The controlling influences on effective risk identification and assessment for construction design management

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Abstract

Project risk management (PRM) can provide a decisive competitive advantage to building sponsors. For those sponsors who take risks consciously, anticipate adverse changes, protect themselves from unexpected events and gain expertise to price risk, gain a leading edge. However, the realisation of this commercial advantage on design-intensive multi-disciplinary capital projects hinges to a large extent on the approach to the initial identification of risk. The very way the identification process is conducted will have a direct influence on the contribution that risk analysis and management makes to the overall project management of construction projects. This paper examines the steps involved in conducting the identification and assessment process and how they may influence the effectiveness of risk analysis. A series of issues are examined in turn, which are considered to have a direct bearing on the quality of the identification and assessment process. By focusing on these issues, our understanding of the contribution that risk management makes to improving project performance may be enhanced. © 2001 Elsevier Science Ltd and IPMA. All rights reserved.

Keywords: Risk identification; Risk assessment; Risk analysis; Design process

1. Introduction

The literature, in the main, implies that there has been a tendency for the approach to Project risk management (PRM), to be overly prescriptive and mechanistic. In addition that there has been undue emphasis on the techniques of the process rather than focusing on the most crucial areas of the overall process, identification and assessment [1]. While it may be obvious that the quality of the outputs from a quantitative analysis are largely dependent on the identification and assessment process, prescriptive methods underplay the importance of this initial sub-stage. Unidentified and therefore unmanaged risks are clearly unchecked threats to a project’s objectives, which may lead to significant overruns. Should the circumstances be so extreme, then the failure of a single project may be seriously damaging to the financial status of a company. The degree to which the identification process will influence the effectiveness of risk management and its contribution to the overall project management of any particular project, is dependent on the way the steps of the process are implemented. The purpose of this paper is to review the steps of identification and assessment in turn, so that their contribution may be better understood.

2. Setting risk identification and assessment in context

The overall process of project risk analysis and management may be described in simple terms as being composed of two stages, risk analysis and risk management, as illustrated in the risk breakdown structure (RBS) included in Fig. 1. The figure provides a readily assimilated subdivision of the tasks to be undertaken. Thompson and Perry [2] adopted this two-stage subdivision in their model of the stages of risk analysis and management, which they advise has proved acceptable to a wide range of experienced practitioners. It was also incorporated in the series of publications produced by the CCTA which includes Introduction to the Management of Risk [3] and within an article entitled Specialising in risks [4]. The risk analysis stage of the PRM process may be considered to be divided into two sub-stages; a qualitative analysis sub-stage that focuses on identification together with the assessment of risk, and a quantitative analysis...
Fig. 1. Risk breakdown structure.
sub-stage that focuses on the evaluation of risk. The risk management phase is concerned with the monitoring of the actual progress of the project and the associated risk management plans. It specifically involves identifying, implementing and tracking the effectiveness of the planned responses, reviewing any changes in priority of response management and monitoring the status of the risks. While the activities are the same, more recently the process is described as being composed of a series of phases which commence in a staggered pattern subsequently running in parallel and conducted in an iterative cycle, as described in the PRAM Guide [5] and Chapman and Ward [6].

3. Scope and plan

Prior to embarking on any PRM study, it is necessary to define the PRM scope and to plan its implementation in operational terms as if it were a project in its own right. The aim is to provide a clear unambiguous shared understanding of the process that will be implemented. The tasks required to accomplish this aim are the production of a scope document and a plan document. The scope document identifies information such as who is undertaking the analysis for whom, the reason for the formal project risk analysis and management process, the desired benefits and the overall project objectives. This is a critical document as it will be a benchmark against which the deliverables will be judged. The plan document addresses the resources to be used, the time frame, the models and techniques to be employed, the software to be used, the way in which the results will be recorded and the confidence levels that will be shown. Once these documents are prepared, signed-off by the client and disseminated, the PRM process can be commenced.

4. The process of risk identification and assessment for design projects

The two principle approaches to risk identification and assessment, are semi-structured interviews conducted with individual design team members in turn and the risk analyst leading a working group. Whichever approach is adopted, it will be necessary to put into effect a series of incremental steps including, knowledge acquisition, selection of the representatives of the core design team, presentation of the process to the core design team, identification, encoding and verification. While these steps are numbered below for ease of reference, the approach adopted will vary for each project to suit its particular circumstances and it may be appropriate to omit a step, combine steps or introduce additional ones. In addition, like design itself, risk analysis can be a highly iterative process; whereas more information becomes available, it is necessary to revisit earlier steps, test decisions and assumptions and make revisions as appropriate.

4.1. Step 1: knowledge-acquisition

The first step involves knowledge-acquisition. That is, first and foremost, understanding what the project objectives are, which are commonly time, cost and quality. To understand the threats to these objectives (or project parameters), it is fundamental to examine the brief, programme, cost plan and quality statement. Where it is identified that there are inconsistencies between the activities recorded in the programme and the cost plan, then these must be remedied. To understand the information supplied, it may be necessary to decompose the project into a set of component activities (or sub-system tasks) and to document what is involved in each. If a work breakdown structure (WBS) has not been compiled, then at this juncture the activities should be coded. Every time an activity is referred to in a project document, it is accompanied by its identifying code. The rationale for implementing this coding system is to ensure clear communication. This breakdown should be based, when appropriate, on the Common Arrangement of work sections published by the Co-ordinating Committee for Project Information [7], the benefits of which are clearly set out in the CCPI guide. In addition, where it is transparent that any of these key documents are incomplete, project management activities must be undertaken to fill the gaps. This can be particularly time-consuming. Moreover, it is necessary to review: the project execution plan (if one exists), the sequence of design activities (compare with the RIBA Plan of Work [8]) and the procurement route to be followed. The thoroughness with which this task is undertaken will directly influence the risk analyst’s ability to assess whether all of the principle project areas have been covered during the Identification step.

4.2. Step 2: selection of the representatives of the core design team

The second step is the selection of the “core design team” or principal designers from the project team who are to participate in the identification and assessment of the risks facing the project. These are the essential personnel upon whom the progress of the design would ultimately depend and who have a full-time committed role throughout the project life cycle. These personnel would include the senior representative of each design discipline such as the architect, landscape architect, structural engineer, mechanical and electrical engineers, together with the project manager and quantity surveyor. It is essential that all the design disciplines are represented otherwise there is potential for critical risk areas to be overlooked. Hence, on large complex projects it is
common to include the “second tier design team” or specialist designers, such as the geotechnical engineer, arboralist, acoustician, fire engineer, environmentalist and interior designer.

4.3. Step 3: presentation of the process to the core design team

The analyst describes the thinking behind the approach and encourages the airing of any doubts or scepticism among the core team that can be laid to rest and encourage participation in and adoption of the process [9]. Efficient management of building projects demands clear effective communication and if risk analysis and management is to be used as a tool to assist the management of projects, then it must itself be clearly communicated and understood.

The aim of this third step is for the risk analyst to clearly communicate the:

- objectives of the risk management process;
- the question the risk assessment is required to answer (definition of scope);
- potential benefits;
- timeframe;
- steps involved;
- participation required of the core design team/second tier design team;
- deliverables (such as, risk register and cumulative frequency curve);
- definition of the measures of impact and probability;
- construction of the PI “scoring” grid;
- allocation of risk owners;
- how the responses are to be defined and managed and conditioning.

The active participation and commitment of the project team to the overall risk management process has a significant influence on its success and hence the benefits must be emphasised and repeated as appropriate.

4.3.1. Step 3 process: constructing measurement criteria

A key component of the Presentation Step is to elicit from the core team or obtain confirmation of acceptance of proposed measures of the likelihood of occurrence and impact, to ensure consistency of assessment. Without these measures, any assessment would be seriously impaired. By the application of these measures together with a probability/impact (PI) matrix, risks can be scored so that attention can be focused on those risks that have the greatest potential to jeopardise a project. When dealing with subjective assessments in the construction industry, team members appear to be more comfortable with five classes of risk, i.e. very high, high, medium, low and very low. Against these five classes must be allocated a likelihood of occurrence and an impact, as shown in Table 1. The time and cost increments selected to match the scales of severity must be tailored specifically to the project priorities. An assessment must be made of the criticality of late completion (e.g. the project completion date linked to the expiry of a lease) and project overspend (e.g. a specific limit set on the size of the development loan).

4.3.2. Step 3 process: comprehension of probability distributions

Where the intention is to follow the qualitative sub-stage with quantitative analysis, the assessment of the impact of any risk must reflect how the risk would occur in reality. This in turn will have a direct bearing on the cost and time information that will need to be collected to feed into representative probability distributions. As a consequence, the Presentation Step should include a description of what probability distributions are, the circumstances under which particular distributions would be used and the data required to construct them. Seven of the most commonly used distributions are triangle, trigen (available in @ Risk) uniform (also known as rectangular), general, normal (also known as Gaussian) discrete and pert. All the distributions permit modelling using limited parameters, when historical data is not available.

4.3.3. Step 3 process: comprehension of conditioning

A further component of the Presentation Step is to minimise cultural differences between the team members and to increase their awareness of the influence of potential biases on their judgement of the magnitude of risks facing the project. Historical records are commonly limited and in consequence data collected from the core team will, mainly be composed of subjective judgements. Tversky and Kahneman [10] have demonstrated that these judgements are arrived at by reliance on a limited number of inference rules known as heuristics, which are employed to reduce difficult mental tasks such as assessing probabilities and likely impacts, to simpler ones. They go onto to say that these heuristics sometimes lead to severe and systematic errors with serious implications for decision makers. This unreliability is the result of the heuristics generating biases in the minds of the individual core team members; however, for risk analysis and management to aid effective decision making the data collected must be as reliable as possible. The core team must be helped to confront their biases.

4.4. Step 4: identification

The third step in assessing risk involves identifying as exhaustively as practicable, the risks associated with
each activity and documenting what is involved. Most authors claim it is important to understand exactly what is meant by risk before it can be managed. There are numerous definitions of risk which attempt to draw together into one definition the likelihood of occurrence and the degree of impact of a negative event adversely affecting an activity. These definitions appear to have changed little over the last twenty years. The definition by Wideman [11] which follows is appealing, for he places risk in the context of project management. He defines project risk “as the chance of certain occurrences adversely affecting project objectives”. However, this definition ignores positive outcomes. The definition of risk adopted here is “an event, which should it occur, would have a positive or negative effect on the achievement of a project’s objectives”. This definition deliberately excludes any reference to the term uncertainty which is considered here to be distinct from risk. The terms are not considered to be synonymous as some authors state, and hence are not used interchangeably. The term uncertainty is adopted here to describe the lack of certainty over the quantum of an activity which is considered certain to take place. An example would be the length of time required to obtain a planning decision — the activity is certain but the duration is uncertain.

The literature states that all risks should be considered at the outset. Identification is considered by many to be the most important element of the complete process, as once a risk has been identified it is possible to take action to address it. This issue is acknowledged or stressed by, Cooper and Chapman [12], CCTA [13], CCTA [14], Perry et al. [15] and Hertz and Thomas [16]. The success of the identification process, , to a large degree, will be dependent on the design team’s in depth knowledge of the design process and the sources of risk. Their understanding will be influenced by their professional training together with their length of exposure to the construction industry, the role occupied, the level of responsibility held, the number of designs seen through from start to finish, the materials deployed, the architectural “styles” adopted and the building types involved in. Direct experience of projects will influence the team’s knowledge of the characteristics of the process. Hence, Step 2 “selection of the representatives of the core design team” is critical to ensuring identification is as penetrating and complete as possible.

4.4.1. Step 4 process: comprehension of the characteristics of the design process

The characteristics of the design process include its highly iterative nature, the use of primary generators (a relatively simple idea to test solutions), the sequence and content of the common design stages, the sequencing of the exchange of information, the impact of external agencies and the management of client changes to the brief. The team’s understanding of these issues will determine their comprehension of the risks which may erode their ability to keep the four main components (see Fig. 2) of the design process — “the four Ts” (Team, Targets [or objectives], Tactics [or controls] and Tasks) in balance for the achievement of a project’s objectives. (The RIBA Plan of Work can be re-defined using those component descriptions as illustrated in Table 2). Accomplishing this balance has been historically proved difficult to accomplish, as reported in the literature, for design management is highly exposed to risk and uncertainty, regardless of the size of the project, building type or construction value.

4.4.2. Step 4 process: comprehension of the sources of design risk

Past performance of construction projects demonstrates that risks have proved difficult to manage with the result that projects have not met their stated objectives. This difficulty emanates from the exposure of design to diverse sources of risk and uncertainty similar to the Information Systems/Technology industry. For instance, the risks described within the CCTA publication “Management of Project Risk” [14] can be directly translated into design risks, as follows:

- difficulty in capturing and specifying the user requirements;
- volatile and innovative nature of the environment;
- difficulty of estimating the time and resources required to complete the design;
- difficulty of sequencing the exchange of information required to match the iterative design process;

### Table 1

<table>
<thead>
<tr>
<th>Scale</th>
<th>Probability</th>
<th>Mid-value</th>
<th>Impact Time</th>
<th>Impact Cost</th>
<th>Impact Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
<td>&gt; 70%</td>
<td>85%</td>
<td>&gt; 15 weeks</td>
<td>&gt; £20m</td>
<td>Project does not satisfy business objectives</td>
</tr>
<tr>
<td>High</td>
<td>51–70%</td>
<td>60%</td>
<td>10–15 weeks</td>
<td>£5m–£20m</td>
<td>Major shortfall in satisfaction of the brief</td>
</tr>
<tr>
<td>Medium</td>
<td>31–50%</td>
<td>40%</td>
<td>5–10 weeks</td>
<td>£0.5m–£5m</td>
<td>Minor shortfall in brief</td>
</tr>
<tr>
<td>Low</td>
<td>10–30%</td>
<td>20%</td>
<td>1–5 weeks</td>
<td>£0.1m–£0.5m</td>
<td>Failure to meet specification clauses</td>
</tr>
<tr>
<td>Very low</td>
<td>&lt; 10%</td>
<td>5%</td>
<td>&lt; 1 weeks</td>
<td>&lt; £0.1m</td>
<td>Failure to meet specification clause</td>
</tr>
</tbody>
</table>
frequent reliance on the specialist skills of subcontractors;
- difficulty of measuring progress during the development of the design;
- enormous choice of materials of varying cost, colour, durability, maintainability, and aesthetic appeal;
- variety of working practices between disciplines and design practices;
- fragmentation of the industry;
- number of external agencies that have to be consulted or complied with;
- volume of standards and codes of practice to be consulted or complied with.

From this list it would appear that design is bombarded by risk from all directions making it difficult to grasp the primary sources of risk. Authors are clearly undecided on how to categorise the source of risk. While there might be similarities between the categories proposed, there is no common consensus. Flanagan and Norman [17] define the sources of risk as a risk hierarchy composed of four “layers”: the environment, the market or industry, the company and the project/individual. Wideman [11] has compiled a risk identification breakdown structure as a framework of the major sources of risk which is subdivided into five classifications of risk: external unpredictable, external predictable but uncertain, internal (non-technical), technical and legal. British Standard 6079 [18] considers that risks or adverse events generally fall into one of the following five categories: technological, political, managerial, sociological and financial. Raftery [19] considers that there are three separate areas of risk: risks internal to the project, risks external to the project, and the client/the project/project team and project documentation. Conroy and Soltan [20] refer to four categories of risk, namely human failings, organisational failings, design group failings and design process failings. Perry [21] describes sixteen sources of risk, five of which relate to construction and three to finance issues.

One possible way of understanding and structuring the risks facing a project is to combine the holistic approach of general systems theory with the discipline of a work breakdown structure as a framework [22]. General systems theory is a useful vehicle for the examination of the management of projects as its approach to the examination of complex processes enables the interrelationships of the parts and their influence on the total process to be better understood and improved. A project can be viewed as a “sub-system” of a client’s “system”, which in turn is a “sub-system” of the industry within which the client operates all enveloped in an environment known as the “external system”. These four elements can be adopted as the major components of a risk identification breakdown structure. Such a breakdown structure is included in Fig. 3.

Fig. 2. Four main components of the design process.
<table>
<thead>
<tr>
<th>Inception</th>
<th>Feasibility</th>
<th>Sketch Plan</th>
<th>Scheme Design</th>
<th>Production Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Team</strong></td>
<td>Agree consultant's form of appointment. Agree team composition</td>
<td>Assemble nucleus team. Establish roles and responsibilities for this stage</td>
<td>Assemble design team. Establish roles and responsibilities for this stage</td>
<td>Identify need for any specialist design support</td>
</tr>
<tr>
<td><strong>Targets</strong></td>
<td>Establish project objectives. Clarify initial statement of requirements. Discuss quality parameters.</td>
<td>Restate project objects and review attainability. Commence development of the brief and conduct studies</td>
<td>Establish user expectations. Develop brief and conduct studies</td>
<td>Agree quality standards</td>
</tr>
<tr>
<td><strong>Tactics (controls)</strong></td>
<td>Establish financial limit.</td>
<td>Prepare programme State cost range</td>
<td>Prepare outline cost plan. Update programme</td>
<td>Prepare final cost plan</td>
</tr>
<tr>
<td><strong>Tasks</strong></td>
<td>Make initial site visit. Obtain OS map</td>
<td>Site inspection. Examine accommodation requirements against site</td>
<td>Produce diagrammatic analysis and try out solutions</td>
<td>Prepare full scheme design</td>
</tr>
<tr>
<td></td>
<td>Assemble details of those to be consulted to develop the brief in subsequent phases</td>
<td>Assemble data for feasibility report</td>
<td>Prepare outline scheme indicating main spaces and uses</td>
<td>Prepare presentation drawings</td>
</tr>
<tr>
<td></td>
<td>Review planning status. Make enquiries with LA Prepare report, present and discuss</td>
<td>Make outline planning application as appropriate Prepare report including outcome of application, present and discuss</td>
<td>Discuss scheme with Local Authority Make planning application</td>
<td>Prepare report including outcome of application, present and discuss, Freeze design</td>
</tr>
<tr>
<td></td>
<td>Identify need for any specialist design support</td>
<td></td>
<td>Ensure design reflects planning conditions Complete Building Regulations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Assemble data for feasibility report</td>
<td>Prepare outline scheme indicating main spaces and uses</td>
<td></td>
<td>Prepare documentation in a format to suit selected procurement process</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prepare presentation drawings</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Fig. 3. Risk identification breakdown structure.
4.4.3. Step 4 process: comprehension of controllable and uncontrollable risks

Controllable (endogenous) risks are those risks over which, in part, a project manager has direct control, whereas uncontrollable (exogenous) risks (predominately emanating from the environment) are those which he cannot influence. However, it is normally possible to reduce the degree of exposure to such risks. A limited number of examples of these types of risks are included in Table 3.

4.4.4. Step 4 process: comprehension of cause, risk and outcome

When identifying risks it is important to ensure that the participants in the risk identification process remain focused on the distinction between risks and their potential effect or outcome. Perry [21] and the HM Treasury Procurement Guidance note No. 2 [23] refer to the importance of the distinction between risks and their effects without stating why it is important. In simple terms the distinction is important as it prevents the risk log becoming a confused mixture of risks and effects, making the response process particularly difficult, if not impossible. For instance, where a risk has been recorded as “programme overrun” it is difficult to think through a response without knowing what the risk nominee thought would trigger the delay. “Programme overrun” is the effect or outcome, not the risk itself. Each risk will have one or more causes and it is important that these are recorded alongside the risks within the risk register, as intimated in the RAMP approach [24], to facilitate the identification of responses. Included above are examples of causes, risks and their effects relating to cost, programme and business case. Each risk is given a unique identification number and each cause is given a reference which combines its own unique number together with the risk to which it is attached. Hence, C1/R1 represents Cause 1 pertaining to Risk 1 (see Table 4).

4.4.5. Step 4 process: comprehension of correlation

Correlation is a quantitative measurement of the strength of a relationship between two variables. Correlation may be negative or positive. Coefficients are used to describe correlation and range from −1 to +1. A value of 1 indicates a complete positive correlation between the two variables, a value of −1 indicates a negative correlation. A value of 0 indicates that there is no correlation between the variables, they are independent. The understanding of risk relationships and groupings is often aided by representing them in the form of precedence, influence diagrams or flow charts which can be appended to the risk log. With the aid of the allocation of unique numbers to causes and resultant risks, the log and illustration of the relationships, can be readily read together. Included in Fig. 4 is a graphical representation of the basic relationship pattern of five risks drawn from a hypothetical rail infrastructure project, together with their respective causes. The figure shows that a risk may have multiple causes and be correlated to other risks.

4.4.6. Step 4 process: comprehension of risks in series and parallel

The terminology of series and parallel is borrowed from the description of the different ways of arranging electrical circuits described within the science of physics. The term series refers to say bulbs connected in a row, one after another. Should one bulb fail, it will break the circuit. The term parallel refers to the parallel lines of a circuit. A parallel circuit allows separate lights to be switched on and off without affecting the others. This terminology is used to define the characteristics of risks which are decided not only by their own features, but also by other risks occurring on the same project. Commonly risks mutually affect, magnify or diminish each other. This kind of mutual influence among risks on a project is defined as the risk relationship [25]. Comprehension of and a study of the relationship between the risks on a project are fundamental to implementing PRM. The two main classifications of risk relationships are dependent risks in series and independent risks in parallel. Risks occurring in series, describes the situation where one risk event generates another risk event in a continuous sequential action. In other words, risk event B is dependent on the occurrence of risk A. If risk A occurs, then risk B occurs directly as a result of A. If risk A does not occur, then risk B definitely does not occur (see Table 5). Risks occurring in parallel, describes the situation where several risk events occur at the same time. Where three risk events have been identified, which will occur at the same time and have an impact on the same programme activity; then it is the risk which will have the largest negative effect, that is considered in any probabilistic analysis (see Fig. 5). For example, where the risks of changes in legislation, late Client changes to brief and design rework to realign design to cost plan have been identified against a programme activity called “production information” and the risk of design rework to realign design to cost plan is

<table>
<thead>
<tr>
<th>Table 3: Controllable and uncontrollable risks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controllable</strong></td>
</tr>
<tr>
<td>Late planning submission</td>
</tr>
<tr>
<td>Lack of change control procedure</td>
</tr>
<tr>
<td>Lack of design co-ordination</td>
</tr>
<tr>
<td>Late commissioning of sub-contractors drawings</td>
</tr>
<tr>
<td>Late completion of drawings</td>
</tr>
<tr>
<td>Production information errors</td>
</tr>
</tbody>
</table>

Note: The table lists examples of controllable and uncontrollable risks.
assessed as having the highest probability and impact, then it is this dominant risk which is incorporated into any assessment of the risks in combination. If one or both of the other risks materialised at the same time, their impact would be absorbed within the programme prolongation caused by the risk — design rework to realign design to cost plan. If one of the other risks materialised on its own, from the assessment, its impact on the programme would not be greater than the impact identified for design rework to realign design to cost plan. In this example the dominant risk is represented by a triangular distribution.

4.4.7. Step 4 process: modelling risks in series

When collecting data during the identification and assessment stages, it is important to uncover and record
the relationships between the risks for evaluation of the risks in combination at some later date. Risk dependency, where the occurrence of risk B is entirely dependent on the occurrence of risk A (as discussed above), can be represented by “IF” equations within risk models which are Microsoft Excel based, as illustrated in Table 5.

4.4.8. Step 4 process: modelling risks where they occur in series and parallel together

In the section above, the occurrence of risks in series and parallel were described (i.e. risks occurring in *series*, describes the situation where one risk event generates another risk event in a continuous sequential action and risks occurring in *parallel*, describes the situation where several risk events occur at the same time). On live projects it is common for risks to be identified as potentially arising in a combination of these patterns. In the example included in Fig. 6, one risk may be followed by one of three risks. This situation can be represented in risk models that are Microsoft Excel based, by a combination of “IF” functions and “MAX” functions illustrated in Table 6. The MAX function selects the largest value from the list of cell references it is instructed to examine.

### Fig. 5. Risks in parallel.

<table>
<thead>
<tr>
<th>Design</th>
<th>Construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity A</td>
<td>Production information</td>
</tr>
<tr>
<td></td>
<td>uncertainty</td>
</tr>
<tr>
<td>Activity B</td>
<td>Tender action</td>
</tr>
<tr>
<td>Risk</td>
<td></td>
</tr>
<tr>
<td>Risk</td>
<td></td>
</tr>
<tr>
<td>Risk</td>
<td></td>
</tr>
<tr>
<td>min</td>
<td>most lik.</td>
</tr>
<tr>
<td>risk represented by triangular distribution</td>
<td></td>
</tr>
</tbody>
</table>

### Fig. 6. Risks in series and parallel.

### 4.4.9. Step 4 process: determining multiple permutations using probability theory

Probability theory can be applied to determining the likelihood of different combinations of events (in series) using “tree diagrams” also known as decision trees. In the example included in Fig. 7, dependent risks are examined arising from the risk of changes in legislation. As you progressively move through the tree (working from left to right) the risks become less likely and hence the probabilities are multiplied together. It can be seen, for instance, that the likelihood of having to make alterations to the “structural engineering” is only 3.6% arising from a 20% chance of having to make “fabric alterations” and a 90% chance of having to make “changes to the juxtaposition of spaces”.

### 4.4.10. Step 4 process: comprehension of identification techniques

There are several techniques available for risk identification. (These techniques may also be described as methods or procedures.) The two techniques most commonly used are structured one-to-one interviews and brainstorming. The Nominal Group and Delphi techniques are less frequently employed. All of these techniques may be implemented with the aid of support “tools”. These may include check/prompt lists, influence diagrams, system dynamic models (see Chapman [26]), repertory grids and activity schedules. Each of these techniques and support tools is described in outline below. A fuller appraisal of the different techniques is provided in Chapman [27].

- **Semi-structured one-to-one interview technique:** This technique is an interactive dialogue aid for eliciting risks directly from the interviewee. Expert knowledge, however, is not easily captured and requires an effective method for drawing it out. The process is time-consuming and due to commercial pressures normally present during risk analysis assignments, the risk study must be carefully managed to optimise the time invested in each stage. There are a series of problems that are commonly encountered which must be addressed if the interview process is to be productive. Similar problems have been described by those constructing expert systems and refer to the specialist being misunderstood, the specialist’s explanations wandering, interruptions, false information being given, biased questions asked by the interviewer and inaccurate representation of the information gained. These issues must be addressed during the risk analysis and management process.

- **Brainstorming technique:** The brainstorming process, borrowed from business management and not specifically created for risk management, involves redefining the problem, generating ideas, finding
possible solutions, developing selected feasible solutions and conducting evaluation. Originated by Osborn [28] in the early 1950s, brainstorming was proposed as a problem solving method which would produce a much larger quantity of ideas in less time than existing group problem solving techniques. In the third revised edition of his text entitled “Applied Imagination”, originally issued in 1953, Osborn argues the effectiveness of brainstorming is derived from two essential components. These are succinctly described by Johnson [23] as (1) group thinking is more productive than individual thinking and (2) the avoidance of criticism improves the production of ideas. Osborn states that based on experience the optimum size of a brainstorming group is twelve and that the ideal panel should consist of a leader, an associate leader, about five regular or “core” members and about five guests. It has been found that a panel should be composed of people of the same rank or standing as the more senior panel members tend to indirectly discourage “free-wheeling”.

- The NGT technique: The Nominal Group Technique (NGT) was developed by Delbecq et al. [29] in 1968. It was derived from social-psychological studies of decision conferences, management-science studies of aggregating group judgements and social work studies. Delbecq et al. [30] describe the operation of the NGT method as commencing with the group members (between seven and ten) without discussion, writing ideas related to the problem down on a pad of paper. After five to ten minutes each individual in turn briefly presents one of the ideas. These are recorded on a flip chart in full view of the group members. Round-robin listing continues until all members indicate that they have no more ideas. Discussion does not take place until all the ideas are recorded. Then each one is discussed. Finally each individual writes down their evaluation of the most serious
risks, by rank ordering or rating. Then these are mathematically aggregated to yield a group decision.

- The Delphi technique: Delphi is perhaps the best-known method of using group judgements in forecasting. It was developed at the RAND Corporation by Dalkey, Helmer and others primarily for technological forecasting, but has seen a wide variety of applications. The Delphi Technique is a method for the systematic collection and collation of judgements from isolated anonymous respondents on a particular topic, through a set of carefully designed sequential questionnaires interspersed with summarised information and feedback of opinions, derived from earlier responses. The basic principles of the multistage method are the elimination of direct social contact providing unattributed contributions, the provision of feedback and the opportunity for the revision of opinions. The participants are asked individually, usually by mailed questionnaires but more recently by interactive computer contact, for their estimates of the variables in question. These are then collated and summarised in such a way as to conceal the origin of individual estimates. The results are then circulated and the participants are asked if they wish to revise their earlier forecasts. These rounds can continue until the estimates stabilise, though in practice the procedure rarely goes beyond a second round.

4.5. Step 5: encoding

The aim of this step is to draw from the interviewees or workshop attendees the assessment of the impact and probability for each of the risks identified, using the measures agreed during the Presentation Step. This information is captured in a risk register or risk log. Depending on the stage of the project, different assessment criteria may be appropriate. At the commencement of a project the focus will be on identifying any “show-stoppers”. Later in the development the assessment may centre around evaluating feasibility options.

4.6. Step 6: verification

The aim is to gain a consensus among the design team members/interviewees to establish if there is general agreement as to the risks identified and the measures assigned to them. In addition, it is aimed at cross checking for consistency between measures assigned to risks by individuals. Verification can be conducted using three different techniques identified by Spetzler and Stael von Holstein [31], cross checking for consistency between values, verification using different elicitation techniques and verification by using the final result. Cross checking for consistency is a simple method for verification where the analyst asks the core team member if he feels that the results are consistent across one stage of the elicitation process; for instance if two different risks have approximately the same probabilities of occurrence, the analyst will ask the expert if he feels this reflects his view of the risks. Having obtained the results the analyst asks the design team members whether they give a fair view of the consequences — that is, do they compare with their own ideas about consequences. This is quite easily done and if discrepancies do occur then they can be traced back to the base data. Verification using the final results can be conducted by providing risk maps for each design stage which have been completed to show the top ten risks identified for each stage. Each map will illustrate the assessment made for each risk in terms of likelihood of occurrence and impact. The design team members are requested to compare the maps to see if the degree of exposure described actually reflects their thinking. The least and most exposed stages are examined to see if there is common acceptance of the assessment.

5. Summary

The steps of the overall process were described as: knowledge acquisition, selection of the core design team, presentation of the process, identification, encoding and verification. From the examination of how these steps are implemented, it can be seen how the effectiveness of the overall process may be influenced and better understood. The observations are a reflection of the rudiments of the process and might be described as obvious to the seasoned practitioner, however they are fundamental if benefits are to be drawn from the process. From the knowledge acquisition step it may be concluded that the contribution of the facilitator is enhanced if he/she has a detailed understanding of the project prior to the commencement of the identification process. The effectiveness of the identification process will be directly correlated to how broad and comprehensive the examination of the threats to a project are. The breadth of examination will be dependant on whether all of the core design team members (and where appropriate the second tier design team members) were present during brainstorming. The participants must be properly briefed during the presentation step. For the measures of impact to be meaningful they must spring from the project objectives, the significance of accomplishing them (or not) and how they have been prioritised. Identification of design management risks requires an understanding of the characteristics of the process and how its main components must be maintained in balance. All design processes, whether they be within the IT or construction industries, have common problems that must be understood and addressed. Identification requires an understanding
of the sources of risk and General Systems Theory is put forward as a way of structuring those sources. In addition, it is proposed that risks have distinctive characteristics and that their interrelationship can be described in terms of whether they are in series or parallel. To conduct the assessment process, encoding is implemented whereby the impact and probability measures are used to “size” the risks to describe their potential influence on the project should they materialise. Finally, verification is used to obtain consensus across the process participants as to the risks, their likelihood of occurrence and impact should they arise.

References

[26] Chapman, R. J., Unpublished PhD thesis "An investigation of the risk of changes to key project personnel during the design stage", University of Reading, Department of Construction Management and Engineering, April (1998).