# 1 Introduction

*A pessimist sees the difficulty in every opportunity,*
*an optimist sees the opportunity in every difficulty.*
Sir Winston Churchill

## Managing Uncertainty, Risk, Threat And Opportunity

'Uncertainty' in the plain English sense of 'lack of certainty' has important implications for what can be achieved by organizations. All management decisions should take uncertainty into account. Sometimes the implications of uncertainty are 'risk' in the sense of 'significant potential unwelcome effects on organizational performance'. Then management needs to understand the nature of the underlying threats in order to identify, assess and manage the attendant risk. Failure to do so is likely to result in adverse impacts on performance, and in extreme cases, major performance failures. Sometimes the implications of uncertainty are an upside form of risk, significant potential welcome effects. Then management needs to understand the nature of the underlying opportunities in order to identify and manage the associated upside risk. Failure to do so can result in a failure to capture good luck, which can give rise to downside risk. For example, a sales campaign which generates unexpectedly high demand for a new product may prove a disaster if that demand cannot be met and this stimulates a competitor to enter the market; a project activity which finishes early may not result in a following activity starting early, and later delays will not be neutralized by this good luck if it is wasted; a contractor may have more resources available than anticipated, but may not be motivated to use them to a client's benefit, ultimately leading to problems for both parties.

In any given decision situation both threats and opportunities are usually involved, and both should be managed. A focus on one should never be allowed to eliminate concern for the other. Opportunities and threats can sometimes be treated separately, but they are seldom independent, just as two sides of the same coin can be examined at one time, but they are not independent when it comes to tossing the coin. Courses of action are often available which reduce or neutralize potential threats and simultaneously offer opportunities for positive improvements in performance. It is rarely advisable to concentrate on reducing risk without considering associated opportunities, just as it is inadvisable to pursue opportunities without regard for the associated risk. Because resources expended on risk management may mean reduced effort on the pursuit of opportunities, and vice versa, effort on each needs to be balanced, in addition to balancing the total effort expended in relation to the benefits.

To emphasize the desirability of a balanced approach to opportunity and threat management, the term 'uncertainty management' is increasingly used in preference to the more established terms 'risk management' and 'opportunity management'. However, uncertainty management is not just about managing perceived threats and opportunities and their risk implications. It is also about managing the various sources of uncertainty which give rise to and shape risk, threat and opportunity. Understanding the nature and significance of this uncertainty is an essential prerequisite for its efficient and effective management.

Uncertainty is in part about variability in relation to performance measures like cost or duration or quality. But uncertainty is also about ambiguity. Both variability and ambiguity are associated with lack of clarity because of the behaviour of all relevant players, lack of data, lack of detail, lack of structure to consider the issues, working and framing assumptions being used to consider the issues, known and unknown sources of bias, and ignorance about how much effort it is worth expending to clarify the situation. Clarification is primarily about improving effectiveness and efficiency. Improved predictability is sometimes a useful by-product. Uncertainty management as addressed in this book is about effective and efficient decision making given this comprehensive and holistic view of uncertainty.

## The Scope For Uncertainty In Managerial Decision Processes

The scope for uncertainty in any managerial decision situation is considerable. A useful way to see part of this scope is by considering a generic managerial decision process defined as a sequence of stages, each of which involves associated sources of uncertainty, as shown in Table 1.1. The decision stages in Table 1.1 are similar to those used to describe a generic decision process in many textbooks on managerial decision making.

The first stage in the decision process involves continuous monitoring of the environment and current operations in the organization. At some point issue recognition occurs, when those with sufficient influence realize there is a need to make one or more decisions to address an emergent issue. However, uncertainty

**Table 1.1**—Sources of uncertainty in a managerial decision process structure

| Stage in the decision process | Uncertainty about |
|---|---|
| Monitor the environment and current operations within the organization | Completeness, veracity and accuracy of information received, meaning of information, interpretation of implications |
| Recognize an issue | Significance of issue, urgency, need for action |
| Scope the decision | Appropriate frame of reference, scope of relevant organization activities, who is involved, who should be involved, extent of separation from other decision issues |
| Determine the performance criteria | Relevant performance criteria, whose criteria, appropriate metrics, appropriate priorities and trade-offs between different criteria |
| Identify alternative courses of action | Nature of alternatives available (scope, timing and logistics involved), what is possible, level of detail required, time available to identify alternatives |
| Predict the outcomes of courses of action | Consequences, nature of influencing factors, size of influencing factors, effects and interactions between influencing factors (variability and timing), nature and significance of assumptions made |
| Choose a course of action | How to weigh and compare predicted outcomes |
| Implement the chosen alternative | How alternatives will work in practice |
| Monitor and review performance | What to monitor, how often to monitor, when to take further action |

associated with ambiguity about the completeness, veracity and accuracy of the information received, the meaning of the information, and its implications, may make ambiguity associated with the emergence of issues important. Further, defining issues may not be straightforward. Different parties in an organization may have different views about the significance or implications of an existing situation, and differing views about the need for action. Issues may be recognized as threats or opportunities which need to be addressed either reactively or proactively. Alternatively, issues may be expressed in terms of weaknesses in organizational capability which need to be remedied, or particular strengths which could be more extensively exploited. Issues may involve relatively simple concerns within a given ongoing operation or project, but they may involve the possible emergence of a major organizational change programme or a revision to a key aspect of strategy. The decisions involved may be first-order decisions, or they may be higher-order decisions, as in process design choices, deciding how to decide. Ambiguity about the way issues are identified and defined implies massive scope for uncertainty.

'Scope the decision' will depend on how an issue is defined. It involves determining which organizational activities are relevant to addressing the issue, who is already involved with the issue, who should be involved, and importantly, the extent to which other areas of decision making need to be linked with this decision process. 'Determine the performance criteria' involves identifying the performance criteria of concern, deciding how these will be measured, and determining appropriate priorities and trade-offs between the criteria. As with issue recognition, the tasks comprising these two stages can present significant difficulties, particularly if multiple parties with differing performance criteria or priorities are involved. The 'identify alternative courses of action' stage may involve considerable effort to search for or design feasible alternatives. The 'predict outcomes of courses of action' stage builds on this to identify the factors that are likely to influence the performance of each identified course of action, estimating their size and estimating their combined effect. The 'choose a course of action' stage then involves comparing the evaluations obtained in the previous stage, often by comparing relative performance on more than one performance criterion. Ambiguity about how best to manage all these stages and the quality of their output is a further massive source of uncertainty.

The final two stages, 'implement the chosen alternative' and 'monitor and review performance', might be regarded as outside the decision process. However, if the concern is issue resolution then it is important to recognize these two steps and consider them in earlier stages of the decision process.

Most decision processes are not adequately described in terms of this simple sequence of separate stages. It has an operations management flavour, project or strategic management contexts warranting a modified shape to reflect context differences. In any context, the distinction between separate stages becomes blurred by simultaneously working on more than one stage at a time, and by iterative loops between various stages to incorporate revised perceptions and additional information. For example, the determination of performance criteria may be merged with the identification of alternative courses of action, or their evaluation, because views about what performance criteria are relevant are initially ill-defined, and need to be developed in the light of what alternatives are identified. Identification of alternatives and their evaluation is an iterative process involving search and screening processes to produce a shortlist of alternatives which are developed and evaluated in more detail. In the case of major investment decisions, often only one alternative is fully developed and evaluated because alternative courses of action and alternative design choices have been dismissed in earlier iterations through the 'choose a course of action' stage. However, Table 1.1 is a useful portrayal of what is involved in outline.

Experience, as well as this brief overview of sources of uncertainty in a generic decision process structure, tells us that the scope for making poor quality decisions is considerable. Difficulties arise in every stage. The uncertainties listed in Table 1.1 indicate the nature of what is involved. Have we correctly interpreted information about the environment? Have we correctly identified issues in a timely manner? Have we adopted the most appropriate scope for our decision? Are we clear about the performance criteria and their relative importance to us? Have we undertaken a sufficiently thorough search for alternatives? Have we evaluated alternatives adequately in a way that recognizes all relevant sources of uncertainty? And so on.

In order to manage all this uncertainty, decision makers seek to simplify the decision process by making assumptions about the level of uncertainty that exists, and by considering a simplified version or model of the decision components. Often this is done intuitively or informally using judgement and experience. For decisions that are important, where time and other resources permit, decision makers may use formal decision support processes incorporating explicit, documented models to assist with various stages in the decision process. Decision support need not imply formal computer-based information system support, though it often does. The key is formal models and associated analysis and synthesis to help make decisions, without attempting to exclude any relevant decision-maker input. The value of this approach is a starting position for this book. A key aim is to demonstrate that the quality of decision making can be greatly improved by the use of formal decision support processes to manage associated uncertainty.

## Ten Tales About Uncertainty Management

The ten tales in Chapters 2 to 11 of this book focus on different stages of the decision process in a number of important contexts. They illustrate how uncertainties associated with particular stages of the decision process can be explored in order to improve the quality of the decision process. Each tale involves the use of formal analysis, and holistic synthesis, to help the protagonists understand the decision context and the implications of associated uncertainty more clearly. Several tales focus on understanding and evaluating the implications of uncertainty in the ‘predict outcomes’ stage of the decision process. Others range more widely, implicitly addressing each decision stage in a sequence which involves iterative loops. For example, some tales begin with issue recognition, then move to prediction of outcomes for certain alterative courses of action, but as insights from the analysis emerge, the narrative describes a return to earlier stages in the decision process to reconsider issues, decision scope, performance criteria, possible additional courses of action, or re-evaluation of alternatives. All the tales involve situations where uncertainty has significant consequences for the decision owners. The need to understand the extent of threats to organizational performance is a common theme, but the tales also illustrate the linkage between threats and opportunities. In most tales the emphasis is on identifying and creating opportunities, rather than on merely neutralizing perceived threats. And in most tales the need to manage both variability and ambiguity, including deciding whether or not to seek more clarity, is a central issue.

For easy reference each tale is designated by the main protagonist, who typically manages the decision support process at the centre of the tale. However, other parties are involved, and their perceptions and motives are invariably important. This reflects the fact that a key source of uncertainty in most decision contexts relates to the identification of performance criteria together with the relative priorities and trade-offs that decision makers and other influential parties place on these criteria. Taken together the tales range over most of the stages in the generic decision process, and consequently address many of the uncertainties associated with each stage. They also cover the project management, operations management and strategic management areas, and aspects which include marketing, contracting, safety and financial management. The scope of each tale is summarized briefly below.

## Nicola's tale

Nicola's tale involves an example of buffer management in a supply chain. The tale begins with a proposal to change the size of replenishment orders for a particular component used by a family business which manufactures lawnmowers. Nicola starts by using a basic inventory control model to explore the effects of different reorder levels. However, the main body of the tale concerns the identification of assumptions made in the initial analysis and how this suggests a much wider-ranging review of supply chain strategy, including revised arrangements with other suppliers and all major customers. The tale demonstrates the relative importance of variability and ambiguity, and the way analysis can trigger creativity – very general issues which set the scene for other tales. The tale also suggests an approach to managing other forms of resource buffer. Time between activities and budget contingencies are project-oriented examples, but it is useful to see buffers in general terms and to start with a comparatively simple context.

## Martha's tale

Martha's tale deals with the common problem of determining an appropriate bid in a competitive tendering context. Concerned with her company's recent lack of success in competitive tenders, the regional marketing manager of an international computer systems supplier institutes the design of a new process for bid development. This incorporates cost estimation and consideration of the probability of winning with different levels of bid. Using an iterative process to discriminate between uncertainty which matters and uncertainty which doesn't matter, in order to spend more time on what matters, is a general issue at the centre of this tale. Decomposing the uncertainty which matters most (pricing issues associated with competitor and buyer behaviour), not the uncertainty best understood (cost), is facilitated by the process described.

## Eddy's tale

Eddy's tale describes an approach to preliminary cost estimation of a possible offshore North Sea pipe-laying contract. It provides further consideration of cost estimation issues arising in the previous tale. Eddy's approach demonstrates how a minimalist first-pass approach can be used to focus subsequent analysis on important sources of uncertainty. The ideas presented here can be applied in any performance measurement uncertainty estimation context. The focus is understanding what variability measures mean, separating out ambiguity issues associated with 'conditions' in so far as this is possible, and thinking ahead in an iterative process, all very general issues.

## Ian's tale

Ian is an independent consultant called in to comment on the risks associated with a property development project which his client wishes to undertake. Central to the project is a contract Ian's client has been offered by a property developer. Using a formal project risk analysis and management process, Ian demonstrates the significant moral hazard risk associated with the contract. He then outlines the structure of an incentive contract which would address the moral hazard problems and make the deal acceptable to all parties. A general issue of importance in this tale is the relationship between estimates which are conditional on assumptions and actual outcomes, whatever the ambiguities which separate the two, including the extent to which contracts motivate parties (or not) in an aligned manner.

## Roger's tale

Roger's tale continues with the moral hazard theme, but shifts the initial emphasis to internal relationships between departments in a project-based organization. The central issue is the need for the project manager to meet performance targets in terms of cost, time and quality, while relying on the performance of the various contributing departments. Part of the tale focuses on the development of internal incentive arrangements for the design department to ensure that the benefits of better than expected performance in the design department are extended to the project as a whole. This approach to formally capturing good luck is then extended to a linked set of contractors. Aligning the motivation of parties with or without formal contractual boundaries to manage good or bad luck is the general issue addressed.

## Sarah's tale

Unlike all the other tales, Sarah's tale concerns events which have only adverse consequences such as accidents or acts of God, events which the insurance industry often refers to as pure risks. This tale focuses on assessing uncertainty about the likelihood and possible consequences of a particular risk event. Subsequent analysis considers the need for trade-offs between costs and benefits, the problem of unambiguously identifying the benefits of reducing levels of risk, and the politics of basic framing assumptions in the context of a mandatory insurance approach. The tale addresses the management of safety in a railway system, but the form of analysis and synthesis presented is applicable to a wide range of related risk management problems. It can be very important to link issues like safety to other aspects of project conception, development and selection, breaking down functional silo boundaries.

## Norman's tale

Norman's tale addresses the problem of evaluating uncertain costs and benefits over time. Starting with a basic net present value (NPV) discounting framework, it explores the usefulness of a parametric approach employing sensitivity analysis of the key parameters to arrive at evaluations which reflect underlying uncertainties. It then goes on to explore related probabilistic and 'real options' approaches to evaluating possible future courses of action. Norman's analysis is concerned with the problem of nuclear waste disposal and appropriate costing of a deep mine repository project. However, the concepts and issues discussed apply to most capital investment appraisal problems.

## Tess's tale

Tess's tale concerns an investment decision problem for a small manufacturer. To begin with, the decision problem is formulated by Tess as a simple choice between a small number of alternative options, amenable to analysis via a decision matrix and then a decision tree model. However, this formulation is shown to be inadequate. Tess's journey towards a broader perception of the issues, and a wider range of strategic options, involves general issues of relevance in many contexts and most stages of Table 1.1 as well as all areas and all aspects of management. A portfolio of projects requiring multiple-attribute evaluation is the conceptual framework which emerges, with specific process recommendations.

## Sam's tale

Sam's tale is about portfolio analysis in its most general sense: analysing the collective uncertainty associated with a set of component assets. The analysis starts with a basic Markowitz mean–variance model of a portfolio of financial securities and the formalization of the important concept of risk efficiency. It then extends the analysis to exploit the concept of separability. The modelling framework provided then facilitates further extension of the analysis to address issues associated with corporate structure, staff motivation, staff training, staff selection and retention. This tale underpins many of the constructive simplicity notions used in most of the other tales.

## Conrad's tale

Conrad is a consultant contracted to advise a Canadian electric utility on how best to embed uncertainty management into their corporate strategy formulation process. Conrad's analysis distinguishes three levels of planning: short-, medium- and long-term. It considers separability and dependence of the uncertainties associated with each of these horizons. For example, long-term uncertainties involve political and economic issues which drive the mix of hydro, nuclear, thermal and 'conservation' approaches to the energy portfolio of the utility. Given uncertainties about the growth in demand for electricity, medium-term planning for new power stations presents considerable difficulty because of the long lead times associated with the construction of new generating capacity. Conrad's analysis demonstrates that provision and operation of new capacity should lag behind expected growth in demand for electricity because the costs associated with providing capacity excess to requirements are significantly higher than the costs associated with a shortfall in capacity, a profoundly counter-intuitive result for the utility. However, the focus of the tale is the way the framework developed by Conrad facilitates reflection about alternative short-, medium-, and long-term strategies, the linkages between them, and the way synthesis can incorporate bottom-up emergent strategy development as well as top-down analysis. These are all issues of general interest.

### Tales in context

The nature of the tale format employed means that each tale addresses a particular context, but the approaches used in each tale are directly transferable to most other similar contexts, and many other contexts which may seem very different. Managers who deal with contexts like the ones described should find the concepts and approaches discussed directly relevant to their own organizations. However, the ideas presented are relevant to a much wider set of contexts, and collectively the ten tales provide a comprehensive sample of the implications of the constructively simple approach adopted throughout. All the tales are based on cases, but all the organizations, people and stories are composites, to integrate issues and simplify discussion. None of the tales should be taken literally in relation to specific organizations or individuals.

## A General Process For Supporting Managerial Decision Making

Each tale can be viewed from two perspectives: first, as an approach to addressing uncertainty in particular contexts and related situations; and second, as an illustration of key principles in devising analytical approaches that are both efficient and effective. This second perspective is the primary concern of this book. The ten tales illustrate a number of general methodological issues concerning the use of analysis and synthesis to understand and manage uncertainty which are not specific to particular areas of application.

In identifying principles involved in the design of effective and efficient processes for supporting managerial decision making, we do not need to start from scratch. In management science, broadly defined to include operational research (OR) – some prefer operations research, what some may see as separate perspectives provided by soft systems and soft OR, and cognate aspects of what some may see as the separate disciplines of economics, finance, and so on, there is a long tradition of employing models of real management decision situations to understand the key features of a decision and guide subsequent decision making. The tales draw on this experience. In particular, the process adopted in each tale is based on a typical general process followed in OR interventions as depicted in Figure 1.1. This process

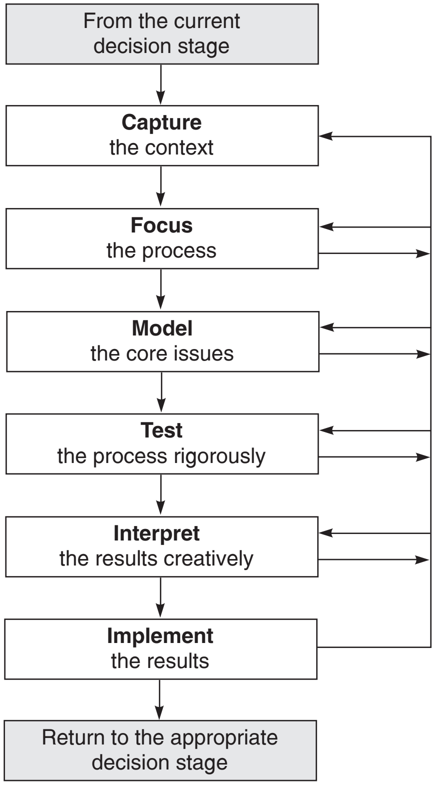


**Figure 1.1**—The general decision support process.

may be applied to support one or more stages of the decision process in Table 1.1. As with most decision support processes, this process is not a simple linear process. The need for an iterative approach arises because of the presence of uncertainty and learning that takes place as the process progresses. Efficient and effective processes to support decision making usually warrant an iterative approach involving multiple passes through one or more phases in the process.

The six-phase structure of Figure 1.1 captures the spirit of modern OR-based management science approaches to decision support processes in a manner shaped to reflect the constructive simplicity notion this book develops. The term 'decision support' itself reflects the spirit of constructive simplicity as explored by this book, briefly described later in this chapter. In particular, it is worth emphasizing that the process of Figure 1.1:

- Supports decision making, it does not make decisions
- Enhances the skills of decision makers, it does not downgrade the role of decision makers

- Involves synthesis which attempts a holistic perspective
- Requires thoughtful interpretation, and is concerned with stimulating creativity
- Involves facilitation and guidance, and embraces corporate learning processes
- Can accommodate the idea of specific and general processes (see page 25).

Nicola's tale in Chapter 2 is concerned with clarifying this process in basic terms, and later chapters explore its enhancement in various ways, but the following outline may help to explain it.

## Capture the context

The process of Figure 1.1 begins with 'capture the context', the capture phase. This involves developing a description of the prevailing state of the decision process in terms of the stage reached, the information and understanding obtained, and the uncertainties present.

## Focus the process

The next phase is 'focus the process', the focus phase. This involves identifying the purpose of the support to be provided and selecting an approach which is fit for purpose. The purpose of the process will reflect the stage the supported decision process has reached. For example, if the decision process has only reached the stage of determining performance criteria in a first pass, then the purpose of the analysis may be to help those involved in the decision process to consider appropriate measures for possible performance criteria and identify their preferences in terms of plausible trade-offs. If the decision process has progressed to 'predicting the outcomes of course of action' then the purpose of analysis may be to estimate the outcomes of the alternative courses of action using the previously determined measures of performance.

In a basic context as illustrated in Nicola's tale, choices about the approach have to start with two basic options. First, we can choose a soft systems (Checkland and Scholes, 1990) or a more broadly cast soft OR (Rosenhead, 1989) initial position, perhaps embedding a more traditional OR approach (Ackoff and Sasieni, 1968) at a later stage if appropriate. Second, we can start with a traditional OR perspective, embedding soft OR approaches as appropriate. This book presumes the latter, because this is the authors' preference in the contexts considered, for reasons illustrated in the tales.

Given this choice, another choice has to be made, about the degree of focus on qualitative models or quantitative models. If quantitative models are the focus, a choice has to be made between a modelling approach which is descriptive or prescriptive. A prescriptive model may involve optimizing techniques designed to identify the best course of action given that the decision maker has adopted particular performance criteria and trade-offs. A descriptive model may simply describe the likely consequences of particular decisions. Decision makers or analysts can then vary model parameters to see the effect of different assumptions or choices. Simulation is commonly employed as a descriptive modelling technique. Both prescriptive and descriptive modelling approaches can help decision makers understand more about the associated decision context and guide future choices.

For some purposes a qualitative modelling approach is appropriate and quantification is unnecessary. For example, qualitative modelling techniques can be very helpful in clarifying and addressing uncertainties present in the decision stages of 'issue recognition', 'scoping the decision', 'determining performance criteria', and 'identifying alternative courses of action'. Soft OR approaches like the use of influence diagrams and cognitive mapping (Eden, 1988) can be very useful here. However, quantitative models are often desirable because:

- Numbers form a common language for more effective communication of some issues
- Some decision situations can be more precisely defined and ambiguity minimized
- The logic of the decision process becomes more explicit
- Decisions, and subsequent changes in decisions, can be defended in a rational and consistent manner

In practice, qualitative and quantitative modelling approaches are best used together in a complementary manner. The use of qualitative models can often induce use of a quantitative model, and vice versa. Each of the tales describes a process which focuses on the relationship between quantitative modelling of some issues and qualitative modelling or informal consideration of other issues. As the analysis and synthesis process in each tale progresses, a recurring issue is whether or not it is worth modelling relevant factors in quantitative terms, and the level of precision and detail worthwhile where quantitative modelling is used.

## Model the core issues

A first step in a basic version of the 'model' phase in the process of Figure 1.1 involves the design of an appropriate conceptual model which incorporates structure and detail to reflect the focus and purpose of the process. A second step is to obtain data in an appropriate form which provides relevant values for all model parameters. Such data may not be readily available, and may require estimating. A third step is to solve the model, to determine results using input data.

## Test the process rigorously

The test phase explores important sources of uncertainty introduced by the process which in a basic context include:

- Uncertainty about the accuracy of calculations
- Uncertainty about the pedigree of parameter estimates incorporated
- Uncertainty about the importance of individual model parameters
- Uncertainty about the validity of explicit assumptions which structure the analysis
- Uncertainty about implicit assumptions

This involves scrutinizing the model solution, form and assumptions for accuracy, sensitivity and robustness. It also involves scrutinizing the process used to obtain the model for robustness, implicit assumptions posing particular difficulties. This scrutiny may suggest a need to loop back to earlier phases in the process, typically to revise the model construction, but potentially to consider a different modelling approach, or even to re-examine the decision context. Framing assumptions can be particularly important. All the feedback loops in Figure 1.1 are important, but the loops in the test phase are particularly important.

A useful first step is a reality check, to see if the results are consistent with common sense expectations. If not, then check the model construction, check the quality and pedigree of the data, and check the calculations for errors. Counter-intuitive results which can be explained and defended are the pearls of wisdom being sought, but counter-intuitive results which cannot be explained are a serious risk to the process.

Sensitivity analysis is important because it indicates the extent to which changes in the value of a parameter can affect the model results. If model results are extremely sensitive to small changes in the value of a parameter, then uncertainty about the value of this parameter is important; it needs to be investigated and managed. If model results are relatively insensitive to changes in the value of a parameter, this is useful information about the level of variability or uncertainty associated with the parameter that can be tolerated without significantly affecting the situation being modelled.

A management science approach to model-based analysis following a process like that of Figure 1.1 emphasizes the importance of explicitly analysing the robustness of the assumptions embedded in models. This goes much wider and deeper than sensitivity analysis of model parameters. For example, if someone with statistical training uses a statistical test based on a model which assumes a Normal (Gaussian) distribution for data, he or she should have confidence that the extent to which the data is not Normally distributed is not a critical issue. This is robustness as understood by statisticians. The concern for robustness addressed in the test phase is similar but much more fundamental. The essence of the robustness issue is that we need to pay very careful attention to assumptions, ensuring that no assumptions are made which clearly depart from reality without testing their effect. If we fail to do this, then our models will generate new uncertainty, rather than reduce existing uncertainty. If the theory our models incorporate is a distortion of reality, this can distort associated perceptions and decisions in unpredictable ways. Such theory is not useful. Indeed, it is positively harmful and counterproductive.

Looking for insight from all earlier aspects of this phase and the process more generally is the crucial final step in this phase, and the rationale for the formal modelling aspects of the process.

## Interpret the results creatively

The interpret phase in the process of Figure 1.1 continues the synthesis begun in the previous phase. It involves critical reflection on the results of the previous phases and drawing conclusions which can be used to enhance decision makers' understanding about the decision context and to guide their future actions. It needs to address the implications of all aspects of the previous phase, especially assumptions which are not robust and issues not captured by the formal analysis and the synthesis thus far. It should also involve standing back from the modelling effort to consider the big picture. These deliberations may well suggest that it is desirable to revisit earlier phases of the process or earlier stages of the decision process, in order to pursue more refined analysis, develop alternative modelling approaches, or reframe the decision context altogether, for example.

An important part of reflections in the interpret phase should be to address the implications of:

- Uncertainty about the nature of implicit assumptions
- Uncertainty about the appropriateness of the modelling approach
- Uncertainty about the depth to which the analysis should be conducted
- Uncertainty about aspects of the decision context which have been overlooked

These uncertainties may be addressed to some extent in earlier phases of the process, but a more informed assessment and consideration of the implications of these uncertainties is possible after completing at least one pass through the preceding phases. Reflections about the above uncertainties usually warrant revisiting early phases of the process, and sometimes result in significant shifts in the focus of analysis and changes in the form of model employed.

It is particularly important that reflection here should include consideration of uncertainties associated with the decision context that have not been adequately captured by the preceding analysis and synthesis. For example, the analysis may prompt questions about who should be involved in the decision process, or what other related decision processes should be taken into account. Further consideration of such questions might warrant major changes in approach. It also might shift attention away from the current decision support process back to the underlying decision process stage, and the desirability of revisiting earlier stages of this decision process, to redefine the decision issue, rescope the decision, or revise the relevant performance criteria, for example.

### Implement the results

The implement phase is included because experience suggests that the need to implement results must be designed into the whole process from the outset. It is also included because it is important to emphasize that this process is about results which can be implemented. A process of this kind can have embedded scientific methods, but it is not about doing science (adding to knowledge without any particular decision in mind) unless it is embedded in a scientific process, an issue not addressed in this book.

Nicola's tale in Chapter 2 provides a direct illustration of the use of a basic version of the process of Figure 1.1, illustrating and developing the discussion of this section, as indicated earlier. The concept of constructive simplicity also builds on this basic version of the process of Figure 1.1, and it requires some exploration at a conceptual level in this chapter.

## Constructively Simple Models

A key concern in the process of Figure 1.1 is deciding how much detail to incorporate in a model of the decision situation, and in what manner to introduce it. Models which attempt to mirror reality in every detail are not usually appropriate or feasible, but at the same time, excessive reduction in complexity must be avoided if the model is not to obscure issues or produce misleading inferences. What is needed is a model that captures all the key features of the decision context which matter a lot, but ignores all the detail which matters relatively little. What matters depends critically on the immediate purpose of the model. For example, detailed 2 cm to 1 km scale maps produced by the Ordnance Survey are useful for planning a walk, but a one-page map of the whole country is more useful for planning a 500 km car trip. Both are graphical models of geographic features, but each is designed for and best suited to particular uses.

In terms of model construction there are good reasons to start with a model which is simple in terms of construction detail, whatever the purpose of the model or the decision context (Ward, 1989). This simplicity can be incorporated into a model by:

- Restricting the number of variables in the model, e.g. by definition of a boundary to the problem
- Quantifying simple relationships between variables, e.g. hypothesizing linear relationships
- Limiting the amount of uncertainty incorporated, or perhaps even ignoring uncertainty altogether
- Assuming a well-defined objective function or set of decision criteria
- Aggregating variables with certain shared characteristics; for example, rather than considering all customers individually, they are grouped for modelling purposes according to size, products purchased, industry or location

Constructively simple models generally have a number of advantages over their counterparts, along the following lines:

- **Transparent assumptions** Assumptions are more apparent and more accessible (transparent) in a constructively simple model. In a complex model it can be difficult and time-consuming to keep track of every assumption incorporated in the model. Even with detailed documentation, some assumptions may be overlooked when model outputs and their implications are being discussed. In particular, the arbitrary or inappropriate nature of some assumptions may go unnoticed.
- **Simple data requirements** Constructively simple models require less data, and where data is limited, a simple model may be the only practicable approach (Cohen and Durnford, 1986). Even when data is available, the larger amounts of data required for a complex model may be difficult or onerous to obtain, prepare, and check. Where the quality of data is low, constructively simple models are more appropriate than complex ones. In this respect, a disadvantage of complex models is that output from such models can imply a degree of precision which is not justified by the quality of the input data. There is always a need to maintain a healthy suspicion of the data used and the processed results.
- **Simple sensitivity analysis** Sensitivity analysis is more practical with a constructively simple model. Unless the number of variables is small, the effect of individual assumptions on model output can be very difficult or impractical to determine (Eilon, 1979). In particular, it can be difficult to carry out detailed sensitivity or robustness analysis by varying combinations of model variables. Even complete sensitivity analysis of each variable individually may be onerous in a model with many variables. A notable exception is a linear programming (LP) model formulation. Sensitivity analysis on individual model variables and constraints is readily available on most LP software; the weakness is that simultaneous sensitivity analysis of two or more variables is not conveniently performed. Unless sensitivity analysis can be carried out conveniently, there will be a tendency to rely on 'best estimate' values for model data, with consequent model unreliability in the face of uncertainty.

- **Simple development and maintenance** Constructively simple models can be less time-consuming and costly to develop and maintain. Complex models take a long time to construct and test, often much longer than intended. Delays in producing them do not inspire confidence. Complex models require more extensive documentation.
- **Flexibility** Constructively simple models are easier to alter. Complex models can be very difficult to alter quickly and correctly when new features are required, or assumptions built into the logic need updating.

These advantages of constructively simple models are particularly relevant in decision contexts involving high levels of uncertainty. In the presence of high uncertainty, beginning with a constructively simple model in a first pass through the decision support process, followed by subsequent iterations, is usually preferable to attempting a single pass with a model that may be overly complex. For example, if decision criteria and their relative importance are ill-defined, or the relationships between decision variables are not fully understood, some relevant features may not be identified until later in the process. In these circumstances an initial model may be more useful in terms of refocusing the analysis in a second pass through the phases of the decision support process than in terms of producing immediate guidance for the decision maker. First and subsequent passes through the test and interpret phases lead to correction of errors, changes in model formulation, or the decision maker learning something new about the problem and 'updating intuition' (Roberts, 1977; Little, 1970). To facilitate this, flexible, easily amended models are needed, rather than models of great technical accuracy and complexity (Fripp, 1985).

## Other Aspects Of Constructive Simplicity

Constructively simple models provide the foundation for what we shall term 'constructive simplicity' in a decision support process like that of Figure 1.1. The term 'constructive simplicity' captures the idea of simplicity in model or process detail, and the idea of simplicity which is helpful or constructive. Complementary to constructive simplicity is the notion of constructive complexity, incremental complexity which adds value efficiently at a level appropriate to the context. Two obvious opposite concepts are destructive simplicity and destructive complexity. Destructive simplicity is simplistic, it oversimplifies and obscures, and obstructs the ability to develop understanding. Destructive complexity is overelaborate, adding details or complexities which are not cost-effective in contributing to understanding, and which may even be counterproductive. For example, some forms of model are mathematically attractive but counterproductive for practical decision-making insight purposes, because they obscure more than they reveal.

## Simplicity efficiency in modelling

The tales in this book are concerned with approaches which are as simple as possible, or no more complex than necessary to achieve an appropriate level of understanding of uncertainty in the context considered. We believe that the best way to achieve this balance is to begin with constructive simplicity, only adding complexity when it is constructive to do so. This involves adding the minimum amount of complexity necessary to provide needed insight, or maximizing the amount of additional insight provided by an additional level of complexity. Simplicity efficiency implies seeking efficient trade-offs between insight and complexity. Destructive simplicity or destructive complexity is implied by a serious failure to achieve simplicity efficiency, involving simplification of a starting position or added complexity which is counterproductive. What these terms mean and how we can achieve simplicity efficiency is a central theme in the ten tales of this book.

One immediate implication of a seeking simplicity efficiency is that model development should involve a number of iterations or passes. To begin with we need a first pass model deliberately designed in a minimalist style (introduced in Eddy's tale of Chapter 4). Constructive complexity is then added in the most efficient way possible as it becomes clear what is needed (also illustrated in Chapter 4). To achieve this kind of simplicity efficiency more generally we need to design a very flexible model set for variability issues, which can be used on their own or linked in a nested fashion to all other relevant models. Collectively the models used in the ten tales illustrate what this model set ought to look like, without any attempt to be definitive.

## Risk efficiency

In this book, risk efficiency is central to a constructively simple approach to uncertainty. It has three aspects. Static risk efficiency is risk efficiency in relation to decisions at a point in time, as developed by Markowitz (1959) in relation to a 'variance efficiency' version of risk efficiency. This involves ensuring that decisions at a point in time involve the minimum level of risk (potential variability on the downside) for any given expected level of performance. An inefficient choice in these circumstances involves more risk than necessary for a given expected outcome. Chapter 10 addresses this aspect in the portfolio analysis context which is its birthplace, but all other chapters make use of it.

The second aspect of risk efficiency involves identifying an appropriate risk/expected value trade-off from risk-efficient alternatives. Risk efficiency leads to an efficient set of choices which involve less and less risk as expected performance is adjusted to a less favourable level, and in the limit to a choice which minimizes risk. How much expected performance it is worth giving up to reduce risk (if any), or vice versa, can be seen as a simple matter of preference or taste, a behavioural issue. This book suggests a minimal backing away from risk as a matter of policy, driven by the third aspect of risk efficiency, dynamic risk efficiency.

Dynamic risk efficiency is risk efficiency in relation to all the decisions over time which are relevant. Over the long haul it is important to optimize expected values unless this involves a chance of catastrophic outcomes which are more of a problem than a more risk-averse stance with respect to each decision. For example, a contractor who never takes a chance that a particular contract will lead to bankruptcy may be certain of bankruptcy through lack of business: the issue may be balancing the risk of bankruptcy on each contract against the risk of going bankrupt through lack of business. Dynamic risk efficiency does not eliminate the preference aspects of balancing risk and expected value, but it couples opportunity management and threat management at a basic conceptual level. It does not in general lend itself to direct mathematical optimization, but it provides a direct rationale for favouring a bold approach to risk taking which is central to this book.

## Simplicity efficiency in basic concepts and terminology

Risk management, opportunity management and other aspects of uncertainty management have become increasingly fashionable over the past decade. However, these terms mean different things to different people. Current applications are building on many decades of pioneering work by many different groups of people with different perspectives and different concerns. Constructive simplicity requires a simple set of basic uncertainty concepts and associated terms which are common across these groups. In particular, we need to avoid terms and concepts which are restrictive and which inhibit our approach because of framing assumptions. For example, many people working in the area of safety analysis (and some others) define 'risk' as 'probability times impact', assuming the use of objectively determined probabilities that hazards (threats) will occur, and objectively assessed impacts if they occur. In our terms, 'probability times impact' is an expected value measure, 'risk' is the implications of significant departures from expectations, and any available objective assessments must be embedded in subjective judgements. The implications of this broader perspective in terms of safety are explored in Sarah's tale (chapter 7). The point here is that anyone who insists on defining risk in probability times impact terms cannot make use of 'risk efficiency', a core issue in risk and opportunity management in terms of the perspective of this book. They gain simplicity but lose generality. This is simplistic, and it implies destructive simplicity. Destructive complexity might be associated with attempting to use this narrow definition of risk and a more general inconsistent or contradictory definition.

Constructive complexity may involve additional meanings for basic terms, providing the context makes the meaning clear and more than one meaning is useful. For example, the term 'risk' is often used by many people to mean 'threat' in the sense of a source of uncertainty with downside risk implications. This is a useful and acceptable second meaning for the term 'risk', but in this book the term 'risk' is used in a wider sense to mean the implications of significant uncertainty. Constructive complexity may also involve additional terms for the same basic concepts in a different context when this is useful. For example, 'threat' in a project risk management context usually becomes 'hazard' in a safety context, in terms of the common language of the context. It would not be constructive to attempt to avoid additional terms for the same basic concept in such circumstances in general, although this book avoids doing so. It is very important to eliminate the use of restrictive meanings for basic terms and concepts, but it is also important to avoid terminology imperialism. This book is about setting people free to take a wider view of their concerns, not limiting them to particular terms when other terms are more familiar and equally effective.

All ten tales preserve the same common basic uncertainty concepts and terminology, in an attempt to achieve simplicity efficiency. Some readers may not welcome unfamiliar terminology and associated concepts. However, this book uses a common basic uncertainty concept and terminology set to attempt to explain how to manage uncertainty in any context, using ten fairly different example contexts, and those who wish to develop a similarly broad perspective will need similar common terminology and concepts. This principle of constructively simple basic concepts and associated terminology has been extended beyond 'uncertainty' issues in a limited number of related cases. The use of 'decision support' to describe the nature of the process of Figure 1.1 is one example. The general use of plain English wherever possible is another. Our view is that the simplest concepts and terminology in terms of constructive simplicity are the most robust to changes in context or approach or form of model. They are portable and flexible and unrestrictive. They are also plain English, which helps to avoid or minimize the need for jargon and to simplify communication.

## Simplicity efficiency in processes

In this book we are not just concerned with simplicity efficiency for models, concepts and terminology. We are also concerned that the process of organizing and carrying out analysis and synthesis is efficient and effective in terms of desirable numbers of iterations, the resources the process requires in terms of cost and time, and the extent to which spending more (or less) time on the planning process, or doing it differently, might better meet the expectations of those responsible for the associated decisions. This is a higher-order concern, in the sense that it is a higher level of decision making which should be addressed before the nature of the concepts and models employed is considered. In practice this management of the decision support process is extremely important. We do not have infinite time, information and other resources to perform analysis and make decisions. The way we undertake analysis and synthesis has to reflect the practical difficulties decision processes must contend with.

The previous section identified several reasons for preferring constructively simple forms of model. A further important reason for preferring constructively simple models is that they facilitate an efficient and effective decision support process. Typically, at the beginning of the process, understanding of the relative importance of features of the decision context is limited. Setting out to formulate a model incorporating all identifiable situation variables may be unnecessarily complicated – many variables may subsequently prove to be relatively unimportant. For example, in evaluating a number of decision alternatives against multiple criteria, an initial constructively simple analysis may be sufficient to show that one option is always preferred for a wide range of possible futures, rendering further more detailed analysis unnecessary (Belton, 1985). A more efficient approach would involve starting with a constructively simple model and incorporating additional detail only as necessary and as understanding of the decision context develops. In any decision support process, if we know we are going to use an iterative, multiple-pass approach, it makes sense to simplify early passes to focus on what we hope to achieve in early passes, adding complexity constructively in subsequent passes. This idea is developed in Martha's tale (Chapter 3) and Eddy's tale (Chapter 4), and used in the rest of this book. It is an important aspect of simplicity efficiency, with implications for models as well as processes.

Effective processes also need to facilitate and encourage the involvement of the decision owner and their subsequent commitment to making use of the findings from the analysis. Most of the tales in this book involve scenarios where these requirements are a consideration for the analyst in adopting an approach to the decision support process. An in-depth study requiring much time and resources before any answers or help to the decision owner are forthcoming may not be the best way to proceed. Most OR practitioners in this situation recognize the need for early results, something that will help their client *and* help the client appreciate the practitioner. The real trick is for the analyst to identify an immediately helpful perspective on the issues, and useful objectives for the analysis which can be delivered with a high degree of certainty in an acceptable timescale. Such considerations play an important part in determining the nature of analysis that is carried out. More sophisticated models and solutions may need to wait.

Frequently decision owners will express considerable scepticism over an analyst's claim to be able to help with what the decision owner regards as a difficult or complex situation. Any analysis is seen as likely to be too simplistic. A common example arises in corporate studies of branch or area networks. Each branch or area manager claims that his branch or area has special problems which cannot be adequately considered in a model which uses a similar approach to model all branches or areas. Nevertheless, once persuaded that analysis might be useful, decision owners often express a preference, other things being equal, for a constructively simple form of analysis, particularly in the early stages of the work. Why?

Partly decision owners may see constructive simplicity as a way of ensuring model transparency in the face of untried and perhaps overenthusiastic analysts. Once a degree of understanding develops between decision owner and analyst, the decision owner is usually much more willing for complexity to increase. However, decision owners may also prefer constructively simple models for reasons not connected with making models more transparent to them. These reasons relate to the time available to consider a problem, implementing recommendations, and involvement of third parties (Ward, 1989).

In many cases decision owners see lack of time as an effective constraint on the complexity of analysis that is feasible. Indeed, lack of time due to pressure of other work is often a reason for seeking assistance with a decision problem. In this situation analysts must temper the complexity of analysis undertaken by the need to explain progress and results adequately to a decision owner with limited time available to study and contribute to the analysis. Also significant are situations where there are specific deadlines for making decisions. Then decision makers are often prepared to make decisions with less information than they would require if they had more time. The costs of delay imposed by attempting a detailed analysis may be regarded as prohibitive when compared with the likely additional benefits. Even when a detailed analysis *is* feasible within the time constraint, a relatively simple level of analysis may be preferred by a decision owner because:

- It is more rapidly understood
- It reduces the likelihood of unexpected delays due to technical difficulties with the models or data acquisition
- It reduces pressure on analysts and therefore reduces the chance of mistakes
- It allows more time for sensitivity analysis
- It allows more time to reflect on model results

This reasoning is consistent with earlier comments characterizing decision support processes as learning processes, although it reflects the decision owner's typically more pragmatic attitude to problem solving.

The level of detail worth including in a model will also depend to a certain extent on the precision with which decision options can be implemented, and the associated processes. Complex models which specify desirable courses of action in fine detail will be of limited value if such courses of action cannot be precisely implemented and controlled. Furthermore, decision owners are only too aware that no model can take *all* factors into account. It may be necessary to respond to events and effects which were not considered in the model. Models which produce detailed, precise recommendations will not be welcome if they remove or reduce the decision owner's ability to control events directly. Where uncertainty about future developments is high, the overriding need may be to devise courses of action which preserve flexibility for future actions. Existence of a changing situation and a limited amount of relevant data suggests an emphasis on rough appraisals sufficient to evaluate courses of action in broad terms, and facilitate the consideration of qualitative factors.

For themselves, decision owners may be happy with a relatively complex analysis, but may prefer a simpler form of analysis if third parties need to be persuaded by the results. Where implications of a model need to be understood and appreciated more widely, it is useful to have a form of analysis that can be easily understood by managers other than the decision owner, who may not have the inclination or the need to understand a more complex analysis. Insights that are the product of a constructively simple and transparent model may be easier to sell than recommendations derived from a complex and opaque black-box model.

The foregoing observations illustrate the particular importance of the relationship between the models, the decision support process, the decision context, and the parties involved as decision owners or analysts. The decision support process is the overall vehicle. The model is the engine which powers it. The two have to be designed or selected to complement each other, with due attention to the purpose of the vehicle, the (decision) terrain it has to operate in, and how it is to be driven. Most of the tales in this book discuss models and their relationship with the process and the parties involved, with joint consideration driven by a concern for the relative return for effort expended.

The aspects of simplicity efficiency discussed here are implicitly part of Ward's original (1989) 'constructive simplicity' concept, and to some extent they are implicit in any effective decision process, but it is worth making them explicit. Several other aspects receive explicit attention in this book.

## Constructively simple models of variability

According to the adage, if the only tool in your box is a hammer, every problem looks like a nail. Management scientists operating as consultants usually pride themselves on having a large toolbox and a wide range of tools, borrowed from all feasible sources. They also pride themselves on knowing when to use them. However, modelling uncertainty issues using the full range of tools developed by OR, economics, finance, safety engineers, technology forecasters and others, raises a number of difficulties. For example, traditional decision analysis models are focused on discrete events and discrete choices, whereas traditional portfolio analysis models are focused on continuous variable allocations and continuous variable outcomes, and the utility theory behind decision analysis is not really compatible with the mean–variance basis of portfolio analysis. The models explored in this book attempt to break down these barriers. The end goal is a compatible family of models of the variability aspects of uncertainty that allow us to start with a very simple model appropriate to any context and add complexity in a constructive way whenever necessary without the need to set aside an approach because it cannot deal with required new features another model could provide. Tess's tale (Chapter 9) and Sam's tale (Chapter 10) explore the intersection between decision analysis and portfolio analysis. These tales and the others illustrate the portable, flexible and unrestrictive nature of the approach to modelling variability which this book suggests. This builds on a synthesis of the risk engineering approach to model building developed by Chapman and Cooper (Chapman and Cooper, 1983a; Cooper and Chapman, 1987) and Ward's (1989) original constructive simplicity ideas. For expository purposes this book makes extensive use of simple analytical procedures to combine measures of variability, but in practice Monte Carlo simulation methods or other algorithms could be used, employing generic software like @Risk (e.g. Grey, 1995).

## Constructive complexity via separability

Separability and associated modularity can add complexity to models and processes, but used effectively, very powerful constructive complexity can be achieved. This notion is largely implicit in early chapters, but explicitly touched on in Chapter 3 and developed in Chapters 9 to 12. The use of separability in mathematical programming and utility theory are classic examples, with implications of relevance in these later chapters. The role of statistical independence as an extreme (and often unrealistic ) form of separability is directly relevant throughout this book. At a conceptual level, a core notion for this book is refusing to see either opportunities and threats or variability and ambiguity as independent concepts. We can treat them as separable for some purposes, but they are not independent. The distinction is constructive simplicity at its most fundamental level.

## Constructively simple processes which are specific or generic, with portable components

The decision support process of Figure 1.1 is generic, in the sense that it is suitable for any context or decision stage, as illustrated by Nicola's tale in Chapter 2. In Martha's tale (Chapter 3) this process underlies the analysis, but the target deliverable is a specific version of the process of Figure 1.1 to be used every time Martha's organization makes a bid. That is, because the same sort of analysis is required time after time, it is worth designing and refining a bidding analysis process specific to the problem context to make bidding more efficient and effective. Constructive simplicity in this book includes this idea of designed processes for repetitive use in very specific circumstances. Chapman and Cooper's 'risk engineering' design concept is the basis of this notion, as discussed in Chapman (1992) and illustrated extensively in Cooper and Chapman (1987), which draws on a series of earlier papers.

A key notion here is the extent to which process ideas are portable; portability makes it simpler to design new processes. For example, the foundation of the risk engineering approach was Chapman's development of project risk management processes and models for BP International's offshore North Sea projects (Chapman, 1979). The next step was a very similar reliability analysis process for Petro Canada (Chapman, Cooper and Cammaert, 1984), followed by a related but quite different engineering design strategy analysis for Fluor Engineers and Contractors Inc. (Chapman *et al.*, 1985), followed by an entirely different economic desirability assessment methodology for the Alaska Power Authority (Chapman and Cooper, 1983b). Constructively simple synthesis needs to draw on all relevant similar processes as appropriate, to simplify the design of suitable processes and avoid reinventing similar wheels.

In Ian's tale (Chapter 5) a central role is played by PRAM (project risk analysis and management), a generic project risk management process developed by the Association for Project Management (Simon, Hillson and Newland, 1997), as elaborated by Chapman and Ward (1997) and subsequent papers. For some purposes it can be seen as a halfway position between a general process like Figure 1.1 and a specific process like the one in Martha's tale. It is specific to project risk management but generic to all projects and organizations.

Chapman and Ward (1997) can be used as a practical basis for understanding, enhancing and implementing any of the generic guidelines for project risk management. This book can be used as a practical basis for further understanding, enhancing, expanding the scope, and implementing any of the generic guidelines for project risk management. This book and Chapman and Ward (1997) can be read in any order or used independently. They intersect in Chapter 5 of this book. This book can also be used in a much broader context, with a focus shifted to bidding, safety, security portfolio management, or strategic management, for example, building on an intersection with these aspects of management in Chapters 3, 7, 10 and 11.

## Keep It Simple Systematically

Keep it simple stupid (KISS) is an old adage some people have taken to heart. One way to portray constructive simplicity is as a modified version of KISS: keep it simple *systematically*. What we mean by 'systematically' is characterized by the process notions developed through this book. 'Stupid' is no longer appropriate, because keeping it simple is one objective, but avoiding simplistic approaches which are inappropriate for a range of reasons is another objective. Everyone understands the desirability of 'keeping it simple'. The trick is doing so without being simplistic.

William of Occam (circa 1285–1349) is widely credited with Occam's Razor, an ancient philosophical principle some believe has much earlier origins. Here is how the Oxford Concise Dictionary of Quotations puts it: no more things should be presumed to exist than are necessary. Ward's (1989) original 'constructive simplicity' concept in terms of models has been equated to Occam's razor by several participants in our seminars, and this is quite a useful analogy for some people. Some readers may find it useful to see the generalized version of 'constructive simplicity' used in this book as a refinement of Occam's razor, with what is 'necessary' varying according to circumstances.

Practical OR studies are often described as 'quick and dirty'. Constructive simplicity can be linked to a competent 'quick and dirty' first-pass analysis, followed by thoughtful and effective subsequent passes if time permits and the circumstances warrant it. However, the adjective 'dirty' is not one we favour; 'quick and constructively simple' suits us rather better. More generally, what the reader calls 'constructive simplicity' does not much matter. What matters are the concepts it embodies, which the authors hope the ten tales will clarify.

This book attempts to build a systematic set of rules for producing efficient and effective decision support processes, by building on the foregoing considerations and synthesizing lessons from the tales. However, the overall paradigm is still emerging, and these are working conclusions not definitive guidelines. The opening quote for this chapter is clearly relevant to those who wish to manage uncertainty. It is also apt for those who wish to further develop constructive simplicity. It sets the tone for the whole book, and it is reflected in the dedication.