PROJECT RISK ANALYSIS AND MANAGEMENT

A GUIDE BY

THE ASSOCIATION FOR PROJECT MANAGEMENT

(formerly The Association Of Project Managers)

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the Special Interest Group on Risk Management

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PROJECT RISK ANALYSIS AND MANAGEMENT

1. Introduction

This Guide provides an introduction to the processes involved in Project Risk Analysis and Management, offering a simple but robust and practical framework to help new users get started. It is not a definitive explanation of all the techniques and methods that can be used in the process.

Project Risk Analysis and Management can be used on all projects, whatever the industry or environment, and whatever the timescale or budget.

2. What Is Project Risk Analysis And Management?

Project Risk Analysis and Management is a process which enables the analysis and management of the risks associated with a project. Properly undertaken it will increase the likelihood of successful completion of a project to cost, time and performance objectives.

Risks for which there is ample data can be assessed statistically. However, no two projects are the same. Often things go wrong for reasons unique to a particular project, industry or working environment. Dealing with risks in projects is therefore different from situations where there is sufficient data to adopt an actuarial approach. Because projects invariably involve a strong technical, engineering, innovative or strategic content a systematic process has proven preferable to an intuitive approach. Project Risk Analysis and Management has been developed to meet this requirement.

3. What Is Involved

The first step is to recognise that risk exists as a consequence of uncertainty. In any project there will be risks and uncertainties of various types as illustrated by the following examples:

- the management and financial authority structure are not yet established
- a the technology is not yet proven
- industrial relations problems seem likely
- resources may not be available at the required level.

All uncertainty produces an exposure to risk which, in project management terms, may cause a failure to:

- keep within budget
- achieve the required completion date
- achieve the required performance objective.

Project Risk Analysis and Management is a process designed to remove or reduce the risks which threaten the achievement of project objectives. The next section of this Guide describes the benefits which Project Risk Analysis and Management can bring to a project and also the wider benefits to the organisation and its customers. It should be regarded as an integral part of project or business management and not just as a set of tools or techniques.

The Project Risk Analysis and Management Process

Experienced risk analysts and managers hold perceptions of this process which are subtle and diverse. In order to simplify the process this Guide divides the overall process into two constituents or stages:

- Risk Analysis
- Risk Management.

Risk Analysis

This stage of the process is generally split into two 'sub-stages'; a qualitative analysis 'sub-stage' that focuses on identification and subjective assessment of risks and a quantitative analysis 'sub-stage' that focuses on an objective assessment of the risks.

Qualitative Analysis

A Qualitative Analysis allows the main risk sources or factors to be **identified**. This can be done, for example, with the aid of check lists, interviews or brainstorming sessions. This is usually associated with some form of **assessment** which could be the description of each risk and its impacts or a subjective labelling of each risk (e.g.

high/low) in terms of both its impact and its probability of occurrence.

A sound aim is to identify the key risks, perhaps between five and ten, for each project (or part-project on large projects) which are then analysed and managed in more detail.

Quantitative Analysis

A Quantitative Analysis often involves more sophisticated techniques, usually requiring computer software. To some people this is the most formal aspect of the whole process requiring:

- measurement of uncertainty in cost and time estimates
- probabilistic combination of individual uncertainties.

Such techniques can be applied with varying levels of effort ranging from modest to extensively thorough. It is recommended that new users start slowly, perhaps even ignoring this 'sub-stage', until a climate of acceptability has been developed for Project Risk Analysis and Management in the organisation.

An initial qualitative analysis is essential. It brings considerable benefit in terms of understanding the project and its problems irrespective of whether or not a quantitative analysis is carried out. It may also serve to highlight possibilities for risk 'closure' i.e. the development of a specific plan to deal with a specific risk issue.

Experience has shown that qualitative analysis - Identifying and Assessing Risks - usually leads to an initial, if simple, level of quantitative analysis. If, for any reason - such as time or resource pressure or cost constraints - both a qualitative and quantitative analysis are impossible, it is the qualitative analysis that should remain.

It should be noted that procedures for decision making will need to be modified if risk analysis is adopted. An example which illustrates this point is the sanction decision for clients, where estimates of cost and time will be produced in the form of ranges and associated probabilities rather than single value figures.

Risk Management

This stage of the process involves the formulation of management responses to the main risks. Risk Management may start during the qualitative analysis phase as the need to respond to risks may be urgent and the solution fairly obvious. Iteration between the Risk Analysis and Risk Management stages is likely.

Risk Management can involve:

- identifying preventive measures to avoid a risk or to reduce its effect
- establishing contingency plans to deal with risks if they should occur
- initiating further investigations to reduce uncertainty through better information
- considering risk transfer to insurers
- considering risk allocation in contracts
- setting contingencies in cost estimates, float in programmes and tolerances or 'space' in performance specifications.

Section 6 of this Guide considers some of the techniques of Project Risk Analysis and Management in more detail.

4. Why Is It Used?

There are many reasons for using Project Risk Analysis and Management, but the main reason is that it can provide significant benefits far in excess of the cost of performing it.

Benefits

The benefits gained from using Project Risk Analysis and Management techniques serve not only the project but also other parties such as the organisation and its customers. Some examples of the main benefits are:

- an increased understanding of the project, which in turn leads to the formulation of more realistic plans, in terms of both cost estimates and timescales
- an increased understanding of the risks in a project and their possible impact, which can lead to the minimisation of risks for a party and/or the allocation of risks to the party best able to handle them
- an understanding of how risks in a project can lead to the use of a more suitable type of contract
- an independent view of the project risks which can help to justify decisions and enable more efficient and effective management of the risks
- a knowledge of the risks in a project which allows assessment of contingencies that actually reflect the risks and which also tends to discourage the acceptance of financially unsound projects

- a contribution to the build-up of statistical information of historical risks that will assist in better modelling of future projects
- facilitation of greater, but more rational, risk taking, thus increasing the benefits that can be gained from risk taking
- assistance in the distinction between good luck and good management and bad luck and bad management.

Who benefits from its use?

- an organisation and its senior management for whom a knowledge of the risks attached to proposed projects is important when considering the sanction of capital expenditure and capital budgets
- clients, both internal and external, as they are more likely to get what they want, when they want it and for a cost they can afford
- project managers who want to improve the quality of their work i.e. they want to bring their projects in to cost, on time and to the required performance.

What are the costs of using it?

The costs of using Project Risk Analysis and Management techniques vary according to the scope of the work and the commitment to the process. Below are some example costs, time-scales and resource requirements for carrying out the process.

Cost

The cost of using the process can be as little as the cost of one or two days of a person's time up to a maximum of 5-10% of the management costs of the project, even this higher cost, as a percentage of the total project cost, is relatively small. It can be argued that the cost incurred is an investment if risks are identified during the process that may otherwise have remained unidentified until it was too late to react.

Time

The time taken to carry out a risk analysis is partially dependent upon the availability of information. A detailed cost and time risk analysis usually requires anywhere from one to three months depending upon the scale and complexity of the project and the extent of planning and cost preparation already carried out. However, as indicated above, a useful analysis can take as little as one or two days.

Resources

The minimum resource requirement is obviously just one person within a organisation with experience of using Project Risk Analysis and Management techniques. However, if expertise does not exist within the organisation it can be readily acquired from outside consultants. It is likely that once Project Risk Analysis and Management has been introduced to an organisation, in-house expertise will develop rapidly.

As stated in Section 3, Project Risk Analysis and Management is relevant to all projects and is an integral part of project management. This can make it very difficult to separate the costs of performing it. Some organisations treat these costs as an overhead to the organisation, and not to the project.

5. When Should It Be Used and Who Should Do It?

Project Risk Analysis and Management is a continuous process that can be started at almost any stage in the life-cycle of a project and can be continued until the costs of using it are greater than the potential benefits to be gained. As time progresses, the effectiveness of using Project Risk Analysis and Management tends to diminish, therefore it is most beneficial to use it in the earlier stages of project.

There are five points in a project where particular benefits can be achieved by using it.

- *Feasibility Study* - At this stage the project is most flexible enabling changes to be made which can reduce the risks at a relatively low cost. It can also help in deciding between various implementation options for the project.
- *Sanction* - The client can make use of it to view the risk exposure associated with the project and can check that all possible steps to reduce or manage the risks have been taken. If a quantitative analysis has been carried out then the client will be able to understand the 'chance' that he has of achieving the project objectives (cost, time and performance).
- *Tendering* - The contractor can make use of it to ensure that all risks have been identified and to help him set his risk contingency or check his risk exposure.

- *Post Tender* - The client can make use of it to ensure that all risks have been identified by the contractor and to assess the likelihood of tendered programmes being achieved.
- At Intervals During Implementation - It can help to improve the likelihood of completing the project to cost and time-scale if all risks are identified and are correctly managed as they occur.

Which projects are suitable?

Many experienced users of Project Risk Analysis and Management would say 'any and all' in answer to this question, and experience does show that this is the case - the reasons were stated earlier in the Guide. All projects contain risk and risk analysis and management is an integral part of project or business management.

Attend any conference or read any literature on risk and it is clear that the most extensive applications have occurred on large capital projects such as defence, oil and gas, aerospace and civil engineering - these projects have been the proving ground for many of the techniques. However the process has been applied to smaller construction projects such as a water supply rehabilitation project in West Africa and the proposed construction of a gas pipeline across Hampstead Heath in London.

In other fields there are examples of risk analysis and management applied to insurance, IT projects and software development and projects for organisational change.

The only general guidance is that the more the risks or more innovative the project the greater will be the benefits. On small projects, the budget will probably justify only a low level of application, perhaps omitting the quantitative analysis.

What type of project?

It can be used on any type of project, but it is more beneficial for some projects than others. Some examples of projects which would benefit from Project Risk Analysis and Management are:

- innovative, new technology projects
- projects requiring large capital outlay or investment
- fast-track projects
- projects which interrupt crucial revenue streams
- unusual agreements (legal, insurance or contractual)
- projects with sensitive issues (environment / relocation)
- projects with stringent requirements (regulatory / safety)
- projects with important political / economic / financial parameters.

When should it be done?

There are a few circumstances when it is particularly advisable to use Project Risk Analysis and Management techniques, these are:

- when there are specific targets that must be met
- when there is an unexpected new development in a project
- at points of change in the life-cycle of a project.

When shouldn't it be done?

There are no particular circumstances under which Project Risk Analysis and Management techniques should not be used except perhaps for repeat projects, where such analyses have already been carried out, unless, of course, there are specific differences between the projects.

In the presence of uncertainty, where severe constraints give rise to significant risk, the absence of relevant data may make a quantitative assessment not worthwhile. However, such circumstances must never prevent a rigorous qualitative analysis being carried out.

Who should do it?

Many people advocate the use of an independent expert or external consultant to ensure that they receive an unbiased view, whereas others suggest that Project Risk Analysis and Management support should be an internal function. Opinions differ widely at this stage but essentially anyone can do it provided consideration is given to the 'angle' from which they are viewing the project. In any event, the project management team should be closely involved in the analytical process to ensure validity of the analysis and also to allow them to believe in the results.

6. How To Do It - Techniques And Methods

As outlined in Section 3, Project Risk Analysis and Management can be split into its two constituents or stages - Risk Analysis (Qualitative and Quantitative) and Risk Management. There is no one technique or method for carrying out either stage of the

process. Some of the techniques and methods that can be employed are detailed below.

Qualitative Risk Analysis

The first phase of the qualitative analysis is identification. This is considered by some as the most important element of the process since once a risk has been identified it is possible to do something about it. Identification can be achieved by:

- interviewing key members of the project team
- organising brainstorming meetings with all interested parties
- by using the personal experience of the risk analyst
- reviewing past corporate experience if appraisal records are kept.

All of the above methods are greatly enhanced by the use of check lists which can either be generic in nature i.e. applicable to any project or specific to the type of project being analysed.

Once identified, the risks are then subjected to an initial assessment that categorises the risks into high/low probability of occurrence and major/ minor impact on the project should the risk materialise. It is often advisable to prepare initial responses to each identified risk, especially if risks are identified that require urgent attention. The analysis may be terminated during this phase if the assessment immediately suggests a way in which many identified risks can be mitigated.

It may be necessary to revisit the identification phase after the assessment phase to see if any consequential 'secondary' risks can be identified: a secondary risk may result from a proposed response to an initial risk and might therefore lead to the response being unsuccessful. The necessity of doing this will largely be dependent on the size and/or complexity of the project.

Quantitative Risk Analysis

Once all risks have been identified, during the qualitative analysis, it may be appropriate to enter into a detailed quantitative analysis. This will enable the impacts of the risks to be quantified against the three basic project success criteria: cost, time and performance. Several techniques have been developed for analysing the effect of risks on the final cost and time-scale of projects. However, such techniques do not always readily apply themselves to the analysis of performance objectives.

The main techniques currently in use are:

- **Sensitivity Analysis**, often considered to be the simplest form of risk analysis. Essentially, it simply determines the effect on the whole project of changing one of its risk variables such as delays in design or the cost of materials. Its importance is that it often highlights how the effect of a single change in one risk variable can produce a marked difference in the project outcome.

In practice, a sensitivity analysis will be performed for more than one risk, perhaps all identified risks, in order to establish those which have a potentially high impact on the cost or time-scale of the project. The technique can also be used to address the impact of risk on the economic return of a project. Figure 1 shows an example of a sensitivity diagram.

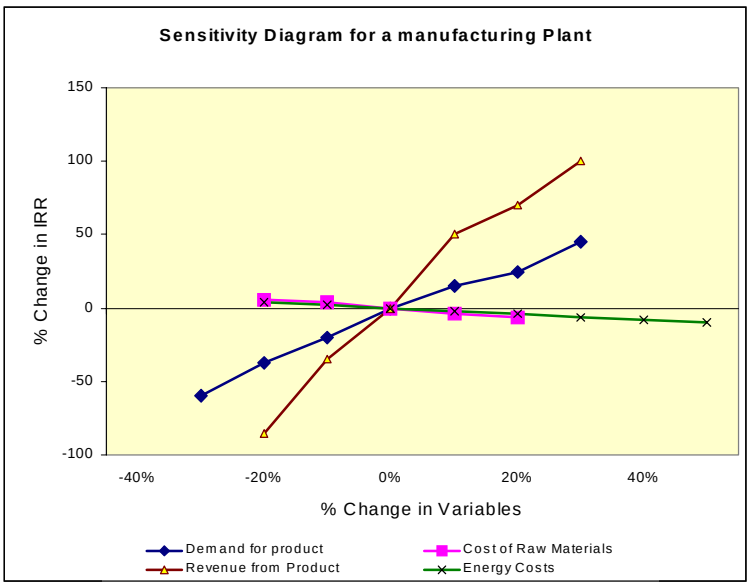

Figure 1 Sensitivity Diagram for a New Manufacturing Plant

This diagram shows that the project is very sensitive, as measured against the internal rate of return, to any changes in both the demand for the product and the revenue from the product, however, changes in energy costs or the cost of raw material have much less impact.

- **Probabilistic Analysis** specifies a probability distribution for each risk and then considers the effect of risks in combination. This is perhaps the most common method of performing a quantitative risk analysis and is the one most people consider, incorrectly, to be synonymous with the whole Project Risk Analysis and Management process. In fact, as this Guide illustrates, it is but one facet of that process.

The most common form of probabilistic analysis uses 'sampling techniques', usually referred to as 'Monte Carlo Simulation'. This method relies on the random calculation of values that fall within a specified probability distribution often described by using three estimates: minimum or optimistic, mean or most likely and maximum or pessimistic. The overall outcome for the project is derived by the combination of values selected for each one of the risks. The calculation is repeated a number of times, perhaps between 100 and 1000, to obtain the probability distribution of the project outcome.

It is usual to carry out a probabilistic time analysis with the aid of a CPM network to model the project schedule. The same method can be used for probabilistic cost analysis especially when the cost estimate can be broken down into the same categories or activities as the schedule and when cost risks are related to time risks. If an independent cost analysis is undertaken then

It may be appropriate to use a spreadsheet method. Figure 2 shows an example of a histogram and cumulative curve derived from a probabilistic time analysis using a model based on a CPM network.

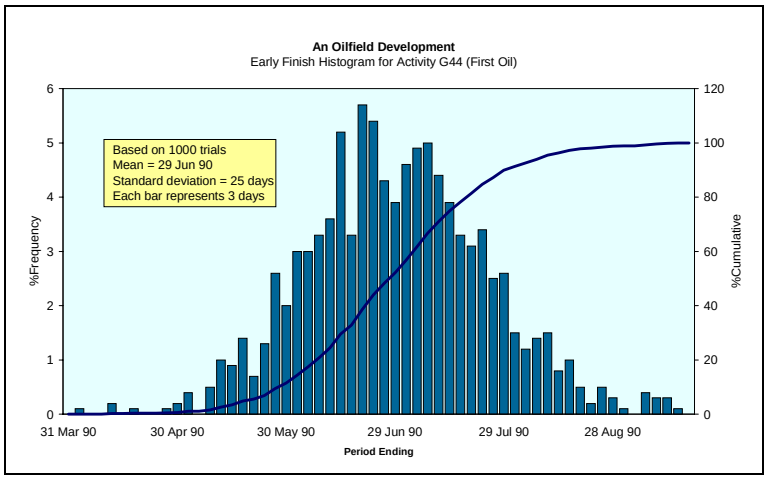

Figure 2 Time Probability Histogram and S-curve for a New Oil Field Development

This diagram shows the distribution of finish dates for the achievement of first oil. It is based on 1000 iterations using Monte Carlo Sampling. The actual finish date of this particular project was achieved within 2 days of the mean.

Another technique is the Controlled Interval and Memory Method for combining probability distributions which provides an alternative to Monte Carlo Simulation. This technique can offer greater precision for much less computerised effort if either complex CPM networks or 'feedback loops' are not involved.

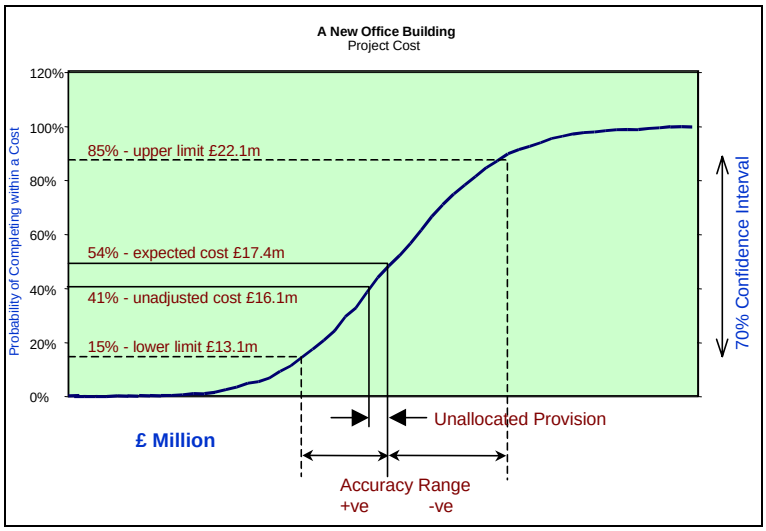

Figure 3 Cost Probability S-curve for a New Office Building

This diagram shows the distribution around a cost estimate for the final, out-turn cost for a new building. It is based on 1000 iterations using Monte Carlo Sampling. The highlighted figures represent the unadjusted cost i.e. the sum of all the cost elements without any risk treatment, the expected cost derived from the statistical mean and a suggested accuracy range. The difference between the unadjusted cost and the expected cost is considered to be an unallocated provision.

- **Influence Diagrams** are a relatively new technique for risk analysis. They provide a powerful means of constructing models of the issues in a project which are subject to risk. As a result influence diagrams are now used as the user interface to a computer based risk modelling tool thus allowing the development of very complex risk models that can be used to analyse the cost, time and economic parameters of projects.
- **Decision Trees** are another graphical method of structuring models. They bring together the information needed to make project decisions and show the present possible courses of action and all future possible outcomes. Each outcome must be given a probability value indicating its likelihood of occurrence. This form of risk analysis is often used in the cost risk analysis of projects.

Risk Management

Risk management uses the information collected during the risk analysis phase to make decisions on how to improve the probability of the project achieving its cost, time and performance objectives. This is done by reducing the risk where advantageous to do so and monitoring and managing the risk which remains.

The project manager uses the information at his disposal to choose between the feasible responses to each risk identified during the qualitative phase. This may involve amending the project plans to reduce the risk e.g. moving high risk activities off the critical path, developing contingency plans to allow rapid response if certain risks occur or setting up monitoring procedures for critical areas in order to get early warning of risks occurring.

There are two types of response to a risk immediate and contingency which can be defined as follows:

- *immediate response*: an alteration to the project plan such that the identified risk is mitigated or eliminated
- *contingency response*: a provision in the project plan for a course of action that will only be implemented should the adverse consequences of the identified risk materialise.

Responses to risks can do one or a combination of five things:

- *remove* - risks that can be eliminated from the project and therefore no longer propose a threat
- *reduce* - risks that can be decreased by taking certain actions immediately
- *avoid* - risks that can be mitigated by taking contingency actions should they occur
- *transfer* - risks can be passed on to other parties, unfortunately this does not normally eliminate the risk it just makes someone else worry about it
- *acceptance* - the benefits that can be gained from taking the risk should be balanced against the penalties.

The risk management phase begins immediately the qualitative analysis is complete and is then a continuing process through the complete life-cycle of the project. The information gained during the quantitative analysis allows the project manager to trade off taking actions now against the likelihood and impact of risk occurring. The project manager may choose to immediately amend his overall time and cost plan in order to increase the probability of achieving his time and cost objectives.

7. What Experience Is Available?

The majority of the methods, techniques and processes described in this Guide have been used in a number of industries since the early 1970s. Project Risk Analysis and Management has historically been associated with very large, high capital projects in specific industries such as defence, oil and gas, aerospace and civil engineering. The experience gained in these industries since the 70s has now begun to disseminate through other industries such as information technology and manufacturing.

The number of companies practising Project Risk Analysis and Management is continuing to increase due to the realisation that the methods, techniques and processes involved form an integral part of project and business management. The increase in its use has led not only to expertise being gained by individuals within companies but the arrival of specialist consultancies that can train, advise and carry out Project Risk Analysis and Management for their clients. Project Risk Analysis and Management has also established itself as an important element in the syllabuses of many universities and higher educational establishments.

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Further information regarding computer software available to assist in performing quantitative risk analysis and references to further information, papers and publications can be obtained from:

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