Appendix A

Risk Management Guidelines

Contents

A1 Introduction

This appendix constitutes a risk management *Guideline* with which to compare current practice. It therefore enables any deficiencies to be highlighted and potential improvements to be advanced. The *Guideline* comprises an amalgam of proven risk management practices worldwide, which can sensibly be tailored to EC-funded transport investment projects.

A1.1 Purpose

The *Guideline* provides a benchmark with which to compare risk management practice in the participating countries. Because of the large number of countries involved in the CFPM commission, guidance is necessarily general. Further, it is not prescriptive; not all techniques being suited to each country. Rather, the *Guideline* provides a toolkit from which to select the most appropriate risk management techniques and tools to use, given the circumstances of an individual project.

A1.2 Scope

The *Guideline* is intended to cover risk management practice at all project lifecycle phases, from appraisal of concept designs to project completion. It allows for the assessment and management of capital cost risk only. Specifically, it addresses the following cost risk types:

- Direct cost risks;
- Programme delay cost risks;
- Cost estimating uncertainties.

A2 Guideline Basis

This Guideline has drawn on risk management guidance and practice, primarily from the United Kingdom (UK), but also from North America, Australasia and the participating countries. Key reference documents are listed in Section A5, *References*.

The Guideline is not intended to be prescriptive. Rather, it provides the reader with a project risk management structure, and a selection of proven risk management tools and techniques, which would provide for effective risk management on projects seeking and using funding from the EC.

A3 Definitions

Avoid:	Eliminating threat usually by eliminating the cause (e.g. clarification of requirements & objectives, acquiring appropriate expertise, doing project in a different way);
Base Cost Estimate:	The base cost represents the cost that can reasonably be expected if the project materialises as planned. It typically comprises quantities and unit rates;
Correlation:	Two input distributions are correlated when their samples are related (i.e. the value sampled for one distribution affects the value sampled for the other);
Discipline:	Refers to technical workstreams (e.g. pavement, signalling, environmental, geotechnics etc.);
Residual Exposure:	Refers to the level of risk exposure having taken account of all the risk response measures explicitly employed in the project preparation ;
Opportunity:	A risk event with a positive outcome;
Pre-Mitigated Exposure:	Refers to the level of risk exposure taking account of existing risk response measures only. In other words, it is an assessment of the current level of risk exposure;
QRA:	Quantitative Risk Analysis: includes modelling and computer simulations in order to quantify cost and programme risk exposure
Risk:	Refers to a chance event which, if it occurred, could have a negative (i.e. threat) or positive (i.e. opportunity) effect on project costs. Risk is typically the product of probability (of the risk occurring) and effect (i.e. consequence were the risk to occur);
Secondary Risks:	Risks which arise as a result of implementing a risk response measure;
Threat:	A risk event with a negative outcome;
Transfer:	Allocating risk ownership to another party, for example, via a contractual transfer;
Treat:	Reduce probability of occurrence (e.g. by using proven technology). Treatment may be by adopting more than one defensive strategy for key failure mechanisms (i.e. defence in depth);
Tolerate:	Either actively (e.g. by developing contingency plan to execute should the risk occur, risk monitoring and reporting, risk reviews and updates) or passively (e.g. by accepting financial losses were risk events to occur);

Uncertainty: Refers to possible errors in cost, income and schedule predictions owing to lack of information. Uncertainties typically reduce with more detailed designs and associated cost plans.

A4 Guideline Structure

A4.1 Overview

Each of the following subsections addresses an individual element within the *management systems* approach to risk, namely:

1. Risk management planning
2. Risk identification
3. Qualitative risk assessment
4. Quantitative risk assessment
5. Risk response planning
6. Risk monitoring and control

It should be noted that, although these elements are typically applied sequentially, they can also be applied concurrently (e.g. risks are monitored in parallel with new risks being identified and assessed) and iteratively (e.g. mitigation plan for one risk may yield another, secondary risk).

It should be noted that, to be effective, risk management needs to be an integral part of the overall system of project management and not just a bolt-on exercise. The application of risk management on transport investment projects should be inextricably be linked to design development, to procurement, to stakeholder management and to project control functions (e.g. cost estimating, cost management, contract management, planning). Consequently, an open communication process, involving the project's key stakeholders (e.g. state ministries, design consultants, contractors, statutory consultees, land owners etc.), should be actively encouraged to provide for this level of integration and engagement with the risk management process.

The references (see Section A5) section lists documents which may provide further reading or additional explanation of the risk management techniques described in this document.

A4.2 Risk Management Planning Guidance

Risk management planning is the systematic process of deciding how to approach, plan and execute risk management activities throughout the life of a project. The exercise should clarify:

- Risk management roles and responsibilities both within and outside the beneficiary's organisation;
- The level of cost risk exposure the beneficiary is prepared to tolerate;
- Risk management techniques and tools to be used;
- The scheduling of risk management activities in relation to the overall project plan.

The risk management plan (RMP) should be updated following award of construction contract to:

- Undertake a survey of the signed contractual documentation to identify which risks have been transferred or retained;
- Document which risks have yet to be resolved as at contract execution;
- Consider potential residual risks;
- Understand risks associated with failing to manage the contract effectively;
- Consider possible changes to the contractual arrangements to manage identified risks more cost-effectively.

A4.3 Risk Identification Guidance

Risk identification should be viewed as an iterative process because new risks may become known and previously identified risks may drop out, as the project progresses through its lifecycle. The frequency of iteration can vary, but should be linked to hold points in the project schedule (e.g. concept design, business case, preliminary design etc.). Ideally, the beneficiary's project team should be involved in the process so that they can develop and maintain a sense of ownership of, and responsibility for, the risks and associated risk response plans. Stakeholders from outside the project team may be able to provide additional objective information.

There are many recognised risk identification techniques, including creative workshops, interviews (with discipline leaders) and reviews (of documentation and databases). In each case, it is important to elicit information from all key project stakeholders. Information can be gathered using:

- Risk prompts: These provide a set of categories of risk that are pertinent to the type of project under consideration or the type of risk being considered by an organisation. The lists are used to help people think about and identify risks. Sometimes different types of lists are used together to further improve the chance of identifying all of the important risks that may occur. For example, in analysing the risks to some project, one prompt list might look at various aspects of the project (e.g. legal, commercial, technical, etc.) or types of tasks involved in the project (design, construction, testing). A project plan and a work breakdown structure, with all of the major tasks defined, are natural prompt lists [Ref.11]. A prompt list will never be exhaustive, but acts as a focus of attention in the identification of risks. Whether a risk falls into one category or another is not important, only that the risk is identified. Table A4.3a is an example prompt list in the form of a matrix. It is designed to prompt the identification of risks at each project lifecycle stage. Table A4.3b is another example, from the Vilnius Western By-Pass in Lithuania;

- Checklists: These can be used in tandem with risk prompts. They are a series of questions one asks as a result of experience of previous problems or opportune events;
- Knowledge of comparable historical projects. This knowledge may have been recorded in a "lessons learned" database, historical risk database or historical risk registers.

Table A4.3a – Example Risk Prompt List #1

CATEGORY	PROMPT	PROJECT PHASE: Design	Procurement	Construction	Testing & Commissioning	Operation & Maintenance	Decommissioning
Miscellaneous	Design standards						
	Interfaces/Coordination with Others						
	Licences, Permits, Consents and Approvals						
	Political Influences						
	Integration						
	Temporary Works						
	Passenger Forecasts						
	Passive Provision						
	Contractual/Legal						
	Funding						
Location	Ground Conditions						
	Earthworks						
	Contamination						
	Utilities						
	Possessions						
	Water						
	Station Ingress/Egress						
	Drainage						
	Access						
	Site Constraints						
	Security/Vandalism						
	Environmental Issues						
	Archaeology						
	Man-made Hazards						
	Land						
	Proposed Developments						
	Working Hours						
	Plant/Materials Availability						
Scope & Brief	Clarity of Brief/Requirements						
	Feasibility of Brief						
	Scope Variations						
	Inadequate Information (e.g. late, inaccurate)						

Table A4.3b – Example Risk Prompt List #2

No.	Risk
1.1	Building permit acquisition
1.2	Utilities (and other) approvals
1.3	Changes in environmental requirements
2.1	Cost of land
2.2	Delays of land purchasing
2.3	Additional requirements
2.4	Land for temporary access to the site
3.1	Inadequate site surveys and investigation
3.2	Changes in the requirements
3.3	Inadequate design cost estimates
4.1	Inadequate construction cost estimates
4.2	Cost overruns
4.3	Inadequate construction quality
4.4	Flooding, land slides and similar
4.5	Archaeological findings
4.6	Inadequate supervision cost estimates
4.7	Inadequate temporary works cost estimations
4.8	Contractor's bankruptcy
4.9	Contractor's resources
4.10	Public procurement
5.1	Protester action
5.2	Change of strategy
5.3	Introduction of tolls
5.4	Lack of national finance
5.5	Traffic

It is important to describe each risk correctly. A risk has a cause and at least one cost consequence. In order to assess risk exposure and respond appropriately, both cause and consequence need to be clearly stated. Table A4.3c illustrates the linkage between risk prompts and risk description

Table A4.3c – Example Risk Prompt – Risk Description Linkage

Risk Prompt	Cause	Effect	Risk Measure
Ground conditions	Inadequate site surveys and investigation	Increased cost of ground improvements	Cost
Security/ Vandalism	Loss or damage to property, plant & structures	Cost of repair or replacement	Cost
Land	Uncertain land costs	Cost of land take different from expected	Cost
Archaeology	Unanticipated discovery of archaeological artefacts	Construction programme delay whilst undertake expert investigation	Programme

A4.4 Qualitative Risk Assessment Guidance

Once cost risks have been identified, their significance should be gauged in order to decide on actions. This is done by multiplying the probability and the cost impact values. To inform these values, project-specific risk classification schemes should be agreed by beneficiaries

An example project risk classification scheme is shown in Table 4.4.2a. The quantified values are not fixed and should be determined based on both the estimated project base cost and the stakeholders' predisposition to risk. The probability or percentage bands (Columns 1 & 2) equate to a value (Column 3). Judgements need to be made as to the most appropriate probability band for each identified risk and the 'value' recorded in the risk register. The same is true of assessing risk severity: the quantified band (Column 5) is used as guides for assigning the appropriate value (Column 6).

Assessments should initially be made of each risk's pre-mitigated exposure (see A3 *Definitions*). Additional assessments should then be made to account for the risk reduction potential afforded by any additional risk response measures (i.e. mitigated risk exposure). It should be noted, however, all risk response measures should be examined in depth to confirm their feasibility and risk control potential, relative to cost, before being implemented. Mitigated risk should therefore represent target levels of risk exposure, whereas pre-mitigated risk represents current levels of risk exposure. To illustrate the difference between pre-mitigated and mitigated risk exposure, the latter could account for the contractual transfer of ground risk to a contractor, whereas the pre-mitigated assessment of exposure would assume the beneficiary owns the risk.

Table 4.4.2a – Example Risk Classification Scheme

Probability of Occurrence (P)			Impact on the Project (I)		
Scale	**Range**	**Value**	**Scale**	**CAPEX Range**	**Value**
Rare	0 – 5%	1	**Insignificant**	<€100k	1
Low	6 - 20%	2	**Minor**	€100k -€1m	2
Medium	21 - 50%	3	**Moderate**	€1m - €3m	3
Likely	51 - 80%	4	**Significant**	€3m - €6m	4
Almost Certain	> 81%	5	**Serious**	> €6m	5

An example of a qualitative risk assessment is shown in Table 4.4.2b, taken from the EIB report 'Construction risk analysis model' (see section A5 References) and based on the construction of a new metro line in Barcelona. This demonstrates how each identified risk is categorised in terms of its impact on the project and its likelihood of occurring. Critical risks can then be identified by looking at the risks which combine one of the higher probability categories with one of the higher impact on the project categories.

Table 4.4.2b - Example #1 of qualitative risk assessment

	Impacts on schedule		Impacts on cost	
	Radial-3		Radial-3	
CONSTRUCTION	Score	Prob	Score	Prob
Construction - General				
- Risk of unforeseen land resumption costs	M	U	W	L
- Risk of unforeseen preparation costs	H	L	W	N
- Risk of unforeseen increased supervision costs	N	U	N	N
- Safety	M	U	W	U
- Risks of cost and time overruns on major structures	M	L	W	L
- Materials used cause unforeseen maintenance costs	W	N	W	U
- Interference with site by third parties	W	N	W	N
- Availability of site	W	L	N	N
- Wayleaves and facilities	W	N	W	L
Construction - Ground Conditions				
- Unforeseen ground conditions	W	U	M	U
- Soil survey underestimates qty of materials needed	W	N	W	U
- Over ordering due to soil survey overestimations	N	N	W	N
- Third party services not where expected	W	L	W	U
- Cost of samples	-	-	N	N
Construction - Environmental				
- Unpredicted environmental factors	H	P	W	L
- Unexpected impact of environmental legislation	W	N	W	N
- Pollution	W	U	W	L
- Noise	W	U	M	L
- Land contamination	W	U	H	L
- Waste disposal	W	U	W	L
Construction - Civil Works				
- Control of labour	W	N	W	N
- Price and quantity of material	-	-	W	U
- Price and quantity of labour	-	-	W	U
- Price and quantity of plant	-	-	W	U
- Risk that material sources will be used by competing works	H	U	W	U
- Risk on price and availability of sub-contractors	W	L	M	P
- Suitability of existing structures and works	-	-	W	N
- Site access	W	U	N	N
- Site communication	N	N	N	N
- Adverse weather	H	L	M	P
- Manufacturing, testing and commissioning of materials and plant	W	U	M	U
- Excavation cost overruns	W	U	W	N
- Excavation safety	W	N	N	N
- Death or injury to workers	W	N	M	N
- Loss or damage to property, plant & structures	W	U	H	U
- Damage to other roads and structures	M	L	W	U
- Failure of tests on materials and plant	N	N	W	N
- Improper work or materials	N	N	N	N
- Suspension of work	H	L	H	U
- Surfaces requiring reinstatement	N	N	W	N
- Hire of equipment	H	U	M	U
FORCE MAJEURE				
- Physical damages	M	L	M	N
- Earthquake	H	N	H	N
- Flooding	H	N	M	N
- Acts of God (other)	W	N	M	N
- Fire	M	N	M	L
- Weather	M	L	W	L
- Terrorism	M	N	H	N

Score

H	High
M	Medium
W	Weak
N	Negligible

Probability

P	Very probable
L	Likely
U	Unlikely
N	Negligible

There are two drawbacks with the Table 4.4.2b: The first is that risks are not described clearly in terms of cause and effect (see Column 1); the consequences being that there's insufficient detail to (a) assess probability and impact values accurately, and (b) consider reliable risk response measures. The second relates to estimating risk exposure, which is either the product or sum of probability and impact. Numbers rather than letters can be used to combine probability and impact assessments, and hence enable the distribution of project risk to be illustrated. Table 4.4.2c shows an alternative assessment. It uses a modified risk classification scheme, similar to that shown in Table 4.4.2a, whereby values of probability and impact are recorded as numbers. They have then been multiplied together to produce risk scores. The latter can then be mapped onto a risk matrix (see Table 4.4.2d) to illustrate a project's risk distribution.

Table 4.4.2c - Example #2 of qualitative risk assessment

Risk Reference	Cause	Effect	Risk Measure	Probability	Impact	Risk
#01	Unforeseen ground conditions	Increased cost of ground improvements	Cost	2	3	6
#02	Loss or damage to property, plant & structures	Cost of repair or replacement	Cost	3	3	9
#03	Worse weather than expected	Construction programme delay	Programme	2	2	4

Impact

H	High	4
M	Medium	3
W	Weak	2
N	Negligible	1

Probability

P	Very probable	4
L	Likely	3
U	Unlikely	2
N	Negligible	1

Once risks have been assessed qualitatively, they can be mapped onto a risk matrix to illustrate the distribution of risk exposure. Table 4.4.2d shows an example risk matrix for highlighting the more significant risks; the different coloured regions representing varying levels of risk exposure and hence tolerability. The coloured regions should be agreed at the risk management planning stage to reflect the importance a beneficiary attaches to different levels of risk .The matrix can therefore be used to prioritise risks for more detailed schedule Quantitative Risk Analysis (QRA) and risk response planning. It presents values of risk exposure (RE) for combinations of likelihood and severity from the *Value* column in Table 4.4.2a. Table 4.4.2e shows the total number of project risks within each cell from a qualitative risk assessment

Table 4.4.2d – Example Probability-Impact Risk Matrix

		Risk Likelihood				
		Rare 1	Low 2	Moderate 3	Likely 4	Almost Certain 5
Risk Severity	Serious 5	5	10	15	20	25
	Significant 4	4	8	12	16	20
	Moderate 3	3	6	9	12	15
	Minor 2	2	4	6	8	10
	Insignificant 1	1	2	3	4	5

Table 4.4.2e – Example Populated Probability-Impact Risk Matrix

	Very Low	Low	Medium	High	Very High
Very High		(4)	(4)	(1)	
High	(7)	(7)	(7)	(3)	
Medium	(11)	(26)	(19)	(3)	(3)
Low	(16)	(27)	(19)	(14)	
Very Low		(12)	(8)	(4)	

The probability rating for cost variability needs to take account of the wider context in the construction industry in that country. For instance, in Task 4 of this project (market context) it has been identified that some countries have experienced higher levels of construction cost inflation through a lack of competition in the market or high demand for materials and labour which have pushed up costs. Similarly, it has been identified in Tasks 5 and 8 that there are generally a lack of price adjustment clauses in contracts used and a lack of accuracy in cost estimating at early project stages which again will increase the level of risk.

A4.5 Quantitative Risk Assessment Guidance

A4.5.1 Introduction

Cost risk quantification generally follows qualitative risk assessment. It requires risk identification. The qualitative and quantitative processes can be performed separately or together.

There are several quantitative techniques, whose reliability can vary. The following paragraphs briefly mentions three commonly-used techniques:

- Expected Monetary Value (EMV)
- Quantitative Risk Analysis (QRA)
- Optimism Bias (OB)

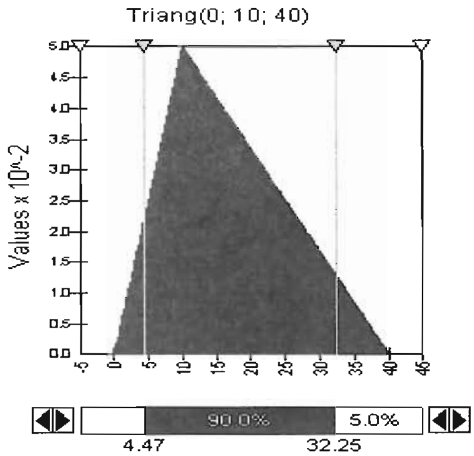
A4.5.2 Expected Monetary Value (EMV)

EMV estimates a single monetary value, were a risk to occur, and weights it by the probability of its occurrence. Whilst it provides a probabilistic assessment of cost risk, it does not account for every possible value each cost variable could take.

A4.5.3 Quantitative Risk Analysis (QRA)

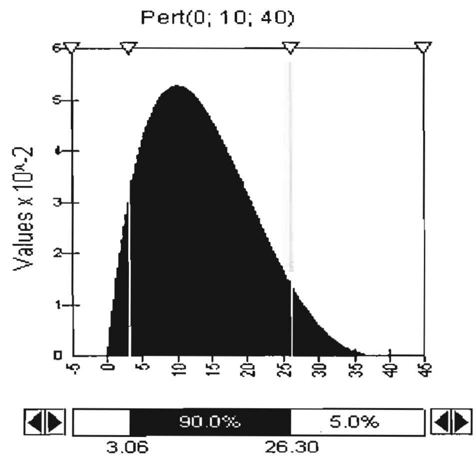
Unlike EMV, QRA enables each variable to be represented by a probability distribution function rather than a single value. It allows impact ranges (e.g. minimum, most likely and maximum), which should be relative to base cost estimates, to be described by probability distributions. For cost, the triangular and PERT distributions are typically used. The former distribution is the most commonly used distribution for modelling expert opinion. It is defined by its minimum (a), most likely (b) and maximum (c) values (see Figure 4.5.3a).

Figure 4.5.3a – Example Triangular Distribution



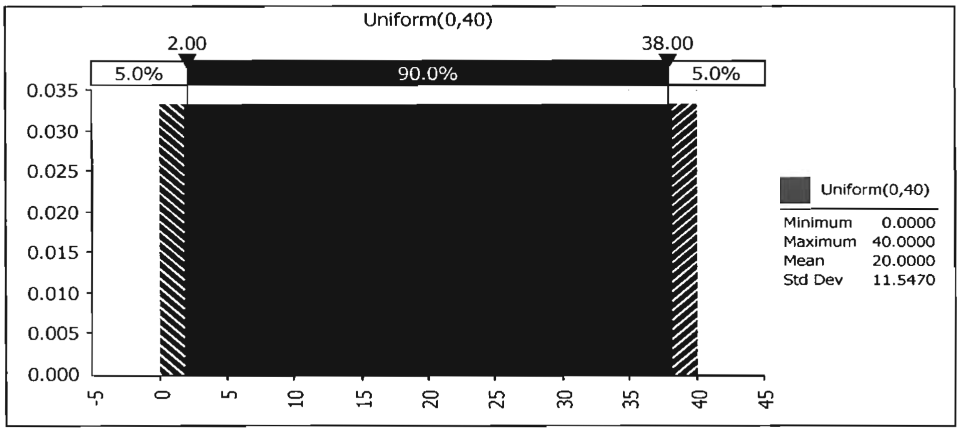
The triangular distribution is, however, limited in that the mean is equally sensitive to the three input values. The PERT distribution (see Figure 4.5.3b) is a reliable alternative. The mean for the PERT distribution is four times more sensitive to the most likely value. It is, consequently, better suited for modelling estimates gathered from experts.

Figure 4.5.3b – Example PERT Distribution



In cases where all cost values are equally likely, the Uniform distribution (see Figure 4.5.3c) is most appropriate. Such cases are especially prevalent in the early stages of a project's development, when there are relatively high levels of uncertainty

Figure 4.5.3c – Example Uniform Distribution

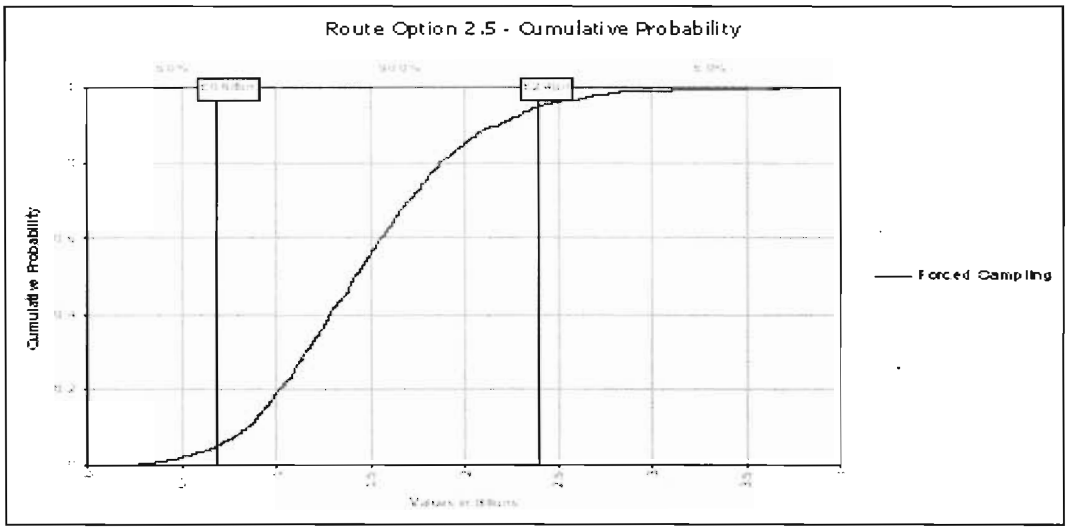


Risk analysis software programs (e.g. Crystal Ball, @RISK, Predict!, Pertmaster) can then combine the risks and uncertainties, and provide an overall cost risk distribution for a project. Also, it also enables correlation and interdependencies to be modelled. Monte Carlo simulation is used with a large number of iterations to produce a probability distribution of the cost estimates.

QRA is increasingly being used worldwide, especially when appraising capital investment projects. Based on the level of risk that the client is willing to accept, beneficiaries can make a more informed choice of budget values to use for funding and for controlling the project. It can offer reliable answers to the following questions:

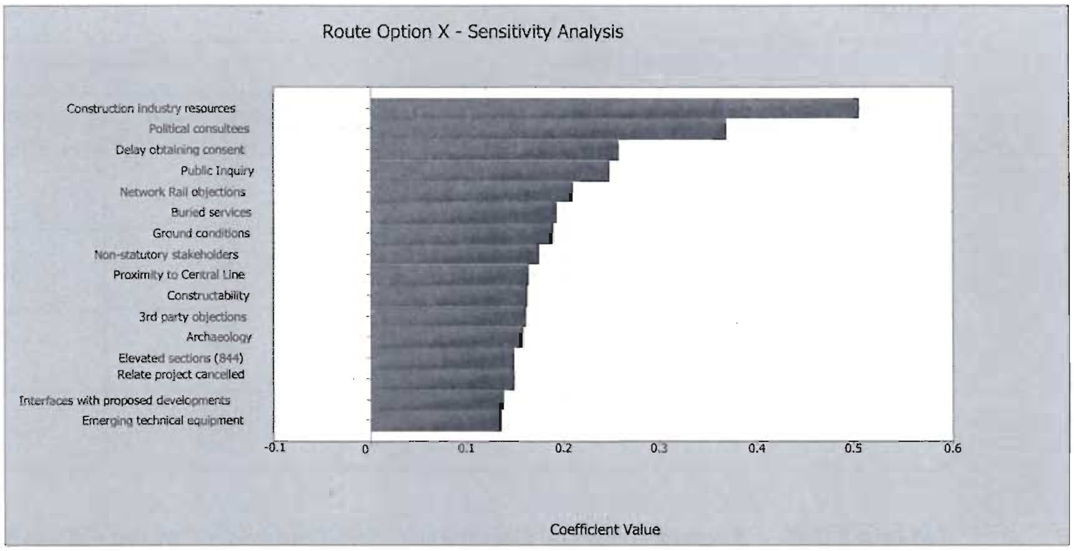
- If there is budget overrun, what is the likelihood of such an event (see Figure 4.5.3(d))?
- What is the level of exposure associated with any overrun that may occur (see Figure 4.5.3(d))?
- Where do the individual risks lie that need to be controlled to avoid overrun (see Figure 4.5.3(e))[1]?

Figure 4.5.3(d) – Example Cumulative Cost Risk Distribution



[1] A regression coefficient of 100% or -100%, indicates a 1 or -1 standard deviation change in the output from a 1 or -1 standard deviation change in the input. In other words, it indicates the degree of correlation between the two sets of values: +100% being highly correlated, 0% no correlation, -100% inversely correlated

Figure 4.5.3(e) – Example Sensitivity Analysis



A4.5.4 Optimism Bias (OB – CFPM Task 9 refers)

For the last five years in the United Kingdom, publicly procured projects have been obliged to account for Optimism Bias (OB), defined as the historical tendency for projects to underestimate project costs. OB is supposed to complement Monte Carlo QRA. It is a percentage uplift on the sum of the base estimate and Monte Carlo QRA value. The percentage uplift is estimated based on empirical data from comparable projects. For example:

Base Cost Estimate	*€70m*
QRA (mean value)	*€12m*
Optimism Bias (+15%)	
Total Scheme Cost	*€82m x 1.15 = €94.3m*

Treasury Green Book[2] and the Department for Transport's (DfT) related procedure[3] respectively (see Section A5, *References*). These uplift percentages are applied to projects of the same type. Upper bound values should be assumed at early project stages. Thereafter, reductions are justified to account for more design definition, more detailed cost estimating and QRA.

The types of transport schemes under the direct and indirect responsibility of the DfT have been divided into a number of distinct groups where the risk of cost overruns within each of the groups can be treated as statistically similar. For each of the groups, a reference class of completed transport infrastructure projects has been used to establish probability distributions for cost overruns for new projects similar in scope and risks to the projects in the reference class. Based on this, the necessary uplifts to ensure that the risk of cost overrun is below certain pre-defined levels have been established. For example, (from Table 4.5.2(d)), an uplift percentage of 32 percent should be applied to the base cost of a roads scheme if the sponsor wants no more than a 20 percent chance of the sum total (i.e. base cost X 1.32) being exceeded.

Task 9 of this CFPM commission has involved collecting historical cost data, from all participating countries, from three points in a project's lifecycle, namely appraisal, contract award and completion. The output is uplift percentages to be applied to cost estimates at project appraisal. For the road sector across the nine countries, the uplift percentage to be applied is 30% if the sponsor wants no more than a 20 percent chance of a cost overrun and 47% if the sponsor wants no more than a 10 percent chance of a cost overrun.

Table 4.5.2(c) – Extract from UK HM Treasury Capital Expenditure Optimism Bias Uplifts[2]

Project Type	Optimism Bias (%)	
	Upper Bound	Lower Bound
Standard Buildings	24	2
Non-standard Buildings	51	4
Standard Civil Engineering	44	3
Non-standard Civil Engineering	66	6

Table 4.5.2(d) - Extract from UK Department for Transport Capital Expenditure Optimism Bias Uplifts[3]

Category	Types of projects	Applicable optimism bias uplifts	
		50% percentile	80% percentile
Roads	Motorway Trunk roads Local roads Bicycle facilities Pedestrian facilities Park and ride Bus lane schemes Guided buses on wheels	**15%**	**32%**
Rail	Metro Light rail Guided buses on tracks Conventional rail High speed rail	**40%**	**57%**
Fixed Links	Bridges Tunnels	**23%**	**55%**

[2] UK Her Majesty's (HM) Treasury *Supplementary Green Book Guidance – Optimism Bias*
[3] The British Department for Transport - *Procedures for Dealing with Optimism Bias in Transport Planning* Guidance Document, June 2004

A4.6 Risk Response Planning Guidance

As with risk assessment, the required level and type of risk response should be determined by risk exposure. There are four broad strategies of responding to negative risks or threats:

- **Avoid**: involves changing the project plan to eliminate the risk or to protect the project objectives from its impact. Some risk causes that arise early in a project can be dealt with by clarifying requirements, obtaining information, improving communications, or acquiring expertise. Reducing scope to avoid high-risk activities, adding resources or time, adopting a familiar approach instead of an innovative one, or avoiding an unfamiliar contractor are examples of risk avoidance.
- **Transfer**: seeks to transfer the impact of a risk to a third party, together with ownership of the response. Transferring the risk does not eliminate it, but simply gives another party responsibility for its management. It invariably involves payment of a risk premium to a party taking on the risk. Risks can be transferred via procurement types, contractual clauses, pricing mechanisms, insurance, performance bonds, warranties and guarantees. However, in achieving an optimal risk distribution, there are several considerations the beneficiaries must make. They are, that a risk should only be given to a body who:

    a. Has been made fully aware of the risks they are taking;

    b. Has the greatest capacity to manage the risk effectively and efficiently;

    c. Has the resources available to cope with the risk were it to occur;

    d. Has the necessary risk appetite to own the risk;

    e. Has been given the chance to charge an appropriate premium for owning it.

    By not making these considerations, the beneficiaries would merely be gaining the illusion of risk transfer, since it is likely that the risk will be transferred back to them in the form of higher risks, risk premiums and project problems. To ensure that this does not happen, beneficiaries should develop risk allocation matrices that identify risks and distinguish the party most capable of assuming a particular risk. Care should be taken to ensure these matrices are project-specific since the majority of projects have a different array of risks, which need to be thoroughly evaluated and understood.
- **Treat**: reduce risk exposure either by reducing the probability or reducing the severity of a risk to below an acceptable threshold. Prevention is more effective than trying to repair or reduce the consequences after the event has occurred (i.e. mitigation). Examples include amending the design, or using different materials or different methods of construction.
- **Tolerate**: where risks cannot economically be transferred, avoided or treated, they can be tolerated either actively or passively. The former centres on developing a contingency plan (e.g. cost and schedule reserves) to draw on should a risk occur. The latter requires no action, leaving the project team to deal with the risks as they occur.

Once the most appropriate strategy has been determined, the actual risk response measure, with which to realise the chosen strategy, needs to be designed. Before implementing any risk response measure, a robust evaluation of its cos*t* relative to its risk reduction potential should be made. This should take account of any *secondary* risks associated with implementing a risk response measure. A common example of a secondary risk is risk premiums being charged by contractors in exchange for risk ownership (e.g. of uncertain ground conditions)

A4.7 Risk Monitoring and Control Guidance

Risk monitoring is an iterative process that should occur throughout the life of a project. It comprises four activities:

1. Monitoring current risks: To determine when and if a risk response should be initiated; the effectiveness of the response so that it can be changed, if necessary, before a problem develops; when a response has been successful and the risk can be closed;
2. Identifying new risks: As a result of requirements changes, budget and programme changes, or simply a better understanding of the project. The project manager or risk manager should judge whether a formal workshop is necessary to consider risks associated with these changes. Notwithstanding, all project team members are responsible for reporting project changes so that project management can make that decision;
3. Conducting periodic reviews: Project risk should be agenda item at all team meetings. Risk exposure may change during the life of the project. Any changes may require additional qualitative or quantitative assessment;
4. Periodically reassessing risk exposures: See 3 above.

Activities one and two are on-going events. Items three and four are scheduled events that should be tied to key events in the project programme. The frequency of risk monitoring, and the responsibility for it should be specified in the project risk management plan.

A project risk register should be the primary means of recording risk information and monitoring risk exposure. Table 4.7.2 provides more explanation of the function of typical register fields/columns. It should:

- Record all identified risks and their associated assessments;
- Include necessary risk response plans and responsibilities;
- Indicate the status of all risks;
- Be structured so as to allow risks to be filtered and sorted according to, for example, type, project phase, discipline, (sub) project, exposure or owner.

The recording of historical risk-related information is becoming increasingly common practice. It can reliably inform future, comparable projects of:

- Risks to consider;
- Their likely probability and consequence (qualitative and quantitative assessments);
- Effective (and ineffective) risk response measures;
- Other lessons learned.

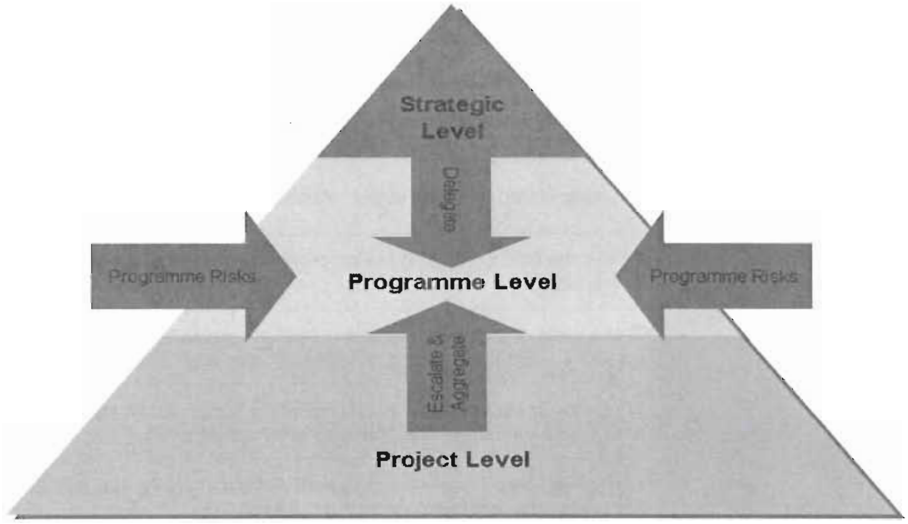
Table 4.7.2 - Typical Project Risk Register Fields/Columns

Risk Register Field	Data Input Advice
Risk ID	A unique identifier for each risk.
Date Raised	Date when risk was first identified
Opportunity or Threat	Indicates whether the risk results in negative (i.e. threat) or positive (i.e. opportunity)
Risk Category	Enables risks to be grouped, sorted and filtered to help risk reporting
Risk Title	A keyword, or short phrase to summarise the risk event
Cause	A clearly stated initiating event, which can result in one or more consequence.
Consequence	States the effect of the cause on project success criteria (e.g. CapEx, Programme or Reputation).
Risk Owner	The person or organisation that is best placed to ensure the risk is handled correctly. NB: This doesn't necessarily infer any contractual liability.
Pre-Response / Current Assessment	The initial assessment of probability and impact accounts for the benefit of existing risk control measures (i.e. those already implemented)
Probability	The value should cover the probability of the initiating event AND the probability of the initiating event resulting in the consequence.
Impact	The assessment of 'impact' should be measured in terms of the most likely impact magnitude were the risk to occur.
Risk Score	The industry standard for calculating risk exposure is Probability x Impact, although an additive scheme is sometimes used.
Risk Response Strategy	This cell is restricted to a list of terms to describe at a high level what your specific actions (recorded in the next cell) are trying to achieve.
Response Control Action (RCA)	This column is to record specific actions to affect a risk's probability and/or impact.
Action Owner	Allocates responsibility for developing and action an RCA.
Action Due Date	States the target completion date for and RCA
Action Status	Options are 'Proposed', 'Sanctioned' 'Rejected' 'In progress', 'Complete'
Residual Assessment	Assess risk exposure assuming ALL identified RCA's are implemented. NB: if some but not all RCA's are implemented the assessment is assumed 'Current'.
Probability	The probability of the initiating event resulting in the stated consequence, given the implementation of ALL RCSs
Impact	The consequence of a risk event, given implementation of ALL RCAs.
Risk Score	Residual Risk is calculated in the same way as Current Risk.
Comments	To provide an auditable trail and a basis for recording assessment scores & related assumptions.
Status	To indicate the current status of a risk (e.g. open, closed)

A4.8 Programme Risk Management Guidance

Programmes need to account for three potential sources of risk, as is illustrated in Figure 4.8a. Risks could arise from its component projects, from governing organisational strategy or from the programme itself. The scope of programme risk management must include all three sources of risk.

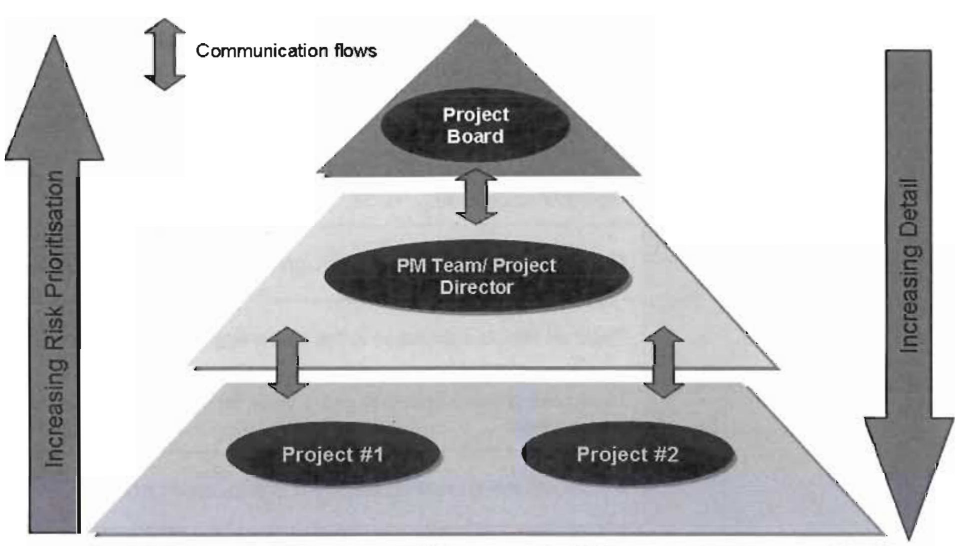
Figure 4.8a – Sources of Programme Risk



The management of programme risks should be both implicit and explicit. The former refers to the inherent structure of the programme itself. This can be effected via project selection. In other words, projects are selected in order to maintain risk exposure at a level which is consistent with the risk appetite of the beneficiaries, while attempting to deliver the required infrastructure improvements. Implicit programme risk management can also be realised by phasing the delivery of component projects, for example to suit prevailing market conditions.

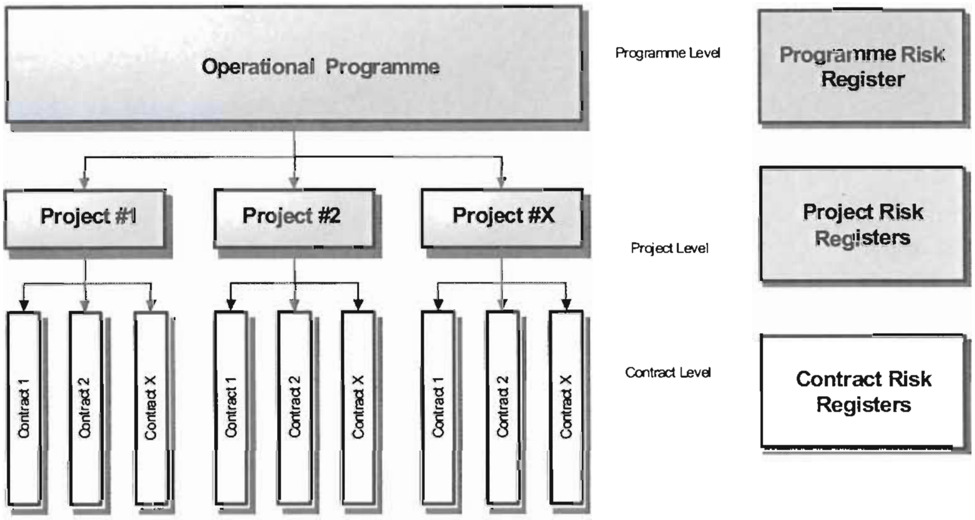
Explicit programme risk management requires a structured process analogous to the project risk management approach (i.e. identify, assess etc.). There are some important differences, however, most notably establishing criteria and protocols for communicating risks within the programme organisation for reporting and ownership (see Figure 4.8b)

Figure 4.8b – Programme Risk Communication



The need to record and maintain risk-related information at different tiers within the programme organisation is also fundamentally important. This has implications for the selection of appropriate risk management computer tools (e.g. ARM, Predict!), which allow a hierarchy of risk registers to be built and maintained within the organisation.

Figure 4.8c – Risk Register Hierarchy



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