, end to end. This enabled problem areas to be identified as well as examples of good practice. These workshops enabled us to clarify the role of behavioural factors in managing risk and contingency.

The sessions were confidential to encourage open discussion of the realities of risk and contingency management. Following the session the key areas were written up and contribute to this Report's Chapter 2 ('Exploring the Challenge').

One learning point to emerge was the importance of also plotting the Policy/ Strategy stage prior to Feasibility. It is here that the factors which contribute to downstream behaviours start to emerge and it is vital to ensure this is properly mapped. For example the approach here, as well as during the later stages, depends on whether the organisation is public or private sector, the nature of regulation, the influence of customers and so on. These factors drive the way the investment programme is developed, appraised and implemented, as noted at the start of this Chapter.

> “IRG will act as the guardian of leading risk and contingency practice.”

6 Forward Programme

Critical friend reviews will help spread good practice.

IRG will act as the guardian of leading practice in risk and contingency management across the UK infrastructure sector. IRG will act to both share and improve leading risk and contingency practice. There are several key objectives in accomplishing this:

These lead to the following actions:

- **Continue to collect case studies and add to the tool collection.**
  There are several organisations represented on the group who have yet to be invited to contribute. There are also gaps in the group to be addressed, for example the energy sector and many aspects of Government.
- **'Critical friend' review.**
  The objective is to help infrastructure programmes and projects utilise the knowledge we have gained in a direct way through a review process. A protocol is required which will be developed through the flow charts in this report, the Green Book Supplement, OGC gates, etc, and the protocols will be productised after initial pilots with HS2 (early-stage) and VSU (late-stage).
- **Developing the risk profession.**
  The Industry Group recognised that more can be done to promote the importance and status of the risk management profession and increase understanding of the various roles. In particular, senior, experienced risk managers should report at sub-Board level given the £billions tied up in major UK project contingencies. This need is frequently underestimated. Several organisations are taking steps to address this, but the challenge remains. We intend to work to achieve this.
- **Provide more detail of the tools.**
  For risk modelling this is likely to cover how to transition from a high level to a detailed assessment (top down to bottom up in one version of the terminology), how to transition from a cost-based perspective to a commercial perspective as contractors are appointed and so on. We will also collect examples of the template risk lists used to Supplement the generic risk breakdown structure, though, it may be problematic to consolidate them, mainly because they will approach risk from different perspectives and are therefore incompatible (see Chapter 9 for further discussion). Eventually it may be possible to act as a repository for software or its specific customisation. For example there would be obvious efficiencies in all projects and programmes adopting the ODA approach to cost and contingency management.
- **Data collection.**
  It is highly desirable for more data to be shared within the group. However this will need careful specification. For example, while the reference class forecasting methods used by Network Rail are very useful, it is not apparent that the information will be relevant to other organisations. On the other hand case histories of how projects performed and specifically the causes of overspends are applicable in principle, not least to help risk analysts and their sponsors understand the range of risk and avoid underestimation. The generic risk breakdown structure is a possible framework for this. This can also be used to collate anecdotes, either from within or outside the infrastructure sector to provide a better view of what can go wrong in projects. To do this we will aim to work with the Saïd Business School which has already collected considerable volumes of data.

6 Forward Programme (cont.)

IRG will share knowledge and experience and promote the risk management discipline.

- **Pilot trials.**
  It is intended to test out the tools within organisations in a controlled way using pilot trials. This will enable the benefits to be gauged and lessons to be learned in advance of wider roll-out of the tools and techniques.
- **Provide advice on risk maturity.**
  The leading organisations in IRG have considerable experience in developing the levels of risk maturity that we recommend. In some cases they have also developed their own assessment tools. We will seek to collate this knowledge and experience and pass it on to other organisations.
  A particular focus will be the promotion of the importance of the risk management discipline within infrastructure clients. This will be a parallel activity to the following point designed to support the enhanced visibility and effectiveness which will result.
- **Sharing the information.**
  All of these tasks will be enhanced by effective communication of their content, whether this is more detail of a tool, or a protocol for the critical friend review. We expect that a website will be developed, either as part of the IUK website, or in some other way, to do this as comprehensively and usefully as possible.

Part C
Supporting Material

7 Glossary

Common language is essential to communication about uncertainty and its management.

In line with Recommendation 7 we have tried to use terms straightforwardly and consistently in this report. This is essential to communicating the concepts clearly and unambiguously. It is worth repeating that this is not intended to be a glossary of all risk terms; it is simple a set of 'defined terms' to ensure clarity in the reading of this report.

We first start with an explanatory overview and then present a definition for each specialist term. We also note other common usages and explain how we deal with them. However in the rest of the report we use our preferred terms only.

Overview

The final cost of a project is unknown until it is complete. There is cost risk and uncertainty throughout the project lifecycle. We use risk analysis to characterise this which tells us the risk exposure at each stage of the project. The risk exposure represents inherent uncertainty and must be considered as a range, a probability distribution or the like. In order to recognise risk exposure we make risk allowances in our management procedures. Risk allowances are added to base cost to create the anticipated final cost (AFC).

Both base cost and risk allowances are context-specific. The risk allowance for appraisal purposes under the forthcoming Green Book Supplement is the Financial Risk Exposure; for financial management purposes to cover risk materialising it is contingency. We recognise that contingency is a term which is widely used with different meanings. Depending on the approach, the early stage base costs may already recognise the risk exposure, but as they mature the risk element will be refined and moved into the risk allowance.

Glossary Listing

3-point quantification
a 4-point quantification of an uncertainty where the probability is set equal to 1.

4-point quantification
the quantification of a *risk (2)* with a probability (of the risk event occurring) and maximum, most likely and maximum values of the consequence (if it does) – a common practice. There is also a 2-point variant in which all three consequences set equal leaving just a probability and an impact.

AFC
anticipated final cost.

anticipated final cost
an estimate or forecast of the *final cost* made before the project is complete which takes on board the risk exposure at the time the estimate is made using *risk analysis*.

base cost
an assessment of the cost of the project without *cost risk and uncertainty*. The ground rules on which the base cost estimate has been prepared need to be recorded and understood. Care is needed here: base cost may mean the cost derived from reference data which therefore includes the occurrence of risk.

budget
set of authorised costs for financial control purposes which may contain a *contingency*. This may be broken down by projects and programmes. It is not necessarily the same as the prospective costs used for appraisal or business case purposes.

Key terms are: final cost, cost risk and uncertainty, risk analysis, risk exposure, risk allowance and AFC and contingency.

contingency
that part of a *budget* not allocated to specific activities but retained to deal with uncertainties crystallising and risks materialising. It may be allocated at project or programme level but this does not necessarily imply that expenditure of contingency is delegated to the relevant project or programme manager.

cost risk and uncertainty
the concept that we do not know what the *final cost* of a project is going to be until the project is complete. The term cost uncertainty would suffice (see *risk*) but we have added 'risk' to be clear that this includes the impact of events which may or may not materialise, as advocated by some practitioners – see also *uncertainty*.

draw down
allocation of a contingency to a specific activity for spending. This will be subject to appropriate governance procedures.

early stage risk analysis
the *risk analysis* that is carried out during the initial stages of the project, especially appraisal or feasibility, which is likely to be less detailed than during implementation, for example, reflecting the materiality of different risk issues.

EFC
estimated final cost or expected final cost, both equivalent as far as this report is concerned to *anticipated final cost*.

expected cost
mathematical term for the average cost predicted by a *risk model* taking the probability element into account.

expert assessment
the quantification of risk models using the experience and knowledge of suitable people.

final cost
the eventual cost of the project which is subject to *risk exposure* until the project is completed.

FRE
financial risk exposure.

Financial Risk Exposure
a term used by the *Green Book Supplement* for the *risk allowance* during a project and related to the *base cost* and *AFC* through the relationship AFC=BC+FRE; where there is a probability distribution this would be the expected value according to the Green Book.

Green Book Supplement
the anticipated companion document 'Determining risk and uncertainty in the early cost estimates of (infrastructure) projects and programmes' to update guidance on appraisal in the presence of risk.

initial cost estimate
the cost estimate that is created at project inception in the model used in the *Green Book Supplement*, built from initial risk estimates and *reference class forecasting*, and associated with the strategic outline business case (SOBC).

mature cost estimate
the cost estimate that is created prior to commitment in the model used in the *Green Book Supplement*, built from bottom-up risk analysis, and associated with the outline business case (OBC).

Monte Carlo
see *risk model*.

optimism bias (1)
belief that things can be built more quickly and cheaply than is the case.

7 Glossary (cont.)

optimism bias (2)
an adjustment (or *uplift*) made to the base cost of projects at the appraisal stage, originally to compensate for *optimism bias (1)*.

out-turn cost
same as the *final cost* of a project.

P50, P80, etc
see *percentile*.

percentiles
a measure of confidence constructed using *probability*. For example the 80th percentile cost (also known as the *P80*) is such that the probability of the *final cost* being less than P80 is 80 % . (P50 is also known as the median).

portfolio effect
the concept that the relative variability of a portfolio (or programme) of projects is less than that of the individual projects. This is a mathematical concept (valid only where there are not strong dependencies between the projects) that justifies, for efficiency reasons, holding contingency at programme level rather than allocating it to projects. In other words the programme P80 will be significantly less than the sum of the project P80s.

probability
mathematical construct used to quantify the likelihood of an event occurring.

reference class forecasting
the use of data from other projects to estimate the *final cost* of new projects.

quantitative schedule risk analysis
the construction of a *risk model* aimed at estimating the *risk exposure* of project milestones, including the delivery date; generally implemented by *Monte Carlo* analysis of a logically linked project programme.

QSRA
quantitative schedule risk analysis.

reference class forecasting
see *reference data*.

reference data
information about the *final cost* of previous projects which can be used to characterise the *risk exposure* of future projects using *reference class forecasting*.

RBS
risk breakdown structure.

risk (1) (the concept of risk)
(ISO 31000) the effect of uncertainty on objectives.

risk (2) (a specific risk)
a description of a specific event which may or may not occur, together with its causes and consequences.

risk allowance
an amount added to base cost to recognise *risk exposure* for application in management processes. It is context-specific depending on the process in question: appraisal, budgeting, implementation, etc. It might be set at the *expected value, P50, P80,* best/worst case, etc.

risk analysis
the process of estimating *risk (1)*. This may include *uncertainty*, sensitivity to scoping options and so on.

risk breakdown structure
a hierarchical expression of the possible *risks (2)*, or types of risk, in a *risk analysis* and therefore likely to be a key element of a *risk model*.

risk exposure
the output of *risk analysis*, a representation of the range of final costs (in this context) which credible, essentially the same as the *risk profile*. May be expressed as best and worst case, a confidence interval (e.g. P10-P90) or a complete probability distribution.

risk management
(ISO 31000) coordinated activities to direct and control an organisation with regard to risk (1).

risk mitigation
the part of *risk management* which is focussed on identifying and implementing actions to reduce risk.

risk model
quantified model of *cost risk and uncertainty* constructed using *probability*. Risk models are often calculated using Monte Carlo methods, a technique involving random sampling.

risk profile
essentially the same as *risk exposure*, though generally has an implication of the many types of impact of risk (safety, reputation, etc) and is therefore less used in this report which focuses on cost risk.

risk reduction
a quantification of the extent to which risk has been reduced, for example the reduction in an *AFC*.

risk register
a list of risks (as per *risk (2)*) together with other information such as the likelihood of the risk materialising, planned *risk mitigation*, etc.

risk release
release of a contingency from a budget so that it can be allocated elsewhere, a different project or a higher level contingency. This is necessary for financial efficiency.

scope
defined in the Green Book Supplement as a statement of the requirements, functionality and benefits of the project with a view to emphasising that the scope may legitimately vary until quite a late stage in the lifecycle – in which case it needs to be controlled – or may be fixed early on.

uncertainty
see *cost risk and uncertainty*. Uncertainty is often used to describe situations where the outcome is not known, but there is no identified event which may or may not occur, the impact of future inflation for example. Often uncertainty has an upside whilst risk is generally a downside.

uplifts
a generic term for estimating *risk allowances* which does not benefit from specific project *risk analysis*, for example *optimism bias (2)*.

8 Case Studies

The following case studies were prepared in conjunction with the Client Group representatives of the relevant companies. They do not cover all aspects of risk and contingency management in these leading organisations but are designed to cover the relevant points for illustrating good practice.

Case Study 1
London Underground

Enterprise risk management is well established in London Underground (LU), being part of integrated financial control and capital project delivery. This reflects the organisation's prioritisation of risk management and cost control at all levels. In addition, the LU Stations Programme has ongoing activities to go further, and more closely align project risk incentives with the objectives of the organisation. This comprises a standardised formalism for assessing risk, the setting of quantitative targets for risk mitigation, and maintaining adequate contingencies. Altogether this is termed the Ring-Fenced Risk Model.

Risk management is supported by company-wide risk software holding all risks faced by the organisation. This risk database holds all risk quantification, and the usage in LU is to record the pre-mitigation and post-mitigation numbers. This then feeds into the financial control procedures. Specifically the project is authorised at the pre-construction stage and, in addition to base costs, 'risk money' is set at the post-mitigated P50 level of the risks in the database. This money is then allocated to the project manager.

This has led to a number of unexpected behavioural issues. Background economic and cost pressure has led to risk assessors feeling incentivised to over-estimate the effectiveness of planned mitigations and undefined future mitigations (expected to be implemented later in the project). This is a form of optimism bias which could potentially expose the company to a serious cost overspend event. A further, crucial side effect of the approach was that project managers were, in effect, discouraged from developing effective early risk mitigation plans, as these would result in reduced contingency. If these lower contingencies were subsequently exceeded, it was felt that the project managers would be held personally to account, with career-limiting results. Overall, all these factors served to encourage the 'gaming' of risk numbers at the expense of actually mitigating risk.

To counter these effects, the LU Stations team has introduced a standardised risk assessment methodology which provides the so-called Engineer's Best Estimate risk numbers. These reflect the project team's judgement of the **effectiveness of mitigations**. This requires the project team to form a professional view as to how likely individual actions are to be successful. These standard quantifications allow the contingencies to remain reasonably realistic in the light of the risks each project faces, irrespective of background economic pressures.

LU implements the 'Engineers Best Estimate' and the 'Ring Fenced Model' to promote standard approaches, incentivise risk reduction and minimise gaming.

Having established this, the project managers were then challenged to further mitigate their risks. This was implemented through the setting of Risk Mitigation Targets for each project manager. These Targets challenged these professionals to develop innovative mitigation actions. When such a measure has been implemented and has demonstrated its effectiveness, the accompanying risk reduction (measured by reduced Expected Value), contributes to helping the project manager achieve their Mitigation Target. Monthly mitigation meetings were introduced to supervise and monitor the scheme; risk mitigation dashboards supported it. Furthermore, performance against the Target is a key element of the manager's annual appraisal, thereby ensuring the scheme receives serious attention. To date it has achieved savings of £175m+.

Nonetheless it seems these changes have still not fully succeeded in encouraging more risk mitigation in the minds of most project managers; the concern is still that hitting these Targets will result in the premature release of contingency, especially when there is very strong pressure on cost control. This leads to the final piece of the Risk-Fenced Risk Model jigsaw. The intention is to make sure that the contingency allocated at the pre-construction stage is strictly maintained until project completion (literally **ring-fencing** the risk budget). It is hoped this will remove the disincentive to mitigate risk. Once this block is removed, the stations team intends to increase the risk mitigation targets and will seek to push them down into contractors, alongside the integrated risk management concept.

8 Case Studies (cont.)

Case Study 2
Network Rail

Network Rail carries out risk management throughout the life cycle of projects as they progress from outline solution to completion. This features a feedback loop from the final cost data of completed projects and a contingency dashboard system which balances the needs of project managers to maintain sufficient funds with those of senior managers requiring to make reallocation decisions.

The approach has evolved to meet the requirements of a regulated environment in which the ORR needs to understand that project cost estimates are realistic whilst Network Rail has to maintain sufficient funding to deal with the impact of significant uncertainty.

Figure 7 illustrates the way the risk modelling is undertaken, informed by information from other projects and the Network Rail approach to risk allowances. This is now described in more detail.

Risk Modelling

At the earliest stage, before the solution has been scoped, Network Rail applies an 'uplift for risk' to the first set of costs prepared by the estimating team. This uplift is 60%, a figure which is based on experience and analysis of historical data and is informed by conventional optimism bias. However, importantly, the uplift tends to be eventually used to cover additional scope, the need for which emerges as the project develops.

Once a concept solution has been defined it is possible to be more specific with regards to what the main risks are. This is quantified using a 3-point estimate on a global basis in the early stages. The range of final cost is developed for the project as a whole in the light of the risk profile, but not through aggregating the impact of each specific risk. This provides a rough 'S' curve and confidence ranges, e.g. P80.

The next stage is to create a high level risk model when the outline design has been completed. This will typically cover the main sources of uncertainty on a limited number of cost line items and an additional quantification of the specific significant risks. In these early development stages the challenge is to understand the significant assumptions that need to be true and test their sensitivity and stability.

The full risk register is developed further as the design acquires more detail and the project moves into contract and construction. The AFC is maintained at P80 and is the sum which is authorised for expenditure by the project manager. The P80 is used for authorising enhancement projects once there is at least an outline design.

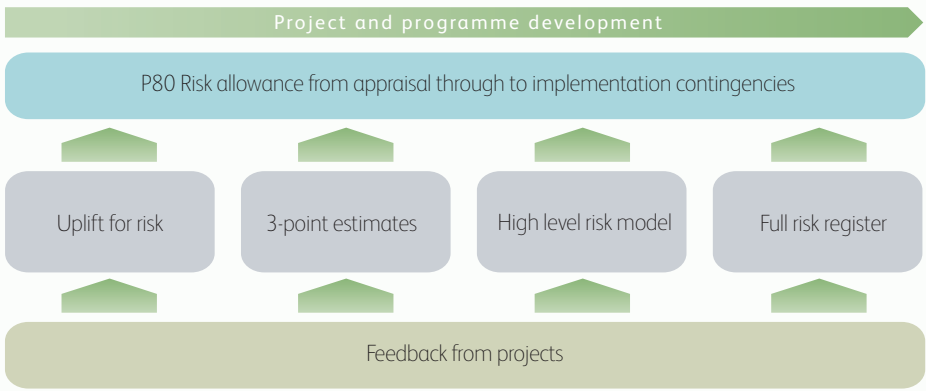
Schedule risk analysis is carried out on possession and blockade activities, due to the business importance of minimising their length whilst being confident of achieving planned handback times. More schedule analysis is now being done for interlinked programmes to understand and test the logistics of projects and how they all fit together.

Risk Analysis Data

Network Rail takes snapshots of project costs at determined control points in its project development process and this provides useful data for project estimation, codified in terms of unit costs. This is termed reference class estimation, using past projects to predict cost of further ones. One issue is that this information contains all the cost of the projects and therefore, by definition, the risks that were realised. Hence there may be double accounting for risk, if the risk teams apply only broad uplifts to reference class estimates.

Network Rail increase the detail in their risk analysis at each stage of project development.

Fig 7: Network Rail risk processes through the project lifecycle



Reference class estimation collects project performance data to support risk analysis of future projects.

This is managed by close working between the estimators and the risk teams, and by the compilation of a body of knowledge (Cost Analysis Feedback – CAF) which records typical risk allowances for projects based on type and stage of development. Cost and risk estimates and the associated assumptions can then be challenged. Project sponsors may justify apparent anomalies and test the key assumptions.

One interesting feature of the data collected is the difference between the performance of large projects compared with small projects as defined by a cost threshold. Small projects tend to deliver final costs which are lower than the Anticipated Final Cost forecast earlier. For larger projects the reverse is true. This may be attributed to the greater difficulty of realistically understanding all the interdependencies and estimating risk for these larger and more complex projects.

Cost Control

Project managers have the authority to spend up to the project P80. However, as the project proceeds and risks fail to materialise, the manager is encouraged to review the AFC and transfer some of the authorised sum into a 'project reserve' account if the funding is significantly above the AFC. This is a form of risk release, but it is not committed as it is maintained within the original authorisation in the event that significant risk materialises. Thus there is visibility of the contingency which may not be required whilst project managers have a reasonable means to meet foreseeable risks. If it becomes necessary to reallocate funding, the reasons are clear and can sustain challenge.

This approach is facilitated by a useful and informative contingency dashboard where contingency funds available are reported against the actual risk exposure. This is supported by a culture in which all parties understand the impact of risk and uncertainty and are familiar with how they are analysed and managed.

8 Case Studies (cont.)

Heathrow uses OGC gates and requires schedule risk analysis in the later stages.

Case Study 3
Heathrow Airport

In order to meet the challenge of a multi-billion capital investment programme which is under the scrutiny of the regulator, airlines and other stakeholders, Heathrow operates a highly quantified risk and contingency system. This system evolves to meet changing requirements and to benefit from the experience the company has gained.

Heathrow has an ongoing portfolio of asset replacement and improvement programmes which includes the construction of the new £2.5 billion Terminal 2, providing annual capacity of up to 20 million passengers.

The cost of this capital programme is recouped through the regulatory building blocks, set by the CAA, which allow for depreciation and an appropriate return on capital. A 5-year regulatory cycle applies with the current period ending in March 2014. At this point the previous period's work is reviewed and the next quinquennium planned for. The regulatory framework creates its own incentives and raises some complex issues.

Heathrow faces two major risks associated with Development. Firstly, if the work is shown to have been inefficiently carried out or has not been adequately consulted upon, the relevant costs can be disallowed by the CAA with Heathrow earning no return on part of its investment. Secondly if there is an under spend within a regulatory period then Heathrow can benefit from this efficiency, however stakeholders may consider that they are overpaying, and this could be reflected in the negotiation for the next 5 years. Conversely an overspend will see Heathrow earning no return on the additional outlay within the current regulatory period. Estimating is therefore a key issue and Heathrow is incentivised to have robust forecasts as it can suffer if there are overspends, under spends or late delivery. An overall Capex forecast must be built into each regulatory period in advance despite the component projects being at various stages of maturity when the CAA completes its review.

Fig 8: OGC Gateways and Heathrow's risk approach

Gateway	Risk Model	Risk Exposure
Prior to G0 Portfolio/Programme	Programme level qualitative risk register	Represented by cost outturn range driven by 3-point estimates and analysis of high level risk
G0 to G2 Initiation and options	Qualitative risk register including mitigation plans – risk report	Represented by cost outturn range driven by 3-point estimates and analysis of high level risk resulting in Monte Carlo range
G2 to G3 Solution Development	Risk register including mitigation plans, QCRA, QSRA – risk report assessed for each option	Represented by Monte Carlo analysis of risk register
G3 to G4 Definition	Risk register including mitigation plans, QCRA, QSRA (incorporating supplier information) – risk report detailing risk sharing strategy	As at previous stage.

Contingencies set at P50.

Waterfall charts enable managers to challenge risk management performance and make contingency decisions.

This has led Heathrow to take quite a formal approach over many years and the OGC gateway system is inherent in the development of their programme – see Figure 8. This is supported by a PRAM-type risk management approach which includes planned assessment of the risk management maturity of each project.

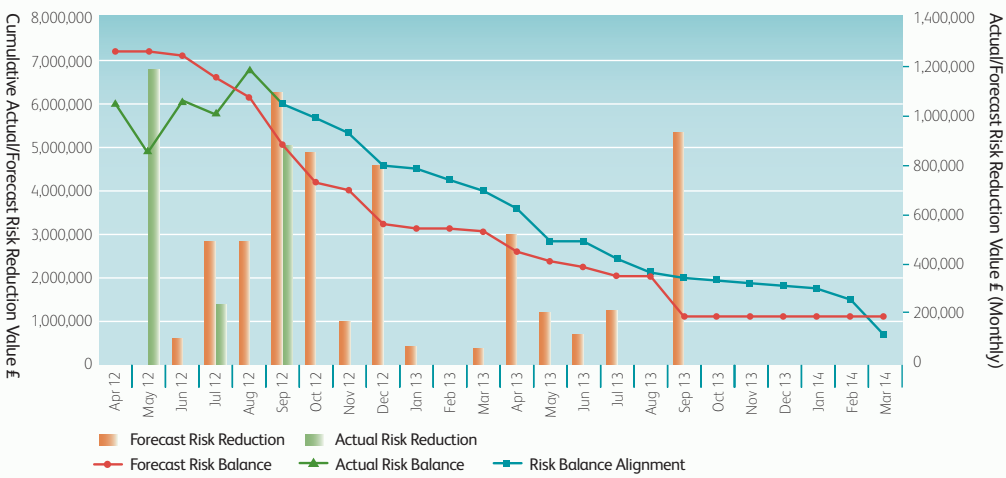
Over time, Heathrow has moved from a single number, formalised system of risk allowances, similar to optimism bias, but reduced at each project development stage, to quantified risk analyses throughout all stages. The nature and detail of the analysis change as the project proceeds.

The first step was to ensure that by Gate 3, when a scheme design has been developed, there is a register-based risk model for each project, supported by a quantified schedule risk analysis (QSRA). Heathrow's risk estimators believe strongly that a schedule analysis is necessary for a meaningful understanding of the cost risk, given the complex environment on the airport with critical security, logistical and operational constraints. It is also important in the light of the importance of meeting many of the various project milestones. Furthermore, the process of completing the risk and schedule analysis provides useful material to assess the quality of tenders to carry out the work.

When contractors are appointed at Gate 4, the expenditure is sanctioned at P50 and the project manager is authorised to incur the relevant expenditure. In other words the project contingency is set at P50 and can be drawn down as required.

From this stage the financial control process is executed though the Change Board. This scrutinises the evolution of risk on each project supported by tools such as a waterfall diagram – see Figure 9 – which shows how the risk is reducing and whether or not this is in line with projections. The Board will approve increased authorities if this is demonstrated under suitable challenges to be necessary. In order to find the funds for this and to initiate other projects, the Board is also very focussed on risk release. This is essential to demonstrate to stakeholders that no unnecessary expenditure is being incurred. The decisions of the Board and the underlying reasoning are recorded and can be scrutinised by stakeholders.

Fig 9: Illustrative waterfall chart



8 Case Studies (cont.)

Case Study 3 (cont.)
Heathrow Airport

Overall the discussions around risk are very objective and effective, supported by data as far as possible, but, more importantly, by a shared understanding of the relevant uncertainties, what is being done to mitigate them and their potential effect.

More recent developments have addressed the early stages. A range estimation approach has been instituted to explore the uncertainty in final cost. This involves a 3-point quantification for each major line in the cost estimate and a further quantification of the main risks, taking care that no double counting occurs. Again the project is costed into the programme at the P50 level.

This risk work is continued at the programme and capital portfolio levels where it is recognised that efficiencies can be gained by considering all the uncertainties together. But it is also understood that there are systematic risks which can affect all projects, for example inflation or industrial action.

Thus the higher level models are careful to recognise and allow for issues which affect more than one project. Furthermore Heathrow aims to ensure it is in a position to deal with low probability, high impact events which could especially affect projects which are now at the early stage. Heathrow believes it is appropriate to maintain a risk allowance at P80 for the early stage projects which have yet to pass Gate 3. Note that this provision is made at portfolio level, not project level, and is correspondingly less than it would be if made for each project individually.

All of these risk analyses are constructed with a firm ethos of rigour, justification of the numbers and actively searching for relevant data. Growing and maintaining this culture is challenging as it goes beyond our current understanding of what is routinely expected of the risk management profession. It is important that the risk analysts are not only accomplished in Monte Carlo techniques, but also understand the importance of getting the input right, modelling correlation, and developing appropriate schedules for the time risk analysis. However, Heathrow management is clear that investment in this activity is well worthwhile given the stakes involved and the benefits of getting it right.

> “Heathrow operates a highly quantified risk and contingency system.”

8 Case Studies (cont.)

The project management processes used for the Olympics are recorded as part of a lessons learnt exercise.

Change control provides the forum for contingency management decisions.

Case Study 4
London Olympics

The Government and the ODA used an integrated set of processes to manage cost and contingency on the London 2012 construction programme. At the centre of this were a budget, containing contingency, which did not materially change, and an AFC which was updated every month. The difference between the budget and the AFC is effectively contingency that has not been drawn down. This system allowed the ODA to remain agile, making decisions in response to changing internal and external circumstances and eventually allowing £470m of contingency to remain unspent.

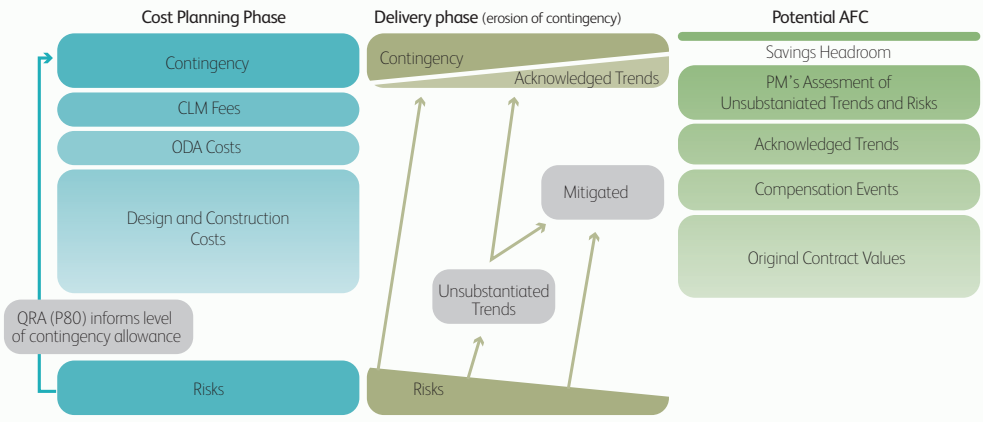
The contingency was initially informed by the risk analysis, being set at P80. As the programme progressed AFCs were recalculated and agreed. If the AFC increased, this essentially means that contingency has been drawn down. So management of contingency is the same as management of the AFC. This applies to individual projects as well as the programme as a whole.

The key elements of AFC updating were a risk process, a trend process and a change process plus three levels of risk and contingency management. These processes tracked potential events as they moved from the possible to the certain, but all were recognised within the AFC. This is summarised in Figure 10.

The risk process was based around a risk database and a quantification which was reassessed every 3 months. Risks were owned at project, programme or funders level, as defined by ability to control. Authority for change was essentially vested at the next level up: project budgets were controlled by the ODA, with change managed by the Change Board which had government representation; programme budgets by the Government Olympic Executive in DCMS, with change agreed with all relevant funders and stakeholders through the Olympic Project Review Group (OPRG); and the funder budget by a Cabinet subcommittee.

The trend process was subject to monthly review and allowed potential changes to be followed at two levels. Acknowledged trends were relatively well established incipient changes for which the financial impacts were known and which would be subject to the formal change control process as soon as possible. Unsubstantiated trends were probable events which were yet to be fully characterised and mitigated.

Fig 10: The Olympic change control and AFC process



Contingency dashboards are a useful tool.

The change process was more frequent still and very intensive. About 5,000 changes were considered during the 4 years of the programme. The change process updated the CBB, the current baseline budget, essentially to break down the OBB, the original baseline budget, into AFC and what was effectively anticipated unspent contingency. In this sense the baseline did not vary, and the change process provided for contingency draw down. Of course contingency was switched between projects. In practice there was one re-baselining, in the depths of the 2009 economic turmoil. This was needed to bring the construction of the Olympic Village into the scope. It had previously been assumed that this would be provided by the private sector.

It was recognised that this system contained gaming opportunities given that contingency was budgeted at project level. The centrally managed risk and trend processes provided supervision of contingency draw down. The whole process was visualised through contingency dashboards. Furthermore, assurance processes were superimposed 'to maintain the integrity of the Baseline.' One factor that was considered to increase motivation was the freedom given to the ODA by the Government to manage its own contingency. Up to a certain level the ODA could keep their own savings and redeploy them. This incentivised project managers to generate savings because they could reuse them internally.

This system also helped acceptance by management of the need for change as requirements crystallised and changed, projects were delivered and the external world evolved. Trends were driven by:

- additional scope proposed, existing scope removed and scope gaps
- contracts and subcontracts awarded above or below budget
- design development
- unforeseen ground or other conditions
- contractor performance
- schedule adjustments; and delays caused by late access.

While not directly relevant to cost and contingency, the ODA programme managers also monitored progress using earned value (EV). Among other things, the actual cost and AFC could be plotted alongside the budget-driven planned and actual earned value curves. Overall programme delivery was assured through a comprehensive cycle of monthly reviews. There was a culture of control and precise reconciliation with a single source of truth. These are important supporting enablers for risk and contingency management.

There are other factors which contributed to the success of this enterprise. There was the commitment necessary for making sure it was supported by accurate and responsive systems. Further support for decisions was provided by the Olympic Project Review Group which was an informal forum for major issues to be discussed, including releases of programme or funders contingency, in preparation for the formal governance bodies. There was a commitment to transparency and openness. There was an understanding that at sponsor level within DCMS as the lead Government department, it was necessary to have people who understood project and programme management. What's more these sponsors were supported by a small team of project control experts who went out into the projects as eyes and ears. Above all the investment was made in attracting the best people available. The lesson is that cultural issues need to be addressed to make the risk and contingency processes work effectively.

This account draws in large part from material – especially 'micro reports' – available on the Olympic legacy website[8] under the project and programme management theme. There is more to be found there including the OBB. A recent Institute for Government report[9] also provides details.

8. learninglegacy.independent.gov.uk. Updated programme baselines can be found at www.london2012.com by searching on 'baseline report.'
9. To be found at http://www.instituteforgovernment.org.uk/publications/making-games.

8 Case Studies (cont.)

Crossrail funding limits were set by the early stage risk analysis.

AFCs are forecasts, not mandated budgets.

Case Study 5
Crossrail

Like the Olympics, Crossrail is a major London-based programme of projects. As would be expected, Crossrail has introduced an integrated approach to risk and contingency management which is very similar in character to that of the Olympics. There are some differences but the main aspects of Crossrail which are recorded here are, firstly, the approach to and use of early stage risk analysis, secondly, a high level commitment to risk management by the senior management and, thirdly, the steps taken to integrate contractors into the process.

Crossrail was proposed in roughly its current form in 2001 when the joint sponsors, DfT and TfL, came together to promote the scheme. Even at this stage (before Optimism Bias had been codified), appraisal of the scheme was supported by a high level, early stage risk assessment. In 2006 this risk assessment was fundamentally restructured, with the high level element Supplemented with more detailed risk assessments prepared by the various design teams and other consultants. Risk analysis was closely aligned with cost estimation. The development of the model and its quantification was carried out with involvement from the joint sponsors and HMT and this is regarded as very important for securing a smooth and well-understood appraisal phase.

Furthermore the risk model, uniquely, was audited by an independent team of consultants at the request of the sponsors and assessed as 'meeting or exceeding industry standards' … 'within the UK and globally'.

Crossrail secured funding in 2008 of £15.9 billion which was set at the P95 value of the then current risk assessment. The Project Delivery Agreement defined staged intervention points which were also determined from the assessed distribution of final cost. If the AFC exceeds a defined intervention point IP0 (set at P50 of the original risk assessment) a remedial plan is required to be delivered to Sponsors; if AFC exceeds IP1 (set at the P80), TfL have the right to take such action as considered necessary to remedy the situation; if AFC exceeds IP2 (set at the P95) sponsors may exercise the option of transferring CRL ownership to DfT. These intervention points have not been cascaded to projects, however, which simply report AFCs at P50.

Fundamental to the success of this approach is the shared understanding that a project will not deliver to a number. The sponsors and programme managers understand that the AFC is a forecast (of a distribution) and that it will change as risks and uncertainties come and go.

When Crossrail reached the implementation stage there was a clear commitment to risk management, very much on the same lines as the Olympics, so the main features will not be repeated. Some of the Crossrail risk team had previous experience of working on the Olympics with CLM. The scale and complexity of Crossrail's works made it critical that a common risk management approach was embedded throughout the programme. One difference was the absence of overall contractor responsibility for complete projects (venues on the Olympics, stations on Crossrail) which has restricted the ability to transfer risk to the supply chain. Risk allocation between projects on this highly interconnected programme remains a challenge.

Crossrail has embedded qualitative risk management into the general management of the programme. As well as monitoring a range of metrics of risk quality and management activity within the risk database, the organisation also measures its risk management performance by monitoring of a number of 'Key Risks' – notionally 100 risks selected from the risk register – over the course of the year. Ownership of Key Risks is with Project and Programme Managers and performance in their management forms part of individuals' objectives. Performance of managing the full set of Key Risks forms part of the organisations performance metrics which is linked to incentives. The Key Risks process has proved valuable in focussing the organisation on risk management process in general, and specifically the effectiveness of risk mitigation actions.

Crossrail undertakes a high-profile, 'Key Risks' process to manage down its risk exposure.

Crossrail engages in joint risk management with London Underground.

Crossrail engages strongly with schedule risk analysis. Each project maintains its own Level 1 schedule which also forms part of the overall master control schedule. Schedules are maintained to be consistent with the more detailed levels and have logic which is suited to schedule risk modelling. A dedicated schedule risk analyst works with projects to apply risks and uncertainties to each Level 1 schedule and to knit these together to create a risk model for the whole programme. This model provides useful insights for management decision making.

Crossrail is committed to integrating contractors into its risk management system. This is regarded as being good practice, especially considering the complexity of the programme and the lean client organisation, and also responded to the interests of the project insurers. The key insurable risks are ultimately managed by contractors and a comprehensive and consistent risk management process is an important part of Crossrail's compliance with JCOP (Joint Code of Practice for tunnelling projects).

The procurement process is predicated on an allocation of risk between employer and contractor which is subject to quantitative assessment prior to contract award. This enables Crossrail to assess bids based on a detailed understanding of the risks transferred and retained and highlights cases where risk is considered to be underpriced. The analysis at present does not take account of commercial details of painshare and liquidated damages, although this would be possible in principle. This is regarded as a conservative approach as most contracts are at a relatively early stage of maturity.

Once contracts are let, Crossrail holds joint risk workshops with contractors as appropriate and contractors are required to report their key risks and management actions on a periodic (monthly) basis. Contractors are required to use the Crossrail risk database. Crossrail has implemented a performance assurance process to drive improved contractor performance in a number of areas including project controls, health and safety and quality. Risk management performance is monitored through a mixture of periodic metrics and annual assessments using a risk maturity assessment tool. The performance assurance process feeds into league tables of contractor performance which are shared with industry partners (Network Rail, London Underground) and other public sector client organisations. Contractors are therefore incentivised to manage risk well.

Early experience of supply chain performance in risk management has been mixed. A key factor has been the quality of risk management resources deployed by contractors. The very best contractors are highly motivated to perform well on risk, not least for purely selfish profit motives. Good risk management should create a win-win situation for both the contractor and Crossrail and indications are that this augurs well for the chances of further improving contractor engagement in managing risk.

A final aspect of Crossrail's integrated risk management with stakeholders is the interface with London Underground. The nature of Crossrail's design is such that the interface with London Underground infrastructure is both extensive and complex. Crossrail is carrying out tunnelling very close to LU assets and all of the central section stations are highly interconnected with LU stations. LU will be the eventual owner and operator of the stations in the central section. To deal with the many risks and issues which arise from this, an interface team has been created which is embedded in both organisations. A high level risk register is maintained which is integrated into the Crossrail system. The mitigations are jointly agreed and implemented.

Interface issues have already been experienced between Crossrail and HS2. It is considered that the interface risk management model employed by Crossrail and LU could usefully be adopted by project sponsors for future projects in order to mitigate risks and reduce the likelihood of contingencies being duplicated on both sides of the interface.

8 Case Studies (cont.)

The HA uses the same risk analysis methodology throughout the project lifecycle.

The HA shares offices with contractors, partly to support joint management of risk.

Case Study 6
Highways Agency

The Major Projects Directorate of the Highways Agency has evolved its risk management procedures in recent years. This involved a move away from single point values, including optimism bias, towards a recognition of layers of risk, the use of ranges and programme level contingencies.

The Agency operates a consistent risk analysis methodology, supported by customised tools, right from project inception through to completion and handover. This is aligned with the OGC Gateway process and is therefore more detailed than the three stage model generally used in this report.

A generic risk analysis sheet is taken as the starting point for each project, populated with the risks that recur. Irrelevant risks are removed and any necessary new ones added. In early stages and as a first pass, risks are assessed on a qualitative basis both before and after mitigation based on the experience of the assessor and from limited, but expanding data. Risks are then assessed for probability and a 3-point quantification of the cost impact. For management purposes, risks are also assessed for other impacts such as reputation, operation, safety and the like. Risk impact costs, adjusted for probability, are then transferred into a standard work breakdown costing sheet. The costing sheet is based on a 3-point approach collated by the estimating model. Each risk is allocated across relevant work breakdown lines in the costing sheet.

The cumulative three values for each work breakdown line are then adjusted to reflect the full range of uncertainty, i.e. to account for any further "risk" 'that cannot be quantified.' This uncertainty adjustment can be both negative and positive. These final values are modelled using Monte Carlo techniques to understand the cumulative effect of the cost risk and uncertainty. As the project proceeds the same format is used to keep the analysis up to date. The uncertainty element reduces until it drops to zero at the start of construction.

Separate additions within the estimating model are made for inflation, based on expenditure forecasts.

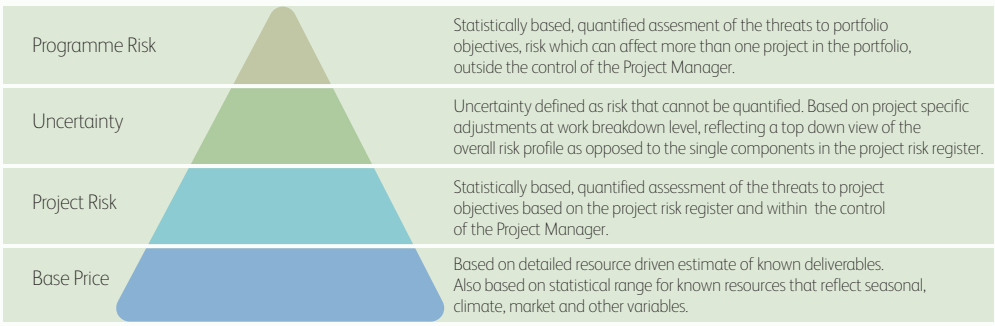
Thus far, this describes three layers of cost: base cost, project risk (which at the start of construction is split into the risk held by the Highways Agency and risk transferred to the supply chain) and uncertainty. On top of this is a fourth layer, a programme provision covering risks impacting all projects, and fall outside the control of the project team (see Figure 11). 21 generic risks have been identified at this level reflecting three themes: imposed risks, value adding risks and time related risks. They are assessed using standard formulas based on experience from the past 5-10 years and reduce through the project life cycle.

The P50 values from the estimating models are used to support the business and economic cases as they are developed. Although costs are always quoted as a range, for example the P10-P90 range, it is the P50 value which is used in preparing the requests for project funding submitted through the corporate governance processes. Project funding is approved for each phase (Options, Development, and Construction) and by financial year to create an annual portfolio budget. The Programme Risk element is retained centrally as a portfolio management contingency, with a governance protocol covering expenditure higher than the P50, but within the range for each phase. Thus there is a limited contingency to fund an AFC realised at more than the P50 for each phase, acting as an incentive to find further efficiency savings. If projects exceed or under spend on their P50 funding levels, this is managed by portfolio management principles within fixed annual budgets, for example by bringing other projects forward or pushing projects back.

In recent years the programme risk layers have tended to be under spent and it is intended to review the standard formulas on which they are based. Notwithstanding this, programme risks can occur and a recent example is ash die-back.

Risk analysis in the HA is highly layered.

Fig 11: The Highways Agency approach to layering risk



Contingency set a P50

The HA is exploring the use of qualitative descriptions for risk.

The management of risks during development and construction is undertaken in close collaboration with the supply chain. In the managed motorway programme, under which the Highways Agency is carrying out a series of improvements to use the hard shoulder as a running lane with the increased safety risk mitigated by technology, there are a number of delivery partners engaged through framework contract arrangements. They are co-located with Agency staff in a Delivery Hub and are incentivised through the target cost pain-gain sharing arrangements to find efficiencies and improve value, both at project level and by cooperating at programme level. The delivery partners work together to share knowledge, level the call on resources, maximise the use of specialist subcontractors and resolve logistical issues.

Where common project risks can be more effectively managed centrally than by each project team, this is carried out by the Delivery Hub. This effectively adds a further level to the pyramid, splitting the Project Risk layer. Examples of these types of risk include the development of the latest digital speed cameras, the development of low light cameras for hard shoulder monitoring and developing the safety case for the revised standards to support all lane running.

It is clear that working together with the delivery partners in the Delivery Hub is very effective in addressing both the softer, cultural issues involved in driving down risk and converting risks into opportunities.

Risk analysis is being improved by recording risk data more thoroughly: through tracking the causes of compensation events, through application of monthly earned value management techniques and utilising a common cause breakdown structure. Work continues to refine the processes and build the risk and opportunity data picture.

The Highways Agency uses a product-based approach to project delivery with the products signed off at the end of each stage by the Senior Responsible Officer. For risk management there are three mandatory products produced: the Risk Management Plan, the Risk Register and a Qualitative Risk Assessment. The last of these is intended to provide a text commentary on the riskiness of the project as the numbers may not portray the deliverability of individual options (perhaps time, safety or reputational impacts).

9 Risk Breakdown Structures

The RBS helps to start to create a risk model.

Creating a model which encompasses all possible futures is not straightforward. However, the issues involved in putting such a model together are not generally explored as thoroughly as they could be. It is often taken for granted that a risk register, a list of events which may or may not happen, can serve as the basis of a risk model. Perhaps it can, but what's just as important is to understand the sequences of cause and effect, how risks combine to produce common impacts, correlation and, most importantly of all, how to achieve realism in our understanding of how the risks will play out.

Leaving this to one side for the time being, a risk register will generally evolve out of a number of sources. Risk workshops may be held to populate it, but it is often possible to build on our experience to create a structure which goes a long way to seeding the creation of a project-specific register. What is useful here is a risk breakdown structure, a hierarchical listing of possible risks and risk types.

This term has been coined by analogy to the work breakdown structure concept used in project planning. Indeed, one way to develop a risk breakdown structure is to consider the risks associated with each element of the work breakdown structure. The key concept here is hierarchy. To continue the planning analogy, individual risks can be combined to produce rolled-up risks, or issues, and this helps us to work both top-down and bottom up to create a comprehensive risk register and model.

It's worth pointing out that issues, in this sense, are not like risks. At the lowest level risks can often be plausibly represented as discrete events with probabilities. As they are rolled up they increasingly have the nature of continuous uncertainties. This is a simplification too, as in reality there is no limit to the extent to which risks can be broken down.

A risk hierarchy can be reconstructed in different ways. Often managers want to know how the risk breaks down by geographical area, by supply contract, by technical discipline and the like, and this is generally outside the scope of a usable risk register. A categorisation of risk is difficult to create for this reason.

There are many published examples of risk breakdown structures. One of particular interest for this report is that used by Mott MacDonald to support the Green Book's optimism bias proposals. This established 26 'project risk areas' under 5 broad headings:

Procurement

- complexity of contract structure
- late contractor involvement in design
- contractor capabilities
- Government guidelines
- dispute and claims occurred
- information management system

Project specific

- design complexity
- degree of innovation
- environmental impact

The HA is developing a cause-based RBS.

Client specific

- inadequacy of the business case
- large number of stakeholders
- funding availability
- project management team
- poor project intelligence

Environment

- public relations
- site characteristics
- permits/consents/approvals

External influences

- political
- economic
- legislation/regulations
- technology

There are many risk breakdown structures available to risk analysts to initiate their work. Many are little more than a set of prompts. Others are customised to reflect the needs of a particular organisation. For example, the Highways Agency provides another example of a risk breakdown structure, this time in terms of cause. This is still under development but at the time of writing contains 97 generic risks under 10 generic causes:

- land and accommodation works
- legislation and statutory processes
- scope changes
- changes in standards
- environmental
- weather
- network operation, traffic management and maintenance
- stakeholders and third parties
- statutory undertakers
- other (27 miscellaneous items).

This structure is clearly very specific to the Highways Agency and it has taken significant work and refinement to reach its current form.

A further risk breakdown structure which may be helpful follows. This is based on the fundamental project lifecycle structure and associated decision processes. These prompts, aids to completeness, were Supplemented by a desire to articulate the items as risks (i.e. uncertain events which may or may not occur) or uncertainties. The structure represents the inherent risk in the sense that it does not account for risk transfer away from the project.

It is structured firstly in terms of the project lifecycle and secondly in terms of decisions, approvals, execution, a changing environment (local or global) and the quality of management. It is shown in Figure 12. Execution of implementation is covered in more detail with a construction risk register in Figure 13.

Specific organisations will find some risks irrelevant or unlikely. Others will need to develop risks in more detail to meet their needs. Indeed at this stage there are likely to be some important omissions.

It is expected that this structure will underpin data collection and challenge reviews in the future. This will be supported by the generic risk registers used by various organisations.

9 Risk Breakdown Structures (cont.)

Risk facilitators are one audience for this risk breakdown structure. They will find that it provides useful prompts for risk identification sessions – please see below:

Fig 12: Further Risk Breakdown Structure

Uncertainty in...	Appraisal/Feasibility	Development	Implementation
... deciding what to do...	Uncertain solution • change in requirements • unclear requirements • business case criteria not met • not affordable • unnecessary gold-plating within budget • new options emerge	Failure to meet requirements. Uncertain cost of developed design • client change • compliance (safety, environmental, security, etc.) • construction method • challenges of complexity • challenges of technology • strategy failure Design delay	Residual design detailing uncertainty. Design error emerges. Poor change control
... getting it agreed...	Prolonged/failed approvals • public acceptability • pressure group action • customer influence • approvals required	Prolonged/failed detailed approvals • internal approvals • TWAO • assurance • planning and conditions imposed • public inquiry • concessions/change of standards Failure to consult/comply with process	Residual assurance risk
... doing it...	Property cost uncertainty. Construction cost uncertainty. Legal cost uncertainty.	Property unavailable or cost uncertainty. Construction risk and uncertainty. Legal risk • IPR infringement • claims	Detailed construction risk register • see Figure 13 Cost impact of delay
... in an uncertain local (micro) environment...	Portfolio optimisation effects • change of policy • change of problem to be solved	Unavailability of partners	Interface risks with other projects • affected by or affecting Interface with operations • incidents • frustrated access or late hand back
... in an uncertain global (macro) environment...	PESTEL uncertainties. Change of problem to be solved	Change of law/tax. Change of regulation/ standards.	Inflation. Exchange rate uncertainty. Incidents elsewhere.
... and managing it.	Suboptimal decision process. Invalid assumptions. Ineffective governance	Suboptimal contract strategy. Set unrealistic pace. Ignore/underestimate risk/uncertainty.	Inappropriate organisational design. Inadequate planning including contingency planning. Indecision.

> “Risk breakdown structures provide useful prompts for risk identification.”

9 Risk Breakdown Structures (cont.)

Fig 13: Construction Risk Register

Frustrated site access
- frustrated possessions

Site occupation problems
- unexpected site costs
- slow mobilisation

Uncertain site conditions
- poor ground/water table
- utilities
- building foundations
- sewers
- contamination
- archaeology/unexploded ordance
- wildlife and other environmental
- demolition problems

External events
- adverse weather
- protestor action
- supplier failure

Logistical disruption
- late procurement
- late manufacture
- disrupted transport/delivery
- security holdups
- insufficient/inadequate storage
- congestion
- inability to dispose of waste

Uncertain resource availability
(at cost foreseen – no double counting with inflation)

Uncertain productivity

Uncertain quantities

Performance failures
- poor quality
- poor supervision
- excessive settlement
- damage
- other non compliance
- site nuisance (noise, light, vibration)
- systems integration problems

Incidents
- force majeure
- HSE incident
- asset failure
- fire
- industrial action

Disrupted completion
- delayed commissioning
- delayed handover or not accepted
- failure to meet performance requirements
- delayed integration into operations

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