Chapter 5
Qualitative Methods and Soft Systems Methodology

This chapter illustrates the role of qualitative methods in risk management. Often the first stage in any assessment has to be a qualitative approach because there is insufficient information available to proceed with any quantitative methods. The value of a risk log is reviewed. Finally, the soft system methodology (SSM) is examined in detail and the way that it structures the investigation of the commercial situation.

5.1 Qualitative risk assessment

The first stage in any risk management process is also the first stage in the qualitative assessment of risk. It is frequently the most useful part of the risk management process and it lays the foundation for all the subsequent stages in that process, including the quantitative analyses that are frequently required to define budgets and timescales. Elsewhere in this book techniques are described which can be used to model the soft issues which influence projects, but the basic techniques for understanding risks and their potential influence are those of identification, assessment, ranking, sorting, classifying, allocating ownership and judging the probability and impact of potential risks. This is qualitative risk assessment. Frequently, no further analysis needs to be done. It is more likely that further analysis is firmly rooted in the qualitative process. Applying weighting factors to the qualitative assessment provides a quasi-quantitative form of analysis. Whatever the eventual outcome, the basis is the identification of potential risks. This process has been outlined in Chapter 4.

5.2 Review of project programmes and budgets

It is important that a project's programmes and budgets are realistic if it is to meet its objectives in terms of its quality and performance whilst remaining within its predetermined timescale and budget. Unless the budget and programme are achievable, it is unlikely that risk analysis will predict the out-turn cost and duration. This depends upon several factors including:

- the experience of the project management organisation;
- the amount of relevant data from closely similar projects which can form the basis of performance specifications, estimates and programmes;
- the extent of innovation; and
- the size and complexity of the project.

Budgets should be based on a realistic programme for the work taking into account resource provision, productivity, time-related costs and risks. Appropriate estimating techniques should be used for the type of project and the project stage at which the estimate is produced.

For example, broad-brush estimates prepared for the purposes of comparison between options during the appraisal stage of projects may be prepared using simple unit rate estimating methods or parametric methods (where suitable data exists). Estimates prepared to give definitive budgets for the selected option should be prepared using the operational technique taking into consideration the programme, resources and materials requirements of the project. Current costing can be applied to ensure that the estimate does not rely on updating of historical data.

The operational technique has the added advantage of facilitating greater understanding of the particular risks and uncertainties in the project and how they may impact on the project.

In the case of the budget, the review should ascertain:

- its adequacy for the scope of the works to be executed;
- any contingencies, allowances, provisional sums, etc. contained within it;
- the reason(s) for their inclusion;
- their adequacy; and
- the adequacy of elements related to overheads, supervision, consultants fees, licences etc. (if any) and any other realistic cost which may be identified.

The outline programme should be checked to ensure that:

- all the key activities have been identified;
- the durations are realistic; and
- the logic links and any other constraints are correct.

Such constraints may include, for example, the links to, or dependencies on:

- other projects;
- approvals for safety cases;
- approvals by statutory authorities (planning permission, etc.);
- approval of programmes on method statements; and
- approval of subcontracts and materials.

If the programme is in network form, the critical path(s), free and total float must be identified. All assumptions underlying the budget programme must be identified and logged.

Within each project, the following interfaces must be identified to ensure that they are included in the programme and managed effectively:

- between design groups;
- between design groups and specialists;
- between design and procurement;
- between design and construction;
- between procurement and construction; and
- with other projects.

Management will be facilitated by ensuring that each such interface is logged as a risk so that the following data are recorded and the following actions are undertaken:

- define data each party requires from others;
- define when they are required;
- agree assumptions if data is not available on time;
- log the assumptions;
- revise assumptions until final data is available;
- specify physical factors:
  - spatial positions;
  - loadings;
  - capacity, etc.;
- monitor progress; and
- achieve agreed dates.

Experience shows that frequently the project programme is in insufficient detail to identify all the areas of uncertainty, all constraints and all the interfaces. Hence, one of the key activities in the risk management process is to ensure that the programme is sufficiently detailed to fully understand all the activities that are required to execute the project.

5.3 The risk log

The results of the interviews and reviews of the programme and budget should form the basis for a risk log or risk register that will list all the identified risks. It will also contain assessments of their potential impact on the budget, programme and quality/performance aspects of the project.

To aid manipulation the risk log can be entered into a database system to facilitate recording, storing and sorting under various headings. These may include inter-alia:

- project phase;
- the owner (holder) of the risk;
- location;
- other use-defined categories, for example, cross references to the project programme and budget.

A database facilitates ranking of risks according to qualitative assessment (high, medium and low). It also permits quantitative estimates in terms of percent probability and cost impact (allowing quasi-quantitative analyses and ranking). Some database applications will allow quantitative analyses using Monte-Carlo simulation.

The output may be shown in the risk map (or matrix) format, also known as the probability/impact grid (PIG) to ease understanding of the results. In the case of quasi-quantitative analyses, cumulative frequency curves and histograms can be produced.

The risk log will also contain the information on actions to avoid, mitigate or transfer risks, the secondary risks arising and possible fallback plans. The risk log will be capable of being updated and will provide an audit trail. It is possible to use the risk log as a management tool to prompt risk owners to take action. Status reports can also be generated. An example of another risk log is shown in Table 5.1. It may be the case that for regular review by senior management, the full risk log or register is too detailed and cumbersome to be used as a management tool.

Given that senior management will be interested in the most significant risks, but are unlikely to be interested in details of modelling data, or the audit trail, it is possible to use an extract of the risk log that omits the detail but focuses instead on the action plans, the progress being made against them and their success in avoiding or mitigating risks. This should be reviewed regularly as part of regular management meetings. The team should be continually aware of any new risks, or those that are increasing in likelihood or severity.

Table 5.1 Main categories of risk.

- The project's constitution and organisational structure including the number of parties and the contractual, or other, relationships between them.
- The project management team including experience and availability of key personnel (in-house, consultants and contractors).
- Management authority and approvals required for work to proceed.
- Site-specific safety procedures: permits required, etc.
- Ground conditions, including special factors such as the extent of contaminated ground.
- Requirements of diversions, for example, to services.
- Risks arising from the contract/procurement strategy, including residual risks if the subcontractor does not perform.
- Risks arising from interfaces.
- Uncertainties and assumptions in the project scope/design.
- Temporary works for construction/dismantling.
- Potential for cost growth due to:
  - design development;
  - increased extent of identified risks such as contamination;
  - delays to approvals, permits, etc.;
  - delays due to contractor default;
  - unforeseen circumstances.
- Familiarity of potential contractors with the specific type of work and location.
- Extent of competition between potential contractors and suppliers.
- Delivery periods of materials and equipment.
- Extent, if any, of novel work.
- Constraints on the project programme, due to resource/staff shortages, possibly due to competing projects.
- Preventative measures to protect staff, labour and the surrounding areas.
- Special measures required for the handling and disposal of waste, spoil or contaminated material.

The reality of projects is that they do not follow a trend of steadily decreasing risk. Risks fluctuate in importance, and the reporting should reflect the changes.

Risks should be linked to the project's programme to understand the timeframe in which they can occur and the lead time to initiate preventative action. Whenever possible and cost effective to do so, risks should be avoided. In reality that must be mitigated as the project progresses. Many of these will be ongoing, that is to say they may span over several activities so that they cannot be closed for a considerable time.

5.4 Using a risk log to formulate risk management strategy

Following from the creation of a comprehensive risk log, an overview of the total likely risk exposure of the project can be formulated, based on the sensitivity of the budget and programme to identified risks and their potential impact in terms of budget overrun, delay and impact on the project's performance objectives.

The aim is to determine the most cost-effective strategy of risk avoidance, mitigation and/or transfer. The factors to be considered are:

- the potential impact(s) of each risk;
- the possibility of avoiding the risk through management action, provided that any secondary risks are not too great (secondary risks are those that arise as a consequence of taking the mitigating action);
- the possibility of taking actions to mitigate the risk, for example, by carrying out more thorough ground surveys to provide better information to the project team, its contractors and consultants. In this case, the risk to the probable cost of the ground works must be more than the cost of the survey otherwise the additional cost of the survey is not worthwhile;
- risks may be passed (i.e. transferred) to other parties, for example, a consultant, supplier, contractor or insurance.

In the case of risk transfer, two tests must be applied:

(1) Cost-effectiveness. It is usual for a premium to be charged by the party accepting the transferred risk. The issue is whether or not the premium to be paid is significantly less than the probable cost of accepting the risk in the first place. There is, however, a second consideration.
(2) The ability of the transferee to manage and accept liability for the risk should it occur. This is particularly important when significant risks to which the project is sensitive are passed to others, for example, contractors or suppliers. It may be that the risk premium charged by the contractor or supplier for accepting the risk is inadequate to

cover the cost of remedial action and the contractor or supplier is unwilling, therefore to carry it out. If this is the case, the project may suffer an adverse impact greater than the cost of retaining the risk would have been in the first place, bearing in mind that the premium paid to the transferee might be irrecoverable. (This is the residual risk of the contract procurement strategy.)

In other cases, the contractor/supplier may claim that the risk was excluded from his contractual responsibilities or was unforeseeable. When such claims are successful, the employer will effectively pay twice for the transfer of the risk:

- once through the premium charged by the contractor/supplier; and
- once through the successful claim.

It is particularly important therefore that the employer gives very careful consideration to risk transfer through contracts, the risk premium which contractors and suppliers are likely to charge and the types of contract available to achieve the optimum risk minimisation strategy. It must be borne in mind that in competitive bidding, contractors may not be able to fully price the risks that they are expected to carry. If the risk occurs, there is in fact no funding for its consequences or mitigation.

Whatever type of contract is chosen, it is essential that specialist contractors and suppliers who are best able to manage specific risks are used. The following factors must be considered:

- the extent of overlap of design, procurement and construction, if any, to achieve the desired completion date;
- transfer of risk and the premium(s) to be paid;
- transfer of control;
- transfer of responsibility; and
- the number of interfaces between contractors/suppliers which must be managed.

It must be noted that theoretical advantages may be difficult to achieve (e.g. price certainty through fixed price contracts where risk is high or the scope is not well defined).

The objective of any procurement strategy is to achieve the best VFM at the least risk. Fundamental to this is the understanding of realistic cost levels for tenders so that unrealistically low bids are not accepted.

In so far as risk assessment by the employer is concerned, a detailed understanding of the risks to be carried by contractors and suppliers, or to be shared with them, will enable:

- tender documents to be drafted to ensure that appropriate information is elicited from bidders;
- tender assessments to include a full appreciation of the risk being carried, how they will be managed by the bidders and what the implications are for the employer.

This is achieved by:

- ensuring that risks are identified and clearly specified in the tender documents;
- that the allocation of risks and responsibilities in the contract documents is clearly defined;
- the risk log can be used as a checklist during the tender assessment.

As noted above, even when risks have been passed to a contractor or supplier, there is the residual risk that they will not manage or will succeed in passing it back totally or in part through claims. Contingent sums should be allowed in budgets for these residual risks.

5.5 Qualitative methods

Commercial environments, particularly those where the management of risk is of prime importance, are frequently unstructured and only partly understood by those involved. Conflicting views are frequently held. The need to provide these environments with a structure should always be recognised at an early stage. Two principal means of achieving this structuring are available. First, the problem could be modelled using a prescriptive decision making tool. Second, a methodology that structured the investigation could be utilised that would permit the use of appropriate analytical tools. Thus, the choice is between a well-structured quantitative method and a project specific qualitative methodology.

Most of the qualitative techniques treat problems in environments where a single answer is assumed to exist, and the selection of an appropriate means to achieve an end that is defined at the start and thereafter taken as given. This approach is perfectly acceptable in the analysis of fixed facilities where the issues are purely technical. However, where human actions play a major role, or where uncertainty exists, these methods are inappropriate. There are arguments against the use of formal systematic models in favour of those methodologies that allow for solution of problems that cannot be fully structured in advance. The former of these approaches creates artificially scientific environments in which the problem is depoliticised, people are treated as passive objects and uncertainty is ignored. The assumptions made are often based on abstract objectives from which concrete actions are proposed for implementation.

Qualitative methodologies concern themselves with how management decisions are actually made, rather than the traditional operational research approach of obtaining the *right* answer. Methodologies that can screen out unfeasible alternatives, study the entire range of solutions, and explore the effect of likely constraints, will develop contrasting possibilities as to what is required. Placing decisions in the context of alternative future environments permits the opening up of discussions about threats and opportunities. Simplicity and clarity are sought, and uncertainty treated as a fact of life. People are treated as active subjects. Outside influences such as technical, commercial and political considerations are identified and considered in direct relation to internal issues. Appropriate strategies are developed to deal with complex interactions within the project. The methodologies utilise a *bottom-up* approach and facilitate participation by those directly involved in the problem. They are non-optimising, and accept that there will be future uncertainties and options should be kept open wherever possible.

A number of methodologies to tackle complex problems have been developed over the past two decades. These include the analysis of inter-connected decision areas (AIDA), conflict analysis, robustness analysis, strategic options development and analysis (SODA), the strategic choice method and the soft systems methodology (SSM). The purpose of these methodologies is to structure inquiry into situations that are characterised by uncertainty, conflicting objectives and significant human involvement.

These methodologies fall into two broad classifications. First, are those that concentrate on the efficiency of the solutions proposed (the first three methodologies listed above falling into this group). Second, are those that concentrate on the effectiveness of the solutions (as represented by the last three methodologies listed above). While these methodologies concentrate on one of the two criteria, they do appreciate the other criteria, rather than excluding it as most multiobjective methods do. Of these, SSM concerns itself with systematically desirable and culturally feasible changes, rather than simply making better decisions. For these reasons, SSM was chosen as the methodology to employ in the investigation of a water company's activities as described in the following section.

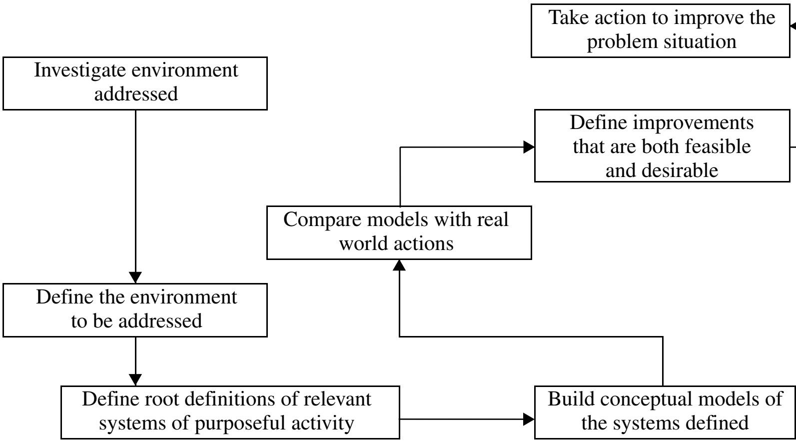

Figure 5.1 The learning cycle of SSM.

5.6 Soft systems methodology

SSM was developed by Peter Checkland at Lancaster University in the late 1970s and early 1980s. Its purpose was to overcome the inability of traditional decision theory and to adequately solve not all but the most structured problems. The importance of these structured problems is usually far less than those involving uncertainty and social considerations. A particular strength of the technique is that it can begin with a simple desire to *make things better*. No definition further than this is required.

SSM is typically employed in a cycle of seven stages, as indicated in Figure 5.1. The first two stages involve finding out about the situation considered problematic. The first two stages investigate the environment and culture in which the problem exists, the specific problems considered, the reasons why the situation is considered problematic and the improvements that are sought in the third stage of SSM. A view of the problem is selected that provides an insight into how improvements can be achieved. This is undertaken through the use of root definitions and neutral definitions of the activities or task to be undertaken that provide insight into the problem.

The fourth stage involves the building of conceptual models that are logical expansions of the root definitions generated in the previous stage. The models developed are those of systems that can adapt and survive to changes through their processes of communication and control. The fifth stage of SSM requires the comparison of the models developed with reality. This provides a means of instigating debate into how benefits in the systems can be attained. This process directs attention on the assumptions made, highlights alternatives and provides an opportunity for re-thinking many aspects of real-world activity.

The purpose of the sixth stage of SSM is to define changes that will bring about mediation benefits. Such changes have to meet the criteria of systemic desirability and cultural feasibility. Systemic desirability will include such factors as creating mechanisms to determine effectiveness and ensuring that logical dependencies are reflected in real-world sequential actions. Cultural feasibility will provide allowance for the illogic of human actions and the political environment in which decisions are taken.

The final stage of SSM is taking action and implementing the changes proposed. Undertaking the proposed changes alters the perceptions of the initial problem. If required, further cycles of SSM can be employed to seek additional improvements. This process would have been made considerably more straightforward through the structuring of the problem undertaken in the first application of SSM.

The use of the CATWOE mnemonic is a means of increasing the understanding of the problems considered and the ease with which conceptual models can be developed. The CATWOE mnemonic represents the *C*ustomers, *A*ctors, *T*ransformation process, *W*eltansschauung (world view), *O*wners and *E*nvironmental constraints on the problem.

The core of CATWOE is the linkage of transformation processes and the world view that makes them meaningful. Any activity will always have a number of transformations by which it can be expressed, dependent upon the perception of its purpose. The other elements in CATWOE add the ideas that purposeful activity must be undertaken, that it could be stopped, that there will be victims and beneficiaries and that this system will take some environmental constraints as given.

SSM employs a number of assumptions. These include that SSM is a process for management, and is a means of achieving purposeful action to obtain a change in an existing situation. In any given situation there will be conflicting issues and remains from the parties involved in that situation. SSM makes use of systems ideas and treats situations holistically.

Systems are considered to be composed of natural activity systems that can be linked together in a logical structure. As a number of possible descriptions for a given situation will always exist, it is imported to be explicit about the view taken of the problem to be studied, the *Weltanschauung*. The next assumption made is that SSM learns by comparing models of purposeful action with perceptions of the real world. This provides a feedback mechanism to determine the efficacy, efficiency and effectiveness of the proposed actions. The final assumption made is that the process must be participative so that all those parties involved make an input, even if they are not aware of the methodology or models employed.

To date, SSM has been used in a wide variety of public and private organisations. The applications include performance evaluations, educational studies and the appraisal of various commercial situations.

5.7 Case study: SSM in the use of the placement of construction projects

Having provided an overview of SSM, an account of the hypothetical commercial situation considered, the procurement of an ongoing series of projects by a UK utility is now presented to provide a summary of the last two stages of SSM. There are a number of ways in which UK utilities can procure construction projects, and several organisational structures that can potentially be employed. These include retaining all design and management in-house, employing consultants for these roles, and design and build contracts. The hypothetical utility considered, procured between five and ten of the specialised projects considered annually, and employed the first of these options, the method considered in this case study. The investigation of the problem, the first stage of SSM, was undertaken investigating the structure, processes and climate of the organisation.

Projects considered were procured in support of one of the utility's core business activities, the majority of projects originated from one of the utility's core business areas or from the company's planning arm. An established database of completed projects existed. This database contained all the tenders received over the past three years and records of expenditure during the construction of the projects, including variations, risk events, post-contract reviews and audits.

A list of pre-qualified specialist contractors was invited to tender for projects. Cost based target contracts are employed. The contingencies employed were tailored to the individual project rather than applied uniformly to all projects, and took account of the ability of the contractor employed. The final process undertaken by the utility was the aggressive marketing of their expertise in this field.

The utility was committed to promotion of specialist construction techniques as a means of reducing the cost of construction. This commitment was expressed through publicising successes, educating internal and external clients and maintaining as high a profile of the utility as possible.

Close relationships existed between the utilities and the contractors employed. The procurement mechanisms employed, particularly the use of cost based contracts, allowed the company to make significant inputs to the construction management of the projects without incurring cost penalties.

Competition is considered to exist within the utilities to procure the projects. The use of cost based contracts can erode the competitiveness of the tenders received from contractors. Thus, whilst the construction division procured projects from a logical and historical perspective, other business areas occasionally retained projects if they thought that they could obtain significantly lower tenders, and hence total project costs. In many cases, however, the tenders obtained by other business areas bore little relation to the final costs.

The third stage of SSM involves identifying those areas considered problematical. The list of problems below is probably not exhaustive.

Technical and environmental

(1) Uncertain ability of construction technique to adequately deal with anticipated and unforeseen ground conditions.
(2) Difficulties in transporting soil away from construction sites.
(3) Problems in detecting existing services.
(4) Difficulties in achieving economic means of disposing of slurry in an environmentally acceptable manner.
(5) Interfacing with existing utilities and obtaining possessions.

Commercial and operational

(6) Inability of the construction technique to compete on cost terms with traditional forms of construction in the majority of cases.
(7) High cost of purchasing and maintaining specialist plant.
(8) Inability of client organisations to guarantee long-term workload of projects.
(9) Contractors attempting to buy work in order to obtain future work from the client.
(10) Inability of clients to motivate contractors in the long term in accordance with their short-term aims.
(11) Continued scepticism of the construction techniques by large sectors of UK industry.
(12) Inability of clients to motivate contractors to perform in accordance with their short-term aims the minimisation of costs.
(13) Uncertainty over means of paying contractors to minimise construction costs.
(14) Uncertainty over the effectiveness of incentive mechanisms, either positive or negative.

(15) Perceived high risk-nature of construction technique.
(16) Even minor risks cause major cost and time overruns.
(17) Difficulty in knowing cause and hence allocation, of construction risks.
(18) Adversarial relationships created when traditional conditions of contract were employed through their inability to allocate risk equitably.
(19) Risk averse behaviour of contractors through their perceived use of excessive contingencies.
(20) Inability to differentiate contractors based on their ability to manage construction risks.
(21) Difficulty in predicting the productivity of specialist plant.
(22) Inability to differentiate contractors based on the efficiency with which they operate their plant.

Of the problems identified, the most fundamental was the inability of the construction technique to compete on cost terms with traditional construction techniques. Where clients are unable to provide a guarantee of long-term workloads of projects, contractors face uncertainty over the number of projects over which they could write off the cost of plant. If the technique is not adopted as the construction technique for a given project, none of the other problems can occur.

The next most important problems considered are the inability of clients to differentiate between contractors based on their ability and their inability to motivate contractors in accordance with their long- and short-term aims.

The abilities of contractors varied significantly in terms of their ability to manage construction risk. Where the differences between competing tenders were lower than single figure percentages, it is difficult for the company to justify the employment of more expensive contractors. These differences in contractors' abilities are influenced by a number of factors, including their size, the duration they have been in existence and the financial requirements of their stakeholders. The financial and operational problems identified above are either indirectly or directly related to the procurement process.

Root definitions

The next stage of SSM is the formulation of root definitions. This requires the naming of systems considered relevant to exploring the problems identified in the exploratory phase of SSM. The following root definition and CATWOE mnemonic were produced; root definitions give neutral definitions of the activities or tasks to be undertaken. For the purposes of the following root definitions, a root definition and CATWOE mnemonic of the activities based on the finding-out phases of SSM, are presented below.

Root definition:	An internal organisation, seeking to employ improved systems to procure special projects for internal and external clients to increase the cost competitiveness of the technique compared with traditional construction methods.
C (Customers):	Utilities, external clients, contractors.
A (Actors):	Utility.
T (Transformation processes):	Construction needs of clients met through increased procurement of specialist construction projects through the greater cost competitiveness.
W (World view):	The increased cost competitiveness of the special construction techniques that can achieve significant financial and non-financial benefits.
O (Owners):	Utility.
E (Environmental constraints):	Water companies capital programme, UK construction market.

The CATWOE mnemonic indicates that the transformation sought is one in which the cost competitiveness of the specialist construction techniques is increased. This increased competitiveness is achieved through the use of procurement mechanisms tailored to the requirements of the projects. A fundamental assumption is that the procurement of the projects is based on an ongoing workload of projects work rather than on an individual basis.

Figure 5.1 indicates the schematic structure of the procurement activity system. This system contains the elements through which microtunnelling projects are currently procured. The system appreciates the direct construction and promotional roles and activities of the utility.

In order to propose systems through which improvements could be obtained, the problems were structured according to the general areas that they address. For this reason, problem numbers 7–11 were considered to be procurement problems occurring at the strategic level. The remainder of the problems were considered at the tactical level in that they are applicable to individual projects.

Problems 12–14 considered the abilities of the payment mechanism employed to reimburse contractors. Problems 15–20 considered the management and allocation of construction risks, and problems 21 and 22 concerned the contractor's operation of their plant. Four activity systems were proposed which address these classifications of problems. The root definitions and associated CATWOE mnemonics of these systems are presented below.

Root definition 1: procurement of microtunnelling projects

Root definition:	A system, appreciative of the construction environment, to procure projects accordance with the client's long-term aims.
C:	Utility, contractors.
A:	Utility contractors.
T:	Projects procured. The procurement of projects improved.
W:	The use of procurement systems tailored to the requirements of the project and the contracting parties will improve the effectiveness and efficiency of the procurement process.
O:	Utility.
E:	Legislation, UK economy, utility capital programme.

Root definition 2: payment of contractors

Root definition:	A system to pay and motivate contractors to perform in the short term in accordance with the client's aims.
C:	Utility, contractor.
A:	Resident engineer, site agent utility client contractor, construction staff.
T:	Contractors paid. Contractors paid and motivated to perform in direct accordance with the client's long-term aims.

W:	The use of financial motivators can have a major effect on construction performance.
O:	Utility.
E:	Local construction markets.

Root definition 3: management of construction risk

Root definition:	A system in which construction risks are allocated between the client and the contractor to minimise the construction cost of an ongoing workload of projects.
C:	Contractors, utility.
A:	Utility.
T:	Workload of projects constructed. Projects constructed at lower cost.
W:	The effective management of construction risks can have a major effect on construction cost.
O:	Utility.
E:	Current/local construction market climate, client's capital programme.

Root definition 4: operation of construction plant

Root definition:	A system to ensure contractors' effective operation of plant and provide a mechanism for differentiating between contractors on the basis of their technical ability.
C:	Contractors, utility.
A:	Contractors.
T:	Contractor's operation of their plant. Contractor's operation of their plant monitored and improved.
W:	The ability of the contractor to operate their plant efficiently can have a major effect on the productivity achieved.
O:	Utility.
E:	Individual project conditions.

The first root definition, concerning procurement at the strategic level, seeks to overcome the problems associated with the use of specialised construction techniques at the organisational, rather than at the construction level. Thus, this root definition considers long-term relationships and contractual arrangements between the contracting parties at the organisational level. The second root definition, describing a system to reimburse contractors, assumes that the payment mechanism employed can motivate contractors to achieve the client's aims.

The third root definition, describing a system to manage construction risks, takes the world view that the effective allocation of construction risks can have a significant effect upon construction costs. The system seeks to allocate construction risks so as to reduce the cost of constructing an ongoing workload of projects. The contractors' operation of their plant is the system described by the fourth root definition.

The management of construction risks exists at the lowest level of the procurement process of the activity systems considered, and is the system addressed further here. If the improvements sought in the procurement of projects are to be effectively utilised, they must have a consistent and coherent hierarchy. If this were not the case, elements of the procurement process could impose conflicting demands and aims on the contracting parties. This is consistent with the *bottom-up* approach employed by SSM.

Figure 5.2 provides a view of the first risk management system component. The left hand branch of this component appreciates the effects of risk on the construction projects (box a), and the construction environment in which the projects are procured (box b). The term construction environment is used to represent the commercial and organisational climate in which contractors are employed to construct the projects. The linking of these elements provides an understanding of the specific effects of risk on the construction of an ongoing workload of projects.

The left hand branch of this component introduces the analytical aspects of risk management. Box c first identifies the locations of primary risk data. Construction risks are categorised according to their source, and their durations incorporated into a database of risk events. The risk analysis alternatives are reviewed in box d in terms of the findings sought and the primary risk data available. When the two branches of this component are combined, a mechanism for calculating the financial effect of utilising alternative risk allocation strategies is obtained (box e). Finally, the development and verification of methods for calculating the effect of employing alternative risk allocation strategies, the fifth stage of SSM, is undertaken, indicated by box f.

This structured approach permits the assessment of a range of risk allocations strategies, using primary data, to simulate the impacts upon the constructing parties.

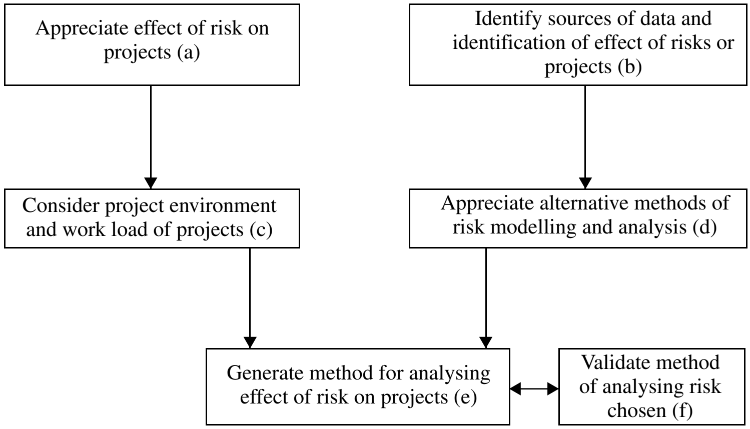

Figure 5.2 Identification, assessment and analysis of construction risks, the first component of the risk management system.

Proposed risk allocation strategy

The risk allocation strategy proposed represents the sixth stage of SSM, defining improvements in the situation. The aim of this strategy is to minimise the construction cost of the portfolio's projects. The client accepts responsibility for all risks caused by unforeseen natural and artificial conditions. The responsibility for all the other classifications of construction risk is shared between the contractor and the client on a 50/50 basis.

The responsibility for delays due to natural and artificial conditions is a frequent source of dispute between the client and the contractor. The reasons for this include uncertainties over the encountered conditions, even after risk events have occurred. These risks have low probabilities of occurrence, but high probabilities of effect, meaning that contractors face a gamble when setting contingencies against them and have at best limited abilities to manage them. This inevitably increases contractors' tenders.

The third reason is the need to provide contractors with motivation to seek to eliminate the occurrence of risks. The level at which this motivation becomes most effective is clearly difficult to identify. However, given the manner in which even minor risk event can have major financial effects, the contractors' reduced exposure to risk will still provide them with an incentive to perform in accordance with the client's aims.

The risks allocated to the contractor are those that they have the ability to manage; they are not allocated based on expediency, as occurs in price based contracts. It is cheaper in the long run for the client to pay for what actually happens during construction rather than what the contractor thinks might happen. The arbitrary transfer of responsibility for risks to the contractor costs money, whilst their effective allocation and management can save money. Removing the responsibility for these risks altogether diminishes the contractors' motivation to operate effectively, meaning that risk events will be more likely to occur. The proposed strategy reduces contractors' responsibility for risk provided they seek to minimise their likelihood of risks occurring. Although the contractor will still estimate the cost of these construction risks higher than the client, the construction costs will be reduced.

It has been proposed on a general basis elsewhere that the client accepts a larger responsibility for construction risks. Where major unexpected events do occur, the client will inevitably face increases in construction cost unless a contract placing all risks on the contractor is employed. However, if the risk was logically the client's in the first place, the cost to the client will be no greater that it would otherwise have been. The approach proposed requires the adoption of a long-term perspective. The workloads of projects are not constructed concurrently. Thus, the time period considered is not just the construction duration of an individual project, but several years. The client must accept a flexible attitude towards risk allocation. This approach would not be suitable for a client with a more introspective culture or fewer projects.

The use of cost based contracts is a prerequisite for the successful use of this strategy as a precise knowledge of the contractor's actual costs is required. The IChemE Green Book contract, already widely used, would be an appropriate vehicle for this strategy. The Institution of Civil Engineers (ICE) engineering and construction contract, or New Engineering Contract (NEC3), would also be suitable, particularly as they have provisions for sharing and transfer of risk between the contracting parties once identified thresholds are met.

The cost of some projects will inevitably exceed the client's estimates, particularly when major unforeseen events occur. However, as the client takes a long-term view these cost overruns should be more than offset by the cost savings achieved on successfully completed projects. The contingencies utilised by the contractor will have the same purpose and effect as those currently used in IChemE cost based contracts. The benefits are shown at portfolio level, where contingencies to cover the impact of the major risks at project level can be held.

In addition to minimising construction costs, a further aim of this strategy is to promote good management and engineering practice by the client as well as the contractor. These aims are compatible. The effect is to have the construction aims of the client and contractor identical. A *win–win* environment is sought in which the minimisation of construction risks and hence costs, is in the best interests of both parties. The contractor's risk becomes their ability to obtain further projects from the client. This approach raises the contractor's risk from the project level to the long-term success of their business, the contractor becoming as good as their last project.

Before such a radical departure from existing practice is embarked upon, a process of validation must be undertaken. The behaviour of the model is tested within the feasible domain to ensure that it is compatible with real life and that it contains no discontinuities or step changes.

There are a number of validation alternatives available, including a comparison with historical and future projected data, and comparing the simulated output with the anticipated outcome of a project in response to a predefined set of parameters. To validate this research a number of prototype contracts would have to be procured and analysed.

5.8 Summary

The initial role and value of qualitative analysis has been reviewed and the use of a risk log investigated. Finally, this chapter has shown that SSM provides a suitable means for structuring the examination of a utility's procurement of an ongoing workload of construction projects. The actual procurement of these projects is assumed to be undertaken by an internal specialist organisation. Root definitions of systems have been proposed indicating areas in which improvements in the use of special construction techniques can be obtained.

The allocation of construction risk, contractor payment mechanisms and strategic procurement mechanisms were identified as the aspects to be investigated. It is not suggested that these are the only areas through which improvements could be obtained. However, these are the areas where it is thought that meaningful improvements can be obtained given the resources and constraints present.

The proposed risk allocation strategy promotes the employment of able contractors, and it has been shown that only these contractors are able to obtain their required returns if the client seeks to limit their contingencies and profits in exchange for guarantees of work.