Chapter 1

Uncertainty in and around projects

I keep six honest serving men, they taught me all I knew; their names are what and why and when and how and where and who.

—Rudyard Kipling

Uncertainty management as addressed in this book is concerned with clarifying *all* relevant aspects of opportunity, uncertainty and risk in *all* projects. In a plain English sense at a basic level:

'*uncertainty*' means '*lack of certainty*',
'*risk*' means '*possible unfavourable outcomes*',
'*opportunity*' means '*possible favourable outcomes*'.

These three definitions are both basic and general, in the sense that they are consistent with *all* definitions in widely used dictionaries (Oxford Concise, 1995, for example). They are *nominal definitions* in the sense that readers can use their own comparable plain English alternatives if they wish – we do not want to open a book with counterintuitive definitions that inhibit colloquial use of words. More specifically, we do not want to inhibit richer or more specific colloquial interpretations, such as 'an opportunity is usefully seen as an occasion when it is relatively easy to achieve what you want', and 'risk is usually associated with problems and danger'. However, it is crucial to avoid the morass soon encountered if simple common practice technical definitions are used. The three definitions provided above are *basic default definitions*, in the sense that they will serve if the reader is unclear about an unrestrictive basic plain English interpretation.

These nominal/default definitions, or any comparable alternatives the reader may prefer, provide sufficient clarity for our purposes without the need for more restrictive formal definitions. This is because we will introduce explicit working assumptions as needed.

Managing opportunity is our top priority, and the identification and pursuit of opportunity are usually the starting points in terms of enhancing corporate performance. Risk may not be relevant provided it is understood and acceptable. However, uncertainty needs to be understood and managed to clarify both opportunity and risk, and that is why exploring the scope for uncertainty in and around projects is a useful place to start to understand how effective uncertainty management can enhance corporate performance.

An appreciation of the potential for uncertainty management in projects has to be informed by three somewhat different views of 'projects'. One is projects as those concerned with 'operations management' see them. A second is projects as those concerned with 'project management' see them. A third is projects as those concerned with 'corporate management' see them. All three perspectives need a common framework and language for communication.

This three-part perspective requires a clear understanding of the scope of decision making involved in project management and the nature of linked concepts. One key concept is the project lifecycle which forms part of the lifecycle of the asset or change created by a project. This lifecycle is a natural framework for examining decisions and associated uncertainty. A structured view of this lifecycle is also important to provide a framework for looking ahead for sources of uncertainty that can be seeded by decisions in earlier stages of the lifecycle. Further, a structured view of this lifecycle is central to understanding how the 'performance uncertainty management processes' (PUMPs) of central interest in this book ought to change as the lifecycle of the project unfolds and the priorities of associated project management objectives change.

An appreciation of uncertainty also has to draw on Kipling's 'six honest serving men' as identified in the opening quote for this chapter – plus a linked 'resources' concept – for convenience referred to as the seven Ws: 'who', 'why', 'what', 'whichway' (how), 'wherewithal' (using what resources), 'when; and 'where'. That is, to clarify in more detail where and how we need to look for uncertainty that needs managing, project uncertainty management has to be informed by seven basic questions associated with these seven Ws.

Exploring the lifecycle structure and the seven Ws is the central task of this chapter. However, our focus on performance uncertainty management needs to be linked to other aspects of uncertainty management, and it has to ensure that *all* aspects of uncertainty are addressed in a holistic manner. Such concerns are addressed in an introductory manner at the end of this chapter.

Begin by considering a standard definition of a 'project' and the 'asset/change' concepts that underlie it.

Projects and the associated 'asset/change' concepts

Turner (1992) provides a useful illustrative definition of a project:

> *an endeavour in which human, material and financial resources are organized in a novel way, to undertake a unique scope of work of given specification, within constraints of cost and time, so as to achieve unitary, beneficial change, through the delivery of quantified and qualitative objectives.*

Turner's definition covers a very wide variety of projects where the 'beneficial change' to be delivered is a tangible asset of some kind that will subsequently be made use of in an operating mode – such as a building, aeroplane or computer system. It also includes the creation of less tangible assets – such as incremental improvements in operating systems, new ways of working, new knowledge acquisition or a new image creation – that have value beyond the delivery of tangible changes. Further, the acquisition of both tangible and intangible assets may be usefully viewed as changes for some purposes. The term 'asset/change' is sometimes a useful reminder that:

- projects may involve the creation of a physical asset, but it may be useful to view them in terms of the change to the organization or system in which the asset operates; projects may involve changing organizational processes, but it may be useful to view these changes in asset creation terms;
- most projects benefit from both perspectives – simple traditional asset creation terms are convenient sometimes, but management of change terms can be more relevant at other times.

A flexible approach to all terminology can be useful, adapting to the context. For example, a culture change project may be approached in change management terms for most purposes, but the initial concept evaluation of that project needs to value the culture change as an asset to justify the effort and expenditure involved. A new electricity generation power station project may be approached in asset creation terms for most purposes, but the initial concept evaluation of the project needs to value the power station in terms of all related changes to the electric utility's portfolio of assets, cost of capital, operating costs, reliability, plus other changes in terms of all relevant objectives, such as a green (environmentally friendly) image. Table 1.1 lists a sample

Table 1.1 Examples of projects and associated asset/change

Project examples	***Examples of the asset/change created***
The design and construction of new built environment facilities	New office buildings, housing, hospitals, schools, prisons
The design and construction of new production facilities	New power plants, factories, processing plants, production lines, storage facilities, computer facilities
The design and construction of new infrastructure assets	New roads, railways, airports, pipelines, power transmission networks, tunnels, bridges, operational infrastructure, communication networks, leisure facilities
The formulation and implementation of organizational process change	New processes for future working or more efficient and effective arrangements for carrying out operations including new procedures
The acquisition of specified data and its analysis	Additional knowledge/information to inform future decision making and actions
The design and creation of new tools, techniques or decision support systems	New software for data processing, data retrieval or data analysis
The modification of existing assets to improve their utilization and operating performance	Refurbished, upgraded or augmented plant or service facilities
The completion of maintenance work while minimising disruption to operations	Serviced or repaired assets with future operating performance assured or enhanced and extended service life.
The organization of a conference or away day for a management team	Enhanced knowledge for participants, development of relationships with work colleagues, suppliers, contractors, customers via networking and discussions
The change of an organizational culture or organizational reputation	Enhanced effectiveness or enhanced perceived effectiveness or both

of example projects in conjunction with the asset/change delivered to illustrate the variety of organizational changes and assets that may be associated with projects.

Turner's definition highlights the change-inducing nature of projects requiring formal management, the need to organize a variety of resources under significant constraints, and the central role of the objectives to be achieved. It also suggests inherent uncertainty related to a novel organization and a unique scope of work. In our plain English terms this uncertainty may imply risk, but it may not. In our terms this uncertainty always implies potential opportunity – projects without possible 'beneficial change' should be rejected, if 'beneficial change' is sensibly defined. As a central part of effective project management, all relevant uncertainty requires attention to clarify opportunity and risk, and enhance performance.

Much good basic project management practice might be thought of as uncertainty resolution by clarifying what can be done, deciding what has to be done, and ensuring that it gets done. For example, good practice in planning, coordination, setting milestones, and change control procedures seeks to progressively resolve and reduce uncertainty as a project progresses. However, uncertainty management is not just about uncertainty reduction – increasing project uncertainty and risk to seize opportunities or to reduce corporate bankruptcy risk may sometimes be the only rational option – and increasing uncertainty and risk when the rewards are worth it is always important. Uncertainty management as discussed in this book is about recognizing uncertainty wherever it matters, and taking appropriate, timely, decisions in the face of this uncertainty. Most texts on project management or project risk management do not take a sufficiently wide view of project related uncertainty, and most do not explore what a coordinated approach to proactive and reactive uncertainty management can achieve in terms of improved performance from a corporate perspective for the project owner.

Part of understanding where uncertainty matters involves appreciating the context within which a project takes place, and the extent to which this context both affects and is affected by the project. The relevant organizational and environmental contexts and the extent of interactions with a project will obviously vary substantially depending on the nature of a project and its scope of work. Sometimes projects can be viewed in very simple terms as largely independent operations. However, sometimes very complex interactions need attention. To deal with all possibilities we must have a sophisticated view which can be simplified in the most appropriate manner for each practical situation.

Operations, corporate and project-related uncertainty

To put projects and project management in context it is useful to consider the overall task of managing organizations in terms of three basic aspects:

- operations management – managing for 'business as usual';
- corporate management – deciding what changes to make at a corporate strategy level, providing appropriate resources and corporate capability, and ensuring appropriate governance;
- project management – designing and creating specific changes or assets.

In common with other ways of characterizing the task of managing, these three aspects should be seen as intimately related – not as separate 'silos'. Corporate management decisions are influenced by current and desired future operational capability; project management is driven by corporate decisions; and future operations are facilitated by project management that maintains or enhances operational capability. All three aspects involve uncertainty and associated challenges of complexity and novelty. In particular, all three aspects are influenced and affected in related ways by the wider environmental conditions prevailing, and by perceptions about the future operating environment.

Operations management

Operations management – managing existing assets for 'business as usual' – is sometimes seen as a relatively low level of management involving limited novelty. However, depending on the organization, high levels of complexity can be involved because of the need to manage the day-to-day behaviour of operating systems in great detail. Operations issues can be a major driver of strategic change, and major opportunities are often first identified by the people 'at the coal face' in operations management terms. 'Intelligent control' (Leitch, 2008) and intelligent organization and careful deployment of assets are usually crucial. Uncertainty, and the extent of its consequences, is typically minimized by frequent or continuous adjustments to operating processes in a control sense. Necessary or efficient specialization encourages a silo approach to various sources of operational uncertainty often involving a number of specialist functions focused on different aspects of control. However, the implications often ripple through the whole organization – as with approaches to health and safety, for example.

Sources of uncertainty can be internal to an operation, associated with the behaviour of employees and other assets, and their interactions, including communications and the provision and use of information. External sources of uncertainty are virtually infinite, but those that can materially affect operational performance are usually the only issues of interest. Further narrowing of attention is possible if only a short-term view of the future operating environment is taken. However, the choice of an appropriate operating horizon depends upon perspective and capability, shaped by the responsibility for making desirable adjustments. At a low level of operations management, horizons may be very short, even hours or minutes, and processes are largely routine, based on extensive experience and perhaps trial and error adjustments. At higher levels of operations management attention is on progressively more aggregated operations, which involves a wider set of contextual factors and related uncertainties, and usually longer planning horizons.

In most organizations, operational interdependencies between assets are significant. Shared objectives, shared supporting resources and common sources of uncertainty may be involved. Further, creating new assets may impact other assets, with goodwill and important relationships being particularly exposed if such effects are overlooked. Consequently, at almost any level in an operations hierarchy, concerns about managing uncertainty can have wider implications for other parts of the organization or strategic implications for the organization as a whole. These strategic implications might relate to the capability of current operational capacity and assets, and their ability to perform into the future. Any strategy formulation process needs to understand this capability, and the nature of all the major sources of uncertainty that can impact on future operational performance, whether these sources are internal or external to the organization. Operational uncertainty, be it short or long term, should be a key driver of strategy.

Corporate management

The uncertainty that must be addressed as part of corporate strategy management includes all significant sources related to operations just discussed. It also includes all significant uncertainty related to necessary resources and corporate capability. Further, it includes all significant uncertainty about the ambitions and aspirations of senior management and key stakeholders, and in relation to the interpretation of the organization's mission and key objectives. The scope of possible future ventures may be very uncertain, their desirability may be uncertain, and the extent to which these ventures need to be related to existing operations and assets may also be unclear. Part of the challenge of strategic management is to identify potential investment options that are suitable, feasible and acceptable in a very uncertain environment (Johnson et al., 2005). Strategy formulation involves developing a coherent and effective set of future investment options that will deliver specified benefits over some future time period. Part of the context is an existing portfolio of assets, current operations, future plans and commitments. Another part of the context is an uncertain environment.

In a top-down approach, long-term corporate strategy leads to the development of a hierarchy of projects reflecting long, medium and short-term planning. Long-term strategy is implemented via a programme of medium-term projects. These in turn may be achieved by a programme of linked, short-term projects, potentially constrained by short-term operations. Scope for managing sources of uncertainty exists at each level, reflecting the corresponding key issues at each level. However, management at each level also needs to be aware of potential impacts from adjacent levels. In particular, managers of medium-term projects need to take into account the potential impacts on their projects from both short-term and long-term issues.

Project management

It can also be important to appreciate and manage how a given project relates to other concurrent projects. For example, a project may be one part of a larger project, part of a portfolio of largely separate projects, part of a sequence of projects, or may itself be managed as a set of sub-projects. Figure 1.1 illustrates three basic interconnected project structures: the chain configuration, the parallel configuration and the project hierarchy.

In the chain configuration a sequence of component projects follows one another over time to complete a 'primary project' which overarches 'component projects', which are 'secondary'. In the parallel configuration a number of component projects run simultaneously, perhaps with interdependencies, to complete an overarching, primary project. In a project hierarchy the primary project is broken down by management into a hierarchy of component projects. The project hierarchy shown in Figure 1.1(c) is a simple example with embedded parallel and chain configurations. Much more complex configurations involving a combination of these three configuration types are employed in most organizations. In slightly different language, one person's project may be an activity in someone else's higher level project – different levels of decomposition may serve the needs of different levels of management.

Large engineering or construction projects are invariably managed as project hierarchies. Large projects may be managed as a set of component projects running in parallel, with each parallel

(a) Chain configuration: stages in a primary project may be managed as a chain of component projects.

(b) Parallel configuration: aspects of a primary project may be managed as a set of parallel component projects.

(c) Project hierarchy: the primary project as a three-level hierarchy of component projects.

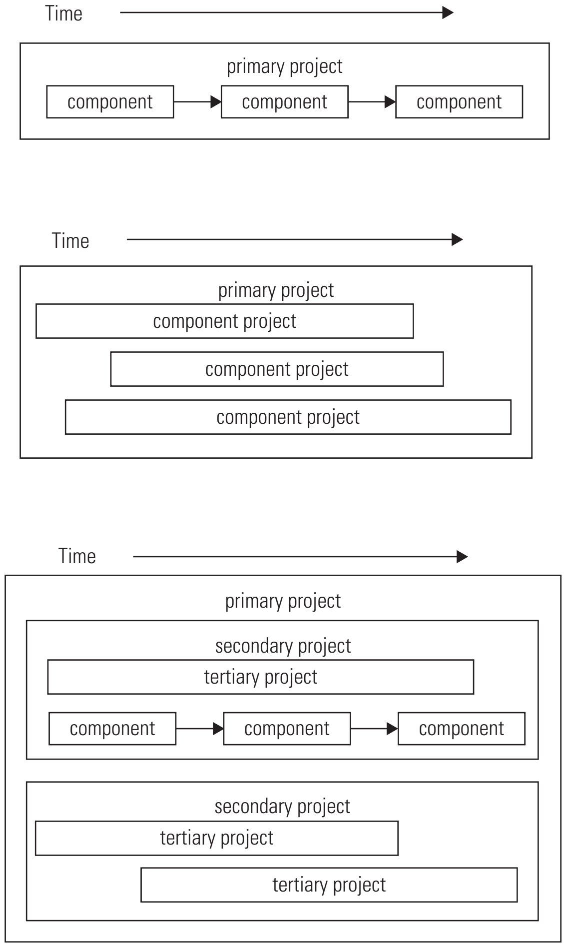

Figure 1.1 Example configurations of project systems

component comprising a hierarchy of component projects. Management of the 'primary project' can be tackled as a complex version of project management and is typically managed at a more senior level than management of the component projects. As a practical matter, managers of primary projects may not be interested in the 'nuts and bolts' of individual component projects, but they will have to understand them well enough to ensure that the component projects fit together as a whole.

The primary project may be thought of by senior management in terms which go beyond that associated with individual component projects – that is, as a strategy or long-term programme, using 'programme' in a 'portfolio of projects' sense, with links between the component projects defined by shared objectives, resources or other factors. For some purposes 'programmes' and 'portfolios' can be usefully distinguished from each other and from 'projects', but this book uses 'projects' in a generic sense which includes programmes and portfolios. It follows that we have to address a spectrum of project complexity, from very strategic projects that are usefully seen as portfolios of programmes for some purposes, to very tactical projects that are usefully seen as single activities or tasks for some purposes.

We shall not engage directly with alternative approaches to 'complexity' or alternative views of 'project', 'programme' or 'portfolio' distinctions, but we will address common concerns from an uncertainty management perspective using an inclusive 'project' concept. Readers may interpret what we are saying in 'programme' or 'other portfolio of projects' terms when such distinctions are appropriate. This issue is revisited briefly at the end of Chapter 12.

The following example illustrates some of the interconnectedness between the management of uncertainty in corporate, operations and portfolio/programme/project management.

Ontario Hydro example

At the beginning of the 1990s Ontario Hydro in Canada developed a 25-year strategic plan which included ten new nuclear power stations. They sought Ontario government permission to proceed with the whole plan. The approval process involved official 'interveners' making a case to receive funding from Ontario Hydro to challenge the basis of the plans. The Independent Power Producers Society of Ontario (IPPSO), representing all non-government power producers, received funding for a critical report on Ontario Hydro's approach to strategic planning prepared by Chris Chapman (1992a).

The report's argument was in two parts. First, confidence bands on Ontario Hydro's load forecast should have been several times wider; other uncertainties were similarly underestimated and, as a consequence of these uncertainties, the Ontario Hydro approach to strategic decision making was not fit for the intended purpose. Second, a very different planning approach, outlined in some detail, was needed. The mathematical optimization approach adopted by Ontario Hydro was flawed because the optimization did not consider uncertainty. But the common practice of addressing uncertainty via scenario robustness tests was not 'risk efficient' in a basic 'portfolio theory' sense, and Ontario Hydro's search for optimality was sound in principle if not in practice.

The applied research funded by the report writing exercise was an opportunity to integrate the thinking underlying this book's advocated approach to project uncertainty management with strategic uncertainty management and operations uncertainty management. About two weeks before Chris Chapman was to appear as an expert witness, demand fell outside Ontario Hydro's confidence band, and the strategic plan was withdrawn. This was clearly *very* lucky for IPPSO. The first part of Chris Chapman's report was validated in traditional empirical terms. The second part remains debatable, but the basic approach to integrating strategy, operations and projects outlined in Chapman (1992a) and developed in Chapman and Ward (2002, chapter 11) illustrates how to approach the management of the interdependencies between operations, strategy and 'projects' defined to include programmes and portfolios of projects.

We will return to this example in Part III, and draw on it occasionally in the interim. Of immediate interest are two points. First, an approach to corporate and operations management compatible with this book's approach to project uncertainty management was needed as a starting point for operational development. Second, the way a utility such as Ontario Hydro has to approach the operations–corporate–projects spectrum illustrates the nature of these interdependences when a top-down strategic perspective is adopted.

Viewing Ontario Hydro's uncertainty structure might start with a corporate level assessment of annual profit, P_t, equal to annual revenue, R_t, less annual costs, C_t, for $t = 1, 2, \ldots,$ n, up to the chosen long-term planning horizon, $n = 25$ years, for example.

Revenue is a key source of uncertainty, worthy of a major uncertainty management effort. Forecast demand will be central here, in terms of consumer demand and industrial demand, with considerable underlying complexity and interactions in both cases. Also important are existing competing utilities, possible new competitors, market regulators, and political players concerned with relevant conservation and environmental issues.

Cost is also important. At the corporate level, cost is driven by long-term strategic planning decisions: What mix of sources of power should be aimed for 25 years hence? What proportion of nuclear, gas-fired, coal-fired units should be planned for? and so on. Through-life costs will be important, including fuel costs, the effects of environmental legislation or technology development, and liability for pollution or accidents.

At a basic operational level, management is concerned with cost effective day-to-day utilization of existing units. At an intermediate level, an important management concern is the timing of decisions to start building new power-generating units. Such decisions may be coupled to both short-term operational issues and longer-term strategic issues. The sudden failure of an existing unit may trigger a need to bring plans forward. Political events may significantly alter the need for a planned unit; or perhaps even eliminate the need for a unit; possibly doing so when construction of the unit is already underway.

The project manager for the construction of such a unit clearly needs to manage the project in a way that deals effectively with the sources of uncertainty for which he or she is responsible, and ensure that the sources of uncertainty for which other members of the organization are responsible are managed in a supportive manner. The director to whom the project manager reports, and all the directors responsible for the way the project fits into the corporate portfolio of projects, also need to understand and manage all important relationships across the operations–corporate–projects spectrum.

Most project managers have comparable concerns, but the relationship between their project and the rest of the organization may be more ambiguous, and a source of uncertainty needing attention. Most directors of organizations with a direct interest in projects also have comparable concerns, often with greater complexity and ambiguity.

Ontario Hydro had a lot of uncertainty to deal with. It is a useful example for the present purposes because its structure is intuitively obvious to most people, and an approach flexible enough to deal with all relevant uncertainty for this kind of utility can be adapted by most other organizations. At the same time, its uncertainty is easily structured by comparison to some organizations. It has only one product – electricity – and the assets are tangible and relatively inflexible. It will also be a useful example to build on later, especially in Part III.

Operations, project and corporate aspects of a single asset

All projects should originate from some level of corporate strategy formulation in the project sponsoring organization. This is usually the case for projects involving substantial investment in the delivery of an asset involving significant corporate change, but it may not be so apparent with projects involving smaller levels of investment or corporate change. Similarly, all projects, whatever their size or impact, ought to involve consideration of any relevant sources of uncertainty that affect both the creation of an asset and its subsequent operational performance, and any corporate change implications. This consideration should include the complete set of corporate sources of uncertainty that impact on an individual project and may require responses from the project manager or other parties. Motivation to undertake this uncertainty analysis in a top-down strategic manner needs to come from the organization's board level managers. Ideally this will be undertaken using an approach comparable to a suitable adaptation of that outlined for Ontario Hydro in Chapman (1992a), its generalization in Chapman and Ward (2002, ch. 11) and its brief treatment in Part III. However, even if a project manager's organization chooses to ignore such issues completely, a competent manager of project uncertainty should not do so.

The focus of this section is projects associated with a single asset. Putting aside the issues noted in the preceding paragraph, linkages between operations, corporate and project management perspectives also exist within the context of a single (primary) project and the associated asset/change lifecycle. Table 1.2 portrays a traditional view of the relationship between the three basic aspects of management and a generic asset lifecycle characterized as four basic stages: conceptualization, planning, execution and delivery, and utilization.

The conceptualization stage encapsulates concept development and the development of a business case for investing in the asset concept. It may be initiated bottom-up to meet operations needs, or top-down to meet corporate level strategic needs, but corporate management considerations usually dominate the end of the conceptualization stage and the beginning of the planning stage. The planning stage encapsulates a complex and potentially lengthy process that begins at a strategic level and progressively refines the design of the asset, an understanding of intended benefits from the asset, how it will be used, how it will be created, what resources will be needed, and when and how it is to be delivered. The execution and delivery stage encapsulates the implementation of plans for the creation and delivery of the asset, with project management preparing for this during much of the planning stage. The utilization stage encapsulates the operation of the asset throughout its operating life to eventual termination of use, with operations staff building on their earlier contribution to the planning stage, assuming they were involved earlier.

This portrayal of the lifecycle uses the term 'stage' rather than the common alternative 'phase' to reserve 'phase' for discussions on related processes. A range of labels similar to those used for Table 1.2 stages may be found in the literature behind this simple four-stage structure, along with alternative views of why such a structure is useful. The asset lifecycle is a convenient way of conceptualizing the generic structure of projects over time for a wide range of purposes. An

Table 1.2 A traditional four stage view of the asset lifecycle and dominant management aspects

Basic lifecycle stages	***Dominant management aspect***
Conceptualization	Operations or corporate management initially, then corporate management
Planning	Corporate management initially, then project management
Execution and delivery	Project management
Utilization	Operations management

alternative terminology example is 'formation', 'build-up', 'main programme' and 'phase-out' (Thamhain and Wileman, 1975), but the underlying structure is essentially the same. Whatever the stage terminology, these stages are commonly described in terms of the extent to which they differ in the level of resources employed (Adams and Barndt, 1988), the degree of definition, the level of conflict (Thamhain and Wileman, 1975), the rate of expenditure, and so on. This can help to show how management attention to the factor being considered needs to vary over the lifecycle. More recent references in the project lifecycle literature include Tummala and Burchett (1999), and Bonnai et al. (2002).

The way the traditional dominant management aspect pattern portrayed in Table 1.2 changes over time, and the lack of real separability between these management aspects, encourages a wide range of different and more detailed project lifecycle structures in different project contexts to ensure that who does what, when and how, in an orderly manner, is clearly defined. For example, the UK rail industry has developed an eight-stage investment lifecycle as part of its GRIP (Guide to Railway Investment Projects) process (Network Rail, 2007) which is widely cited.

Looking at Table 1.2 from an uncertainty management perspective, responsibility for each stage in the lifecycle is clearly important, but the dominant issue is ensuring that all uncertainty associated with different stages of the lifecycle receives appropriate and timely attention. Maximizing the opportunities presented by the creation of proposed assets warrants careful attention to all stages of the asset lifecycle, taken together as a whole, as well as attention to the role the asset will play in the context of the asset owner's other investments and operations.

Taking a traditional corporate management perspective, the basic form, timing, cost and envisaged benefits from the proposed asset are a central concern. From this perspective the prospective asset owner will be considering the need for the proposed investment and the opportunity it represents in the context of an existing portfolio of assets, current operations and the future shape of both. Deliberations can be challenging due to high levels of uncertainty about what is desirable, possible and affordable, future operating conditions, and how the proposed asset will perform as part of a portfolio of existing and future assets. This warrants early consideration of later stages in the asset lifecycle. For example, in projects that involve the large-scale use of new and untried technology, design and future operating issues can be a very early focus in preparing a business case.

With a conventional project management perspective, the central concern is determining how to create the proposed asset once conceptualization and planning have reached a sufficiently well-defined point. Project management in these terms often begins with more detailed design planning and working to create and deliver the required asset at a detailed planning level. Approaches to project management have become increasingly sophisticated, particularly in respect of the design and construction of large physical assets such as infrastructure, buildings, processing plants, transport vehicles, etc. This has led to the development and formalization of the processes involved. Such formalization has encouraged the 'projectification' of all kinds of organizational initiatives in the hope or expectation that the application of project management techniques will bring about a more timely, beneficial and cost effective delivery of initiatives in an organization.

However, critics of conventional project management argue that the focus of project management has been much too narrow, with an overemphasis on execution and delivery of given asset specifications. Conventional project management techniques may help to deliver efficiently well-defined prespecified assets within a well-defined, relatively stable environment, but, critics argue, where asset design and construction is more fluid or uncertain, a wider perspective of associated uncertainty is needed. Further, in some contexts conditioning on (assuming fixed) cost and time, and treating performance as variable, may be more practical than conditioning on performance and treating time and cost as variables. In addition, critics argue that project management should encompass the 'front end' project definition phase – that is both the conceptualization and planning stages in Table 1.2 – and in particular that project management should include a concern for the operational benefits to be derived from a created asset, not just performance of execution and delivery. Morris (2009, p. 60) puts the argument as follows:

> *. . . shaping and delivering projects requires that directions be established, value optimized and opportunities created. Projects need to produce business value as well as deliver predictable outcomes. Both are needed. But whereas most project managers are happy to see themselves as efficient execution tacticians, the prize is for project managers to begin thinking about how the project, as it is developed, can enhance the value of the sponsor's strategic position.*

When considering the management of uncertainty from an asset lifecycle perspective, this wider view of projects and project management seems entirely appropriate, and even essential. In this sense the discipline and techniques of common practice project management may be considered of limited use in managing strategy or programmes, leading to excessive separation of strategy (primary project or programme) management and project management of the component projects. This separation may be formalized by organizational structures, and may increase the chances of the uncertainty management of component projects being treated separately from the consideration of strategic uncertainty, risk and opportunity. An obvious example is a contracting organization where the ongoing business involves tendering for individual contracts. Each contract won is treated as a project, and these contracts form a mixture of the chain and parallel configurations in Figure 1.1. Interdependencies exist between contracts to the extent that they utilize common corporate knowledge, skills and other resources. An important task for senior management is to manage the (often implicit) primary project – the organization's short and long-term strategy. Unless this is managed explicitly at 'the top', strategy is likely to emerge *ad hoc* and 'bottom-up' in an unintended rather than deliberate manner (Mintzberg, 1978).

A lifecycle stage structure with a 'purpose' focus

Characterization of the asset lifecycle as four sequential stages starts to indicate the scope of the basic tasks involved from operations, corporate and project management perspectives and the associated scope of uncertainty that warrants attention. However, a more detailed consideration of the four basic stages of conceptualization, planning, execution and delivery, and utilization with a purpose focus as portrayed by Table 1.3 provides deeper insight into the scope of decisions involved in different parts of the lifecycle: the goals being addressed; the identity of the main players; and the extent and nature of the uncertainty involved. In particular, elaborating Table 1.2 as Table 1.3, suggests three areas of concern.

Table 1.3 A 12-stage *nominal* project (asset/change) lifecycle with a purpose focus

Four basic stages	***Stage purposes***	***Steps***	***Labels***
Conceptualization	Concept, project objectives and business case development in corporate strategy terms	Trigger event Concept capture Clarification of project purpose Concept elaboration Business case development Concept, objectives and business case evaluation in corporate strategy terms	**Concept shaping**
	Governance	Consolidate plans and confirm deliverables	**Concept gateway**
Planning	Design, operations and termination (DOT) strategy development from a design and operations management perspective	Design and operations strategy capture from corporate strategy Development of lifecycle performance criteria Integrated development of design, operations and termination strategy Integrated evaluation of design, operations and termination strategy	**DOT shaping**
	Governance	Consolidate plans and confirm deliverables	**DOT gateway**
	Execution and delivery (E&D) strategy development from a project management perspective	Activity and related resource use capture from corporate strategy and design strategy Development of timing targets and milestones Strategic plan development for execution and delivery Evaluation of execution and delivery strategy	**E&D shaping**
	Governance	Consolidate plans and confirm deliverables	**Strategy gateway**
	Detailed design and planning for execution, delivery, operation and termination purposes	Shifting the perspective to implementation Development of detailed design and planning criteria for implementation purposes Development of detail designs and plans Development of resource allocation and contracting criteria Detailed design and plan evaluation	**Tactics shaping**
	Governance	Consolidate plans and confirm deliverables	**Tactics gateways**
Execution and delivery	Execution	Implementation of actions plans Coordinate, control and monitor progress Modification of all targets, commitments and resource allocations as needed Ongoing execution evaluation	**Execution**
	Delivery	Undertake delivery Deliverable modification Manage stakeholder expectations about delivery and operational performance Delivery evaluation	**Delivery**
Utilization	Operation and support (O&S)	Operational utilization of asset Ongoing development of operations & support criteria Ongoing development of operations & support Ongoing operations & support evaluation	**O&S**
	Termination	Development of detailed plans for transfer of ownership or replacement or decommissioning Termination execution Termination evaluation	**Termination**

First, it is important to distinguish between strategic planning for operations, project execution and corporate strategy purposes. They are related but involve different purposes – a different 'why' in Kipling's terms, with implications for the 'who'.

Second, it is important to distinguish between strategic and tactical planning for all purposes, and to ensure that all strategic planning precedes all tactical planning. Strategic and tactical planning also serve different purposes and often involve different people. In our terms 'strategic planning' must include detailed design and detailed planning to test strategy when appropriate, but detailed design and planning for execution, delivery, operations and termination purposes is associate with 'tactical planning'. It is often useful to recognize an important boundary after the strategy gateway stage, when 'strategy shaping' ends and strategy implementation begins with 'tactics shaping', especially if a contractor responsible for execution and delivery is also given responsibility for detailed planning for execution and delivery purposes. Separating detailed planning to test strategy when appropriate, and detailed planning to implement strategy, helps to facilitate clarity about this boundary.

Third, it is important to understand the difference between 'evaluation' for corporate governance approval purposes and 'evaluation' for internal control of a management process designed to be iterative – again a different 'why' and 'who' are involved.

The second column of Table 1.3 breaks down the basic four-stage characterization of the asset lifecycle. It uses eight stages with traditional lifecycle stage functions. It also uses four 'gateway' processes involving consolidation of plans to date and associated governance, usefully treated as if they were stages. This makes 12 stages in total. It does so in a way that explains the key objectives or 'purpose' of these 12 component stages – the 'why'. The reason more divisions than the traditional basic four are useful is that greater clarity about the purpose of each stage leads to simpler and more effective processes. *Simple and effective processes* are goals that matter.

For simplicity we will often refer to 'the project lifecycle' or just 'the lifecycle', with the default meaning 'the project (asset/change) lifecycle of Figure 1.3' – all 12 notional stages or some comparable equivalent. However, sometimes we will use 'asset lifecycle' to emphasize that we are talking about the whole lifecycle from a client's corporate perspective. Further, sometimes it is important to recognize that some people may use a 'project lifecycle' that starts much later and ends much sooner – for example, a contractor hired to complete a task within one or two stages of a broader client's perspective of 'the project' is working with different lifecycle and project concepts.

The third column of Table 1.3 breaks each stage into 'steps'. The breakdown into stages goes some way towards highlighting important sources of uncertainty and facilitating their management as well as clarifying different purposes. However, the more detailed description of the lifecycle provided by the steps in Table 1.3 is useful to underline where particular sources of uncertainty arise in the lifecycle and how uncertainty management might be most effective. In the early lifecycle stages these steps imply a process of gradually increasing detail and a focus on the nature of the deliverable asset. Later steps focus on delivery and operation of the asset followed by termination in the sense of decommissioning or selling an asset.

For reference purposes the column two 'stage purpose' descriptions are abbreviated to lifecycle stage 'labels' in column four. There is a good argument for adding the word 'strategic' to all the labels for the first five stages – they are all focused on strategy, and a constant reminder can be useful in some contexts. There is also a good case for using '*overall* strategy gateway' as the label for the sixth stage. Further, the design and operations management perspective of the DOT-shaping stage versus the more traditional project management perspective of the E&D-shaping stage may need emphasis sometimes. Finally, the DOT label does not have its common USA interpretation 'Department of Transportation' – an illustration of the virtually impossible task of always using uniquely identified acronyms. However, the labels adopted here are as simple as possible while avoiding obvious ambiguity. They are *nominal* in the sense that if additional words or alternative labels will make communication clearer, such adaptation is clearly desirable and should be used. This notion applies to much of our recommended terminology – there is no need to be dogmatic about terminology *provided everyone understands what is being said – it is the concepts that really matter*. Using minimal labels when the meaning is clear, but adding additional words for clarity whenever this might be useful, is a policy adopted throughout this book. It is also a policy which is highly recommended as a corporate strategy. In our experience simple 'handles' are a form of jargon practitioners need for efficient communication when they all understand each other, but such jargon can seriously impede effective communication when they do not, and effectiveness can be the key.

The lifecycle structure of Table 1.3 is also *nominal* in the sense that alternatives can be used whenever appropriate, but effective uncertainty management should not oversimplify any of the distinctions that matter.

Any organization adopting the uncertainty management approach advocated in this book may wish to preserve features of lifecycle structure variants from Table 1.3 for a range of corporate reasons which go beyond the purposes of project uncertainty management. However, this book assumes that the features of the Table 1.3 *nominal* structure will be preserved, in the sense that compatible expansion of the components may be involved for other purposes, but not a collapse of components which would lead to confusion. An agreed synthesis of Table 1.3 or equivalents, with appropriate simple labels for all stages, is an essential aspect of full integration of project uncertainty management with all other aspects of project management, including integration with operations and strategic concerns. Table 1.3 is a *nominal* framework because it may need simplification or elaboration according to the context in which it is used.

Concept shaping

The concept shaping stage involves strategic planning from a corporate perspective, although it may be initiated top-down or bottom-up. Top-down is often assumed, but bottom-up is often a more important source of strategic initiatives – a marketing department sees new market opportunities, a research and development department sees new product opportunities, a production department sees new manufacturing process possibilities, and so on. This stage involves identifying a deliverable asset to be produced by a project and the benefits expected from the deliverable. In essence, this involves an innovation process that begins with a 'trigger event' (Lyles, 1981), when a member of an initiating organization perceives an opportunity or need for a new asset or an organizational change. At this point the project deliverable may be only a vague idea, and some initial development may be associated with the 'concept capture' step. 'Clarification of purpose of the possible asset' should involve the identification of operational performance objectives and their relative importance to relevant stakeholders, and associated design and delivery criteria. This step may be problematic to the extent that different views about the appropriate objectives are held by influential stakeholders who try to negotiate mutually acceptable objectives. At this stage objectives are likely to be ill-defined or developed as aspirations expressed as constraints (for example: latest completion date, minimum levels of functionality, maximum capital cost, and so on).

Before the concept can be developed further, in 'concept elaboration' and 'business case development' steps, sufficient political support for the idea must be obtained and resources allocated to allow the idea to be refined and made more explicit. Other individuals, organizations or potential stakeholders may become involved. At this stage support from stakeholders may be passive, merely allowing conceptualization to proceed, rather than an expression of positive approval of the project.

Eventually an evaluation of the asset concept, objectives and business case, as defined to date, becomes necessary. The last step for the concept shaping stage is an internal evaluation by the team responsible for concept shaping at this point. It purpose is iteration control. Evaluation for iteration control purposes here (and in later stages) is not simply a 'yes/no' or 'go/no-go' decision – a 'maybe' possibility is very likely and should be anticipated for early iterations, when a 'maybe' decision involves a *planned* iteration through one or more previous steps. For reasons explored later, it is not cost effective to manage uncertainty using a single-pass process. Early passes are about sizing uncertainty, asking 'Does it matter?' Later passes are about 'Where it matters most, what would be the best way to approach managing it?' A 'go' decision takes the process on to the next stage. A 'no-go' decision causes further investment in the project to stop, possibly subject to governance confirmation, or possibly a pause in the project's evolution rather than its elimination.

Concept gateway

It is useful to separate the concept gateway stage because it serves a very different purpose from concept shaping. The parties initiating and controlling the concept shaping stage should be taking a corporate perspective, but they are likely to have views of what matters most which are rooted in particular parts of the organization. The concept gateway is about consolidating the plans as shaped in the first stage for communication outside the concept stage team followed by appropriate governance – ensuring that a balanced overall corporate perspective decides whether more money and effort should be invested in developing plans for the asset or not. A 'maybe' decision is a possibility, but a resulting iteration is *unplanned* and usually unwelcome. A 'no-go' decision may be the appropriate choice, and no loss of reputation for anyone involved may be appropriate. A 'go' decision takes the lifecycle on to the next stage.

Design, operations and termination (DOT) shaping

DOT shaping initiates design, operations and termination strategy formulation, beginning with design and operations strategy capture from the corporate strategy of the concept shaping stage. This usually requires a step increase in the effort and resources involved. The sequence of the words 'design' and 'operations' reflects the usual precedence ordering, but future operation of the proposed asset or corporate changes might be addressed before design to emphasize the importance of future operations at this stage in the lifecycle, with step titles indicating that design is operations-led in practice.

'Development of lifecycle performance criteria' builds on the basic design and operations objectives from the first stage. For many projects this involves refining such objectives, but it may involve the identification of additional objectives and further negotiation where pluralistic views persist among relevant stakeholders. This step influences an 'integrated *development* of design, operations and termination' that leads to 'integrated *evaluation* of design, operations and termination' using the developed performance criteria to assess the current asset design in 'go/no-go/maybe' terms.

As in the concept stage, a 'no-go' evaluation should kill the project or put it on hold. A 'maybe' evaluation is most likely to lead to iteration through one or more development steps, and such loops should be expected *planned* iterations, because this is the most effective way to manage uncertainty. If fundamental difficulties that were not anticipated in the concept stage are encountered, the concept stage may be revisited, but this is an *unplanned* iteration. A 'go' decision takes the lifecycle on to the next governance gateway stage.

Building any relevant termination considerations into the design and operations strategy needs attention in this stage if this was not addressed earlier.

Design, operations and termination (DOT) gateway

The DOT gateway is a consolidation process followed by a governance process with the same role as the concept gateway – deciding whether more money and effort should be spent on proceeding to planning for execution and delivery from a balanced perspective considering overall corporate strategy. A 'maybe' decision is a possibility, but a resulting iteration is *unplanned* and usually unwelcome. A 'no-go' decision may be the appropriate choice, with possible loss of reputation issues if the first gateway 'go' was a clear mistake. A 'go' decision takes the lifecycle on to the next stage.

Execution and delivery (E&D) shaping

The E&D shaping stage initiates formal capture and development of activity and resource use plans at a strategic level, indicating how the asset design will be executed and delivered, and the resources that will be required by these activities in broad terms. 'Development of delivery targets and milestones' involves reconciling how long execution and delivery should take and how long various parties would like it to take. Even more individuals and organizations may become involved. 'Strategic plan development for execution and delivery' follows. This leads to 'evaluation of execution and delivery strategy' in 'go/no-go/maybe' terms.

A 'maybe' decision may require further development of strategic plans, including targets and milestones within the E&D-shaping stage, as part of a process planned to be iterative because this is the most effective way to manage uncertainty. More fundamental difficulties may take the process back to asset design and operations strategy development, or even to concept development, but this would be an *unplanned* iteration. A 'no-go' decision kills the project or puts it on hold, usually subject to gateway approval. A 'go' decision takes the lifecycle on to the next gateway stage.

Strategy gateway

The strategy gateway is a consolidation process followed by a governance process with the same role as the earlier gateways – deciding whether more money and effort should be spent on the project from a balanced perspective considering overall corporate strategy. However, this time the '*overall* strategy gateway' can be a useful label extension because *all relevant aspects of strategy* are involved. This includes E&D strategy as shaped by the preceding stage plus updates to asset design, operations and termination strategy as defined at the DOT gateway. It also includes updates to the overall concept and business case strategy as initially defined at the concept gateway and possibly updated at the DOT gateway. Further, the *overall* strategy gateway is a significant 'watershed', a stage where turning around later means significant extra effort, because expenditure on the project grows at an increasing rate from now on if it progresses. A 'maybe' decision is a possibility, but a resulting iteration is *unplanned* and unwelcome. A 'no-go' decision may be the appropriate choice, with possible loss of reputation issues if either of the first two gateway 'go' decisions were a clear mistake. A 'go' decision takes the lifecycle on to the next stage, but later 'no-go' or 'maybe' decisions could be severely 'career limiting'.

Tactics shaping

Tactics shaping involves an important shift in perspective – to the implementation of a strategy which is assumed to be robust and viable. 'Shifting the perspective to implementation' is a useful first step to ensure that everyone involved appreciates this transition.

Separate tactics shaping is needed for asset design, execution, delivery, operations and support, then termination – in that order of priority. Operations tactics shaping might be delayed for some time – provided the design strategy does not need to be revisited – and does not need to be completed until the O&S stage is about to begin. Termination tactics shaping can be deferred until needed for the termination phase. A detailed allocation of resources and contracts to achieve the design and implement the execution activities is part of the initial priorities. But it is useful to begin with the 'development of detailed design and plan criteria'. This includes issues such as clarifying the level of detail needed, and the extent to which those executing the project can be left to 'plan as they go' as part of execution. Subsequent 'detailed plan development' has to build on this basis.

The tactics shaping stage is a significant task involving decisions about execution and delivery organization, identification of appropriate participants and allocation of tasks between them. Resource allocation and associated contracting with a view to project execution requires much more detail than earlier stages.

Either implicitly or explicitly, the tactics shaping stage involves the allocation of execution uncertainty and associated risk and opportunity between participants unless this has been done earlier. Risk and opportunity allocation is an important source of project uncertainty because it can significantly influence the behaviour of participants and hence impact on project performance – and how best to do it is itself often very uncertain. In particular, allocation of execution and later stage uncertainty influences the extent and manner in which such uncertainty is managed. This warrants careful consideration of the basis for allocating tasks, uncertainty, risk and opportunity in the 'development of resource allocation and contracting criteria' step.

'Detailed plan development' necessarily involves revising detailed design and planning in order to allocate tasks unless this whole stage is contracted out along with the balance of the project. Contract and subcontract structures may require development. Indeed, in some cases 'tactics shaping *including contracting*' would be a better label for this stage, unless contracting was addressed earlier – as in design and build or design, build and operate contracts (with or without a 'transfer' stage), which should be addressed initially in the concept-shaping stage.

The nature of the issues changes with the change of stage as with all earlier stage transitions, and the level of effort escalates as noted earlier.

As in the earlier lifecycle stages, development during this stage is followed by a 'detailed design and plan evaluation'. A 'maybe' decision which requires revisions to aspects of detailed designs or plans should be seen as part of the iterative process of shaping details effectively and efficiently – a *planned* iteration. A 'maybe' decision which involves changes at a strategic level to execution and delivery plans, design and operations strategy, or concept strategy, is usually extremely unwelcome, and a 'no-go' decision will be seen as a serious disaster in many cases. If the 'devil is in the detail', earlier shaping and governance evaluation steps will be seen to have failed unless the environment in which the organization operates has changed to an extent that even risk efficient and robust planning could not have anticipated.

Tactics gateways and a start of execution gateway

Tactics gateways for various aspects of detailed designs and plans provide a pre-execution consolidation of plans and a governance check on internal evaluations used initially for iteration control. They have to assess detail in the context of corporate, operations and project strategy when appropriate. A 'start of execution' gateway can be a useful summary concept for all details gateways relevant to a 'start of execution' decision – a recommended enhancement of the *nominal* Table 1.3 structure.

Separation of consolidation and governance in the four gateway stages

Separation of the four gateway stages from the shaping processes leading to them has benefits which will become clear when the details are considered later, if they are not clear now. One key benefit is distinguishing between *planned* iterations, which are an inherent aspect of effective uncertainty management, and *unplanned* iterations due to earlier shaping and governance evaluation failures. Other aspects include distinguishing the responsible party and the purpose of the exercise, the processes used, and the outcomes of the processes. There is a growing concern about the effectiveness of common practice governance processes. One key issue worth noting now is that governance should test the validity of all plans and associated decisions as well as the processes used to develop the plans and make the decisions. Put slightly differently, it should consider *all* relevant assumptions – working assumptions and framing assumptions.

Separation of three aspects of strategic planning and all tactical planning

The decomposition of the Table 1.2 'planning stage' into six stages helps to distinguish the very different management purposes and attendant issues in all eight of the stages considered above. A possible argument against this decomposition is the interdependent nature of the eight stages, and the need to iterate between them. However, the importance of this dependence, and the process threats and opportunities it generates, is highlighted by their separation. Each stage involves quite different tasks, different goals and end products, different levels of detail in some cases, and different sources of process uncertainty. The importance of decisions to move from each stage to the next increases with each successive stage, because the costs of going back a stage or more escalates. This makes it important to treat the planning stages as separable, while recognizing important interdependencies between them.

There is a very strong case for a clear boundary between the overall strategy gateway and tactics shaping, *provided* strategy is effectively tested by detailed planning on a selective basis when appropriate. Given this proviso, there is a good case for allowing tactics shaping and associated gateways to overlap execution in those areas where this will not lead to delay. For example, shaping tactical plans for the operations stage or the termination stage can wait until they are needed, and some areas of detailed design or tactics shaping for execution may overlap the execution stage.

Assuming a strict boundary can simplify the nominal lifecycle structure. Its relaxation may be important in practice, but the resulting risk needs to be understood.

Execution

The start of the execution stage initiates the main work of the project from the project manager's perspective. The start of this stage signals the start of order-of-magnitude increases in effort and expenditure. The planning is over, the action begins. The four individual steps in this stage are obviously basic project management; they are not worth detailed development here, other than noting that all plan revisions can be supported by a variant of the steps used earlier.

During execution, the essential process threat is that coordination and control procedures prove inadequate. A common perceived threat in the execute stage is the introduction of design changes, but these may be the result of earlier sources of uncertainty, including opportunities that should have been noticed earlier to take full advantage of them. Consequent adjustments to production plans, costs and payments to affected contractors ought to be based on an assessment of how execution, delivery, and future operations performance is affected by the changes and the extent to which revised plans are needed.

For most projects, repeated iteration will be necessary through the steps within the execution stage. Exceptionally, revisiting earlier lifecycle stages may be necessary. Big surprises, including major opportunities missed earlier, could take some aspects of the project back to the concept shaping stage, or lead to project abortion.

Delivery

The delivery stage involves commissioning and handover of the project deliverable. Again the management issues may vary from previous stages because the purpose of the delivery stage is different. In certain respects the delivery stage is a 'gateway' for all earlier effort; however, it is more than that, with a transfer of ownership at its heart. The 'basic deliverable verification' step involves verifying what the delivered asset will do in practice – that is, its actual operational performance as distinct from its designed performance. An important threat is that the delivered asset fails to meet expected operational performance criteria. Modification of operational performance may be achievable, but modification of performance criteria or stakeholder expectations and perceptions may be necessary. Such shortfalls in performance may be a realization of unmanaged sources of uncertainty in earlier stages of the lifecycle. 'Delivery evaluation' focuses on the need for quality assessment and possible revisiting of earlier steps, including compensating for unanticipated weaknesses by developing unanticipated strengths. In principle, revisiting the concept stage or a project abort decision is still possible.

Operation and support (O&S)

The O&S stage involves living with the delivered asset, the ongoing legacy of apparent project 'completion' from a conventional project management perspective, possibly in a passive 'endure' mode, until the asset is replaced, decommissioned or otherwise disposed of. 'Basic operations and support verification' is the starting point once delivery is complete, noting that handover may be an internal matter in a single organization. 'Development of operations and support criteria' informs 'operations and support development' and subsequent 'operations and support evaluation'. These three steps may be repeated periodically, or perhaps many times over the operational life of the asset. The focus of operation and support evaluation is likely to be a within-stage return to development of perceptions, or revisiting aspects of the delivery stage. Exceptionally, the outcome could be unplanned asset withdrawal or other explicit withdrawal of support for the asset as in product recalls, or computer software products. This could result from developments or surprises in the operating environment, or from inadequate management of operational uncertainties earlier in the asset lifecycle.

Termination

Termination may involve simple withdrawal of the asset requiring little prior planning, but it clearly needs corporate approval if not initiation, and the purpose of the termination stage is very different from that for earlier stages. Major infrastructure benefits from decommissioning considerations that are built into the initial business case and design of the asset, as with, for example, nuclear power stations and offshore oil platforms. A speculative office block might have to be sold when there is a market surplus of similar accommodation, so designing a more flexible use into the structure before construction may be a considerable advantage. Most of the detailed planning in most terminations can wait until termination approaches. When it is important to consider strategy at the outset, the costs associated with not doing so can be substantial.

Simplifications and elaborations for the nominal lifecycle

The 12-stage structure of Table 1.3 provides a useful basis for understanding the asset lifecycle, but some projects might warrant a simplified version. As noted earlier, various possible simplifications are one reason for the 'nominal' nature of the 12-stage structure. However, despite the number of stages and steps in Table 1.3, planned iterations within stages, and the possibility of unplanned iteration, this 12-stage description of the lifecycle is still a simple one by comparison with the complexities of some projects. It can be built upon in various ways, illustrated by the following example elaborations.

Separable project dimensions

In practice, some projects are planned and executed in several dimensions that are separable to some extent: physical scope, functionality, technology, location, timing, economics, financing, environmental, and so on. This means that each step in Table 1.3 could be viewed as multidimensional, with each step considering each dimension in parallel, or in an iterative sequence. In this latter case, the lifecycle might be visualized as a spiral of activities moving forward through time, where each completed circle of the spiral represents one completed stage in Table 1.3, and each spiral represents sequential consideration of the various dimensions. Charette (1993) uses similar notions in a related context.

Parallel components

Many projects, especially large ones, may be managed as a set of component projects running in parallel. The stages in Table 1.3 can still be used to describe the progress of each component project, although there is no necessity for the component lifecycles to remain in phase at all times. 'Fast tracking' in construction is a simple example of this, where completion of the parent project deliverable can be expedited by overlapping the planning and execution stages for different components. This implies that some components of the parent project deliverable can be designed and planned, and execution commenced for these components, before designing and planning is complete for other components. As is widely recognized, such staggered execution is only low risk to the extent that the design of components first executed is not dependent on the design of subsequent components. Plans that involve an element of 'fast tracking' should be supported by an appropriate uncertainty management process, with a focus on feedback from more advanced components into the lifecycle steps of following components.

Contracting

When allocation of tasks in the tactics shaping stage involves the employment of contractors, the tendering and subsequent production work of the contractor can be regarded as a component project in its own right. For the contractor, all the steps in Table 1.3 are passed through on becoming involved in the parent project. What the client regards as the tactics shaping stage may be regarded by the contractor as a compressed version of the first eight stages. In the case where the contractor has a major responsibility for design (as in turnkey or 'design and build' contracts), the client will move more quickly through the first four stages, perhaps considering these stages only as a general outline. The contractor then carries out more detailed work corresponding to these stages. For the contractor's project, the initiating 'trigger' event involves both a need and an opportunity to tender for work, usually managed at a high level in the contracting organization. The concept shaping stage corresponds to a preliminary assessment of the bidding opportunity and a decision to tender or not (Ward and Chapman, 1988). This is followed by costing design specifications and plans provided in more or less detail by the client, perhaps some additional design and plan development, evaluation of the tendering opportunity, price setting and submission of a bid. For the contractor's project, the tactics shaping stage involves further allocation of tasks, perhaps via subcontracting, more detailed design work, and production scheduling, as indicated above.

Objectives not easily defined

For many projects, delivery objectives and operational performance objectives for the delivered asset can be refined progressively through the first eight stages of the lifecycle. However, in some projects – for example, information systems or software development projects – it may not be practicable to ensure that all performance criteria and related objectives are well defined or crystallized prior to the execution stage. This becomes apparent in earlier stages, where 'go' decisions acknowledge the situation as part of the 'fit for purpose' nature of the governance evaluation. In this scenario, an 'execution evaluation', which is undertaken each time a milestone is achieved, ought to include a 'configuration review' (Turner and Cochrane, 1993; Turner, 1992) of objectives currently achievable with the project. If these are unsatisfactory, further stages of design and planning may be necessary.

Incomplete definition of methods

In some projects, such as product development, it may not be practicable to define completely the nature or sequence of activities required prior to commencing the execution stage (Turner and Cochrane, 1993). In such cases management expects DOT shaping through to execution stages to take place alternately on a rolling basis, with achievement of one milestone triggering DOT shaping to execution of the next part of the project deliverable. In this scenario, previous 'go' decisions within a DOT shaping to execution sequence are made on the understanding that subsequent execution evaluation steps will send the process through further sequences as necessary when the appropriate milestone has been achieved. In effect, the stages from DOT shaping to execution are managed as a sequence of component projects.

Prototyping is a special case of this scenario, and a natural approach where the intention is to mass produce a product, but the product involves novel designs or new technology. For the production project, the first two lifecycle stages are managed as a prototype project (with its own lifecycle). On completion of the prototype, the production lifecycle proceeds from the execution and delivery strategy stage through to the termination stage in Table 1.3.

Projects involving high uncertainty

Some projects involve speculative product development, the application of novel technology to create new types of asset, new methods of construction, large investment, and/or high levels of organizational and technological complexity. Such high uncertainty contexts warrant careful, early attention to project management strategy, starting with the design of an appropriate lifecycle structure that does not necessarily follow a simple sequential progression through the lifecycle stages in Table 1.3. For example, in addition to variations to address initially ill-defined objectives or an incomplete definition of methods as noted above, novel projects might warrant processes that involve parallel trials and iterative trial-and-error cycles within the basic Table 1.3 structure (Lenfle and Loch, 2010).

The seven Ws framework

In the authors' experience the initial motivation for applying formal risk and uncertainty management often arises because of concerns about design and logistics issues in major projects which involve the large-scale use of new and untried technology. Sometimes shortages of key resources are the issue, including finance. Sometimes communication and trust concerns dominate. Sometimes conservation, pollution potential or political imperatives drive the need to understand the issues. However, in all sizes and kinds of project, and at any stage of the lifecycle, the most important issues requiring management – the underlying drivers of uncertainty giving rise to really significant opportunity and risk – are often related to uncertainty about performance objectives and relationships between project parties. For example, a common and sometimes persistent issue is: 'Do we know what we are trying to achieve in clearly defined terms that link objectives to plans?' It is important to understand why such concerns arise, and to respond effectively, in *any* project context at *any* stage in the lifecycle.

A valuable framework for considering uncertainty around objectives, stakeholders and other parties during the basic project definition process is the set of seven basic questions shown in Table 1.4.

As observed by Kipling in the opening quote for this chapter, there are some very basic questions that can be usefully applied to almost any situation or proposed activity. Table 1.4 just adapts these questions to a project uncertainty management context with Table 1.3 in mind. The underlying structures of Tables 1.3 and 1.4 are closely linked. Stephen Ward initiated a six-Ws foundation for this concept during the development of the first edition of this book, and its role and evolution have been central to the journey of both author in developing understanding about the uncertainty–opportunity–risk relationships since the mid-1990s.

For convenience we refer to the key questions in the middle column of Table 1.4 as 'the seven Ws', using the left-hand column 'W labels' in **bold** as a short form when appropriate. Also, for clarity when appropriate, we use the *italic* designations in the right-hand column of Table 1.4. While somewhat contrived, this terminology helps to remind us of the need to consider all seven of these aspects of a project, their multiple components in some cases, their basic interdependence, and the basis for their links with the lifecycle stages in Table 1.3.

Table 1.4 Key questions in the basic project definition process – the seven Ws

1. who	who are the parties involved?	*parties*
2. why	what do the parties want to achieve?	*motives*
3. what	what is the deliverable product that the parties are interested in?	*design*
4. whichway	how will all relevant plans in each lifecycle stage deliver what is needed?	*plans for: relationships and contracts, business case purposes, operations, activities*
5. wherewithal	what key resources are required to achieve execution of these plans?	*resource plans for: operations, activities*
6. when	when do all relevant events have to take place?	*integration of all plan-based timetables*
7. where	where will the project take place? (in location and all other context terms)	*context*

Figure 1.2 uses the Table 1.4 *italic* designations as well as the **bold** W labels, showing a set of relationships that elaborate how Table 1.3 purposes can be pursued.

In the concept shaping stage the plans for business case purposes should become the central concern before too long. A cash flow model at the heart of the business case may act as the axle of the wheel, while the plans for business case purposes act as the hub.

The 'hub' status of plans for business case purposes is emphasized by bolder lines for its box. The bold lines of the overall box signify the wheel rim. The other boxes are analogous to spokes. Those worried about square wheels and hubs might use circles instead of boxes – we have stuck to boxes as a more convenient shape for most purposes of interest – all analogies can produce problems if taken too far, and the 'spokes' notion is useful but not a perfect analogy.

The 'who' is a good place to begin considering the spokes of the wheel that circles this hub. The 'who' includes 'project initiators' and a much wider set of 'project parties ultimately involved'. Project initiators kick the whole process off in the concept shaping stage of the lifecycle. If a client perspective is the concern, the client is obviously the key party, but contractors, customers, shareholders, other investors, regulators and competitors may also need attention.

The client's objectives should dominate the 'why', but aligning client, shareholder, contractor, and regulator concerns may not be straightforward, and competitor responses may be critical. One or more project initiators first identify the basic purpose of the project, or intended benefit from it, the 'why' or motives for the project. These motives will usually include profit, involving revenue and cost, along with 'other motives'. Initially the nature of these motives may or may not be defined, and they will not necessarily be quantified as objectives. That is, in terms of a mission–goals–objectives hierarchy often used to move from an overall mission statement to quantified objectives, the initial focus of the 'why' may be on mission and broadly defined goals rather than specific performance objectives.

The initial 'what', an outline design, is driven by the initial 'why', the initial conception of the project's purpose. The design should be driven by competing agendas that have been aligned in the client's interests as far as possible, with appropriate concessions to other parties. This implies initial attention to relationship plans and contracts *before* getting too deeply into design, and is usefully seen as early attention to the 'why–who–whichway' (plans for relationships and

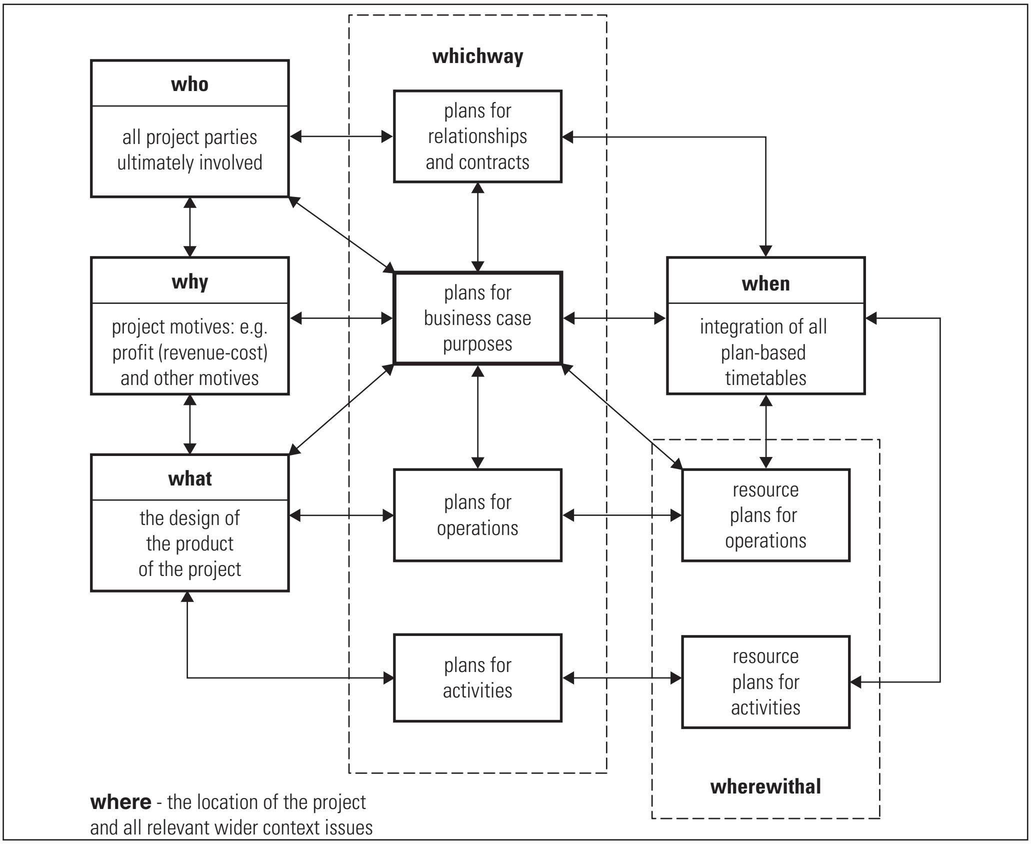

Figure 1.2 The basic project definition process – the seven Ws

contracts) trio as an integrated set. For example, an oil company developing oil wells in a sensitive area may do its best to minimize the intrusive characteristics of all new facilities as well as provide 'planning gain' such as new local jobs plus social and recreational facilities for *all* local residents. All these features can be designed into the facility and the project management process from the start, to plan and manage local resistance in a constructive and transparent manner before anyone is aware of the possibility of such a project.

This outline design, be it of a physical facility such as a building, a less tangible asset such as a service, or a relatively intangible organizational change, drives an initial strategy for operation, the 'whichway' (plans for operation). The plans for operation need to be considered in conjunction with the design from the start, as may the 'wherewithal' (resource plans for operation), and the timing of all these aspects.

The 'who–why–what' trio also drive the 'whichway' (plans for activities) and 'wherewithal' (resource plans for activities) with timing implications, but in the concept-shaping stage the plans for activities and associated resources may be driven by business case considerations from both ends – capital cost and delivery time for a very high level design concept may be all that is required. How the project's asset would be produced is relevant only insofar as its cost, duration and 'quality' impact and interact with the business case.

The 'who–why–whichway' (plans for relationships and contracts) initial development may be driven later by the 'when' and the business case as a whole. The initial pass around the hub may be largely clockwise, feeding the business case through the spokes, with feedback shaping in reverse directions.

In the DOT shaping stage the focus shifts to the way the 'who–why–what' and the business case and overall timetable drives the plans for operations and associated resources from a design and operations strategy perspective instead of a corporate strategy perspective, with feedback as appropriate. The purpose of the exercise and the team of people involved usually change significantly. Involving operations staff or ultimate users and linked stakeholders as well as design staff at this point in the project definition process usually has significant benefits, particularly in terms of building in 'operability' and 'user-friendly' opportunities via feed-forward and feedback between the 'what' and the 'whichway' (plans for operation). This may lead to feedback to modify the 'why' or 'who'. This stage also provides a refined quantification of operating cost, possibly linked to refined revenue feedback, and 'why' in terms of a more developed, measured definition of performance objectives.

In the E&D shaping stage the purpose of the exercise and the team of people involved usually change again significantly. The focus shifts to the way the 'who–why–what' trio drives the execution and delivery strategy shaping from a project perspective, with feedback as appropriate. When execution stage strategic plans are fully developed, delivery stage strategic plans can receive similar consideration. Design development drives the execution plans, associated resource-use plans, and the delivery timetable. But as execution and delivery plans are developed from a project strategy perspective as distinct from a corporate strategy perspective, there is significant feed-forward and feedback between 'whichway' (plans for activities), 'wherewithal' (resource plans for activities) and 'when'. Some 'buildability' opportunity for feedback to the 'what–whichway' (plans for operation) may also prove useful.

As the three strategic planning stages progress, it may be appropriate to bring in other stakeholders, enlarging the 'who' (for example, to banks for resource reasons). It may also become appropriate to consider other interested parties who are not direct players (regulators, or local authorities, for example).

Other lifecycle stages will not be considered now, but later the role of the seven Ws will be explored for each stage. They are of interest when identifying and managing uncertainty throughout the lifecycle.

The 'context 'where' aspect is an obvious influencing factor on the project, and a potentially major influence on most if not all the other six Ws. The physical location of the project execution activity and of the delivered asset in operation are obvious fundamental influences of the context 'where'. However, other aspects of context can also be very important, including:

- the position of a project in relation to a wider set of projects or portfolio of assets operated by the project sponsor;
- the broader economic, political, environmental or technological context;
- the organizational infrastructure provided by key project participants, within which project activities must take place and draw on for support.

Taken together, the seven Ws are key aspects of any projects that need to be explicitly recognized and appropriately managed. They are central to each stage of the lifecycle, although the emphasis and focus vary as the lifecycle unfolds. They should be addressed initially in the context of project definition during the concept-shaping stage, developed and used as appropriate in all subsequent stages.

This brief description of the project definition process in terms of the seven Ws involved is an oversimplification for many projects, but it is sufficiently complex to highlight the nature of important roots of uncertainty in projects. It also helps to make more tangible the nature of the issues involved in the well-known cost–time–quality triad. The limited perspective inherent in the simple cost–time–quality triad characterization of project performance is then apparent. Further, Figure 1.2 provides a useful operational basis for addressing cost–time–quality tradeoffs.

Clearly, significant uncertainty in relation to any of the seven Ws will have major implications for the management of any project. As Figure 1.2 shows, if all of its network of connecting arrows are interpreted as 'the roots of uncertainty', these roots may extend back to the basic purpose of the project and the associated deliverable asset, and even the identity of relevant parties who are not stakeholders in the usual sense. Any uncertainty associated with each aspect earlier in the cycles portrayed by the diagram can be of fundamental concern later because of the potential for significant knock-on effects. A central concern in uncertainty management is ensuring that these interdependencies are understood at an appropriate level of clarity and that they are managed effectively.

Uncertainty associated with project parties

The 'whichway' (plans for relationships and contracts) aspect of Figure 1.2 emphasizes the need to formally address both formal contractual relationships and other important relationships. The involvement of multiple parties in a project introduces uncertainty about important issues that can give rise to massive uncertainty with significant risk and opportunity implications. For example:

- perceptions of influence, roles and responsibilities;
- specification of responsibilities;
- communication between parties;
- capabilities of different parties;
- formal contractual conditions and their effects;
- informal understandings on top of, or instead of, formal contracts;
- mechanisms for coordination and control.

Basic project management processes aim to reduce uncertainty and ambiguity from these areas, but recognizing and managing ambiguity about roles and responsibilities for bearing and managing project-related uncertainty can be crucial. This ambiguity ought to be systematically addressed in any project, not just in those involving formal contracts between different organizations. Informal understandings between different parts of the same client organization or client–regulator relationships can be *very* important. Contractor organizations are often more aware of this source of ambiguity than their clients, although the full scope of the threats and opportunities that this ambiguity generates for each party in any contract (via claims, for example) may not always be fully appreciated until much later. For example, interpretations of risk apportionment implied by standard contract clauses may differ between contracting parties (Hartman and Snelgrove, 1996; Hartman, Snelgrove and Ashfrati, 1997). The nature of assumptions about contractual relationships and associated uncertainty may drive uncertainty about objectives and priorities with further knock-on effects. If a 'fair weather partnership' cracks when the going gets tough, everything else comes apart, and lost opportunities may be the biggest casualty. This is another important part of integrating project uncertainty management and other aspects of basic project management.

Uncertainty about objectives and priorities

The 'who–why–what' trio emphasizes the importance of uncertainty about appropriate tradeoffs between appropriate objectives. Major difficulties arise in projects if there is uncertainty about project objectives, the relative priorities between objectives, and acceptable tradeoffs. These difficulties are compounded if this uncertainty extends to the motives and objectives of the different project parties, and the tradeoffs parties are prepared to make between their objectives. A key issue is: 'Do all parties understand their responsibilities and the expectations of other parties in clearly defined terms which link objectives to planned activities?' The emergence of 'Value Management' (Kelly and Male, 1993; Green, 2001) to address this issue is perhaps indicative of a perceived failure of common practice risk management to address such matters. However they are approached, uncertainty, risk, opportunity and value management need joint integration into project management, and this needs careful, explicit management as part of the definition of project objectives and tradeoffs.

Uncertainty about design and operation and resources for operation

In the process of project definition, the nature of the process deliverable and the process for operating it – with revenue and cost implications – are fundamental uncertainties. In principle, much of this uncertainty is removed in pre-execution stages of the project lifecycle by attempting to specify what is to be done, how, when, and by whom, at what cost. In practice, a significant amount of this uncertainty may remain unresolved even when execution commences. The nature of design and operations assumptions and associated uncertainty may drive a significant portion of the uncertainty about the basis of planning estimates in the early lifecycle stages. This uncertainty needs careful explicit management in two separate modes. One mode is knowledge management as part of the basic project management process – ensuring that knowledge needed later in the lifecycle is generated in a timely manner. The other mode is part of an uncertainty management approach to dealing with incomplete information – assessing ambiguity uncertainty or defining appropriate conditions to achieve unbiased estimates before the first mode has been completed. This is an important part of integrating project uncertainty management with other aspects of basic project management.

Uncertainty about design, execution, delivery and termination logistics

In the process of project definition the nature of the project deliverable and the process for producing it are also fundamental uncertainties. Again, in principle, much of this uncertainty is removed in the pre-execution stages of the project lifecycle by attempting to specify what is to be done, how, when, and by whom, and at what cost. In practice, a significant amount of this uncertainty may remain unresolved even when execution commences.

Sources of uncertainty as both components and composites

Together, the nominal lifecycle and seven Ws frameworks indicate a wide range of sources of uncertainty that ought to be considered in any project uncertainty management process, providing a structure for effective and efficient search processes. They define what might be called 'the roots of uncertainty' in the sense that they are part of complementary generic frameworks. However, 'sources of uncertainty' in this sense do not have a natural or inherent 'base level' of detail for practical analysis purposes. In most contexts, all identified sources of uncertainty may be further broken down or decomposed to provide a more detailed picture, and if we have not yet decomposed them, their composition is uncertain. Alternatively, identified sources of uncertainty may be regarded as components of a higher level, less detailed, composite source that has been decomposed to clarify this composite.

> *Overall total cost or duration uncertainty for a project is clearly a high level composite of many lower level sources of uncertainty. However, even the most decomposed structures that are viable still involve low-level composites. Further decomposition to clarify a source may be possible, but in practice the limits to decomposition will be defined by what is useful. Further, the most effective and efficient decomposition structure is a matter of choice, which is necessarily dependent upon the process objectives*.

Most common practice risk management does not recognize the principle involved in the above paragraph, let alone use it effectively and efficiently. Accepting the last paragraph as a framing assumption provides a different mindset, and explaining its implications is central to this book.

The absolute minimal level of decomposition for total project cost and total project duration is a single source of uncertainty for both – one cost item and a single activity portrayal of a project, with perfectly correlated uncertainty driven by one common source. This is a very special case. If a very modest level of decomposition is involved, the most decomposed sources of uncertainty might equate directly to item cost or activity duration and comparable composites. The nature of any desirable further decomposition will depend upon the goals of the analysis.

However uncertainty is decomposed, identified response options are part of the identified source of uncertainty structure. These response options may be proactive and preventative or reactive and selected after a problem arises. An important implication is that *unidentified* option choices which might be used are an inherent part of the uncertainty involved. Identified option choices that have not been made are also part of the uncertainty involved.

In seeking to identify and manage all sources of uncertainty at an appropriate level of detail, two very different planning processes need to be integrated in an iterative framework: 'top-down' and 'bottom-up'. Most traditional project planning is 'bottom-up'. For example, PERT (Program Evaluation and Review Technique) starts by defining a project activity structure, and individual activity durations are then estimated. The precedence relationships defined by the activity network diagram are then used to compute the project duration. Such bottom-up processes are iterative, in the sense that in a PERT analysis any surprises or difficulties with resources and other issues not considered at the first pass are addressed on a feedback basis. The level of decomposition used initially is usually assumed to be 'fit for purpose' in terms of planning objectives that do not explicitly include understanding uncertainty, and assumptions about the level of decomposition adopted may not be revisited.

An iterative top-down process for planning and costing uncertainty was pioneered by Lichtenberg (2000) in the 1960s. In simple terms, a top-down process might begin with a direct estimate of overall project duration or cost in terms of probability distribution. Two to six of the greatest sources of uncertainty are then identified, and the largest of these sources of uncertainty is decomposed further in the same way. This 'successive' decomposition continues until the structure is considered to be 'fit for purpose'.

The uncertainty management processes explored in this book use an iterative approach to a synthesis of both top-down and bottom-up analysis, specifically avoiding further decomposition in the successive estimation sense unless the insight provided is worth the effort. There is an important synergy between iterative processes, integrating top-down and bottom-up processes, and a flexible approach to composition and decomposition.

Four different types of uncertainty component

In seeking to understand and then manage sources of uncertainty, a further aspect of decomposition is the need to recognize four different forms that uncertainty associated with these sources can take. At a very basic or highly decomposed micro level, 'uncertainty' in the plain English 'lack of certainty' sense can involve four very different types of component: ambiguity, inherent variability, event uncertainty and systemic uncertainty.

1. **'Ambiguity uncertainty'** involves lack of complete/perfect knowledge for various reasons including: a lack of definition of project objectives in the early lifecycle stages, lack of agreed contracts and the unpredictable behaviour of relevant project players, lack of specification of what has to be done in design or planning terms, lack of clarity about proactive or reactive responses if plans do not work, lack of data, lack of detail, lack of structure to consider issues, known and unknown sources of bias, and ignorance about how much effort it is worth expending to clarify the situation. 'Ambiguity uncertainty' or just 'ambiguity' is usefully distinguished because, unlike inherent variability, event uncertainty or systemic uncertainty, ambiguity uncertainty can be reduced by resolving the ambiguity, and the ambiguity may reduce over time without direct action as a consequence of progress with basic project management.
2. **'Inherent variability'** involves the equivalent of events that always happen – it is always a question of degree – like inflation rate variations (referred to as 'issues' by some people, although others use 'issues' to refer to risk events which have been realized already). 'Inherent variability' or 'inherent variability uncertainty' is usefully distinguished from event uncertainty because of its implications for conceptual frameworks and tools that are

limited to dealing with events. It includes the implications of specified or unspecified specific responses – like a client insisting that a contractor takes responsibility for inflation.

3. **'Event uncertainty'** involves events, conditions, circumstances or scenarios that may or may not happen plus associated specific responses – like a particular important piece of equipment failing (or not) in a particular way and being repaired/replaced or not (referred to as 'risks' by many people).
4. **'Systemic uncertainty'** involves simple forms of dependence or complex feedback and feed-forward relationships, including general or systemic responses (often referred to as 'systemic risk') between sources that have been decomposed. A simple example is dependence between all materials and labour prices when markets strengthen modestly or seriously overheat. An effective general response can be early buying and contracting in market lulls. A more complex example is knock-on relationships like a 20% delay in one activity leads to a 30% cost increase but a comparable 20% delay in five related activities leads to a 500% cost increase. An effective general response may be starting the whole project early and proactively managing good luck in early activities to balance later possible bad luck.

In the early stages of the asset lifecycle, ambiguity is the dominant component of all sources of uncertainty. When projects go very badly wrong, systemic uncertainty is usually the dominant component. However, all four types of component are important throughout the lifecycle of most projects.

In operational terms, uncertainty generally has to be considered as an ambiguously defined composite of two or more of these four types of component at various levels of analysis. For example, even a simple event uncertainty source associated with the failure of important equipment usually involves a composite of the many different ways it might fail, including unknown failure modes, plus ambiguity about data, and systemic uncertainty relationships, such as the way three or four minor faults at the same time can lead to total system failure, and systemic uncertainty about the best way to eliminate, transfer or otherwise manage this source of uncertainty. 'Pure event uncertainty' – with no associated ambiguity or systemic uncertainty – is not a practical proposition for analysis purposes. The same is true of inherent variability and systemic uncertainty, because ambiguity uncertainty is ubiquitous – to be found everywhere. We have to get used to the idea that we are normally dealing with ambiguously defined composites of all four kinds of uncertainty even at low levels of composition, without losing sight of the nature of the dominant types of particular interest. The way we choose to structure all relevant uncertainty as suitable composites is the basis of both quantitative and qualitative analysis of uncertainty – it is not practical to attempt full decomposition, and some approaches to partial decomposition are better than others.

The term 'ambiguity' has its critics, for reasons we understand. 'Ambiguity' has the basic dictionary meaning 'capable of more than one meaning', but 'ambiguous' can mean 'of uncertain issue', and 'ambiguity' is the best term we could suggest to capture the idea of uncertainty generated by incomplete knowledge which, in principle, could be completed and agreed. One useful rationalization is the idea that people tend to form hypotheses about everything uncertain; but these hypotheses tend to be different for different people for all uncertainty which involves ambiguity, as distinct from uncertainty which involves accepted explanations – what some people might call 'aleatoric' uncertainty or risk (predictable variability or randomness).

These four categories and their labels involve working assumptions, and alternatives may be preferred. For example, 'ambiguity' might be formally defined as 'incomplete knowledge which could be completed', and given some alternative label. However, some people may prefer seeing all uncertainty as 'incomplete knowledge', which is knowable in principle if not in practice, and others may prefer further decomposition of 'ambiguity' with a variety of labels. Further, some people like the label 'epistemic' when lack of knowledge or lack of predictability is involved, or 'aleatoric' when predictable randomness is involved. In practice what seems important is:

- a reasonably simple and memorable basic structure and terminology;
- an approach that explicitly includes *all* uncertainty;
- recognizing that quite different modelling approaches to events, variability and systemic relationships may *all* be needed;
- recognizing that some uncertainty (such as lack of clarity about objectives) cannot be fully modelled with any of these approaches;
- recognizing that 'fuzzy', 'chaos' or 'complexity' concepts may have a useful role;
- recognizing that an 'incomplete knowledge' view of uncertainty lets us view all processes concerned with knowledge acquisition as potentially relevant;
- recognizing that some uncertainty is about things which are inherently unknowable or unpredictable in the relevant planning period;
- understanding that effective and efficient knowledge acquisition focused on decomposing the uncertainty composites that really matter in any given context is crucial to performance uncertainty management as addressed by PUMPs.

There are other 'type of uncertainty' structures that may also prove useful for some purposes. For example, it can be useful to order the importance of sources of project uncertainty using the list:

1. variability associated with estimates via common practice risk measurement;
2. uncertainty about the basis of estimates;
3. uncertainty about design and logistics;
4. uncertainty about objectives and priorities;
5. uncertainty about fundamental relationships between project parties.

The farther down this list we go, the more important the uncertainty becomes, in terms of risk and opportunity implications. In principle, project manager responsibility may be associated with 1–3, and more senior management responsibility may be associated with 4 and 5. In practice all parties need to be clear about all five: their relationships and their relative importance.

A 'performance lens' and a 'knowledge lens' for uncertainty

The focus of this book is the use of a conceptual 'performance lens' to consider uncertainty. It is always important to be clear when we make working assumptions, and this 'lens' concept is just a way of flagging an important assumption. The central concern of this book is managing performance uncertainty using '*performance* uncertainty management processes' (PUMPs) because we want to shape strategy in the first six stages of the project lifecycle, then shape tactics, then update the shaping of both when execution begins. 'Shaping' in this sense involves making decisions about how best to proceed in terms of project and process objectives – addressing all aspects of uncertainty in performance terms. '*Uncertainty about the achievement of objectives*' is what we see when we look through our '*performance* lens', using all the concepts introduced in this chapter as working assumptions.

We employ this performance lens to answer such questions as 'how much will this project cost?' 'how long will it take?' and 'to what extent will it deliver the intended benefits?' We also need this performance lens to make all decisions that involve tradeoffs between all relevant objectives, using the opportunity and risk concepts discussed in Chapters 2 and 3. Further, we need this performance lens to clarify the relationship between base plans plus contingency plans and performance, to optimize performance by optimizing plans. Effective and efficient use of a performance lens is the basis of the rest of this book.

It can also be useful to use a '*knowledge* lens' to consider uncertainty in the form of incomplete or imperfect knowledge that is beyond the direct focus of PUMPs. Managing uncertainty as incomplete knowledge in our knowledge lens sense is about 'what do we need to *know* to get to the next stage in the project lifecycle beyond what the performance lens perspective will tell us directly?'

'What do we need to know to get to the next lifecycle stage?' is very close to 'What do we need to *do* to get to the next stage?' What we need to *know* and what we need to *do* are so closely coupled, using a *knowledge* lens with associated '*knowledge* uncertainty management processes' (KUMPs) is usefully seen as addressing an important part of the glue between project uncertainty management in performance terms and all other aspects of project management involving uncertainty.

This book will limit its interests in KUMPs to their role when interfacing with PUMPs, but a more general interest in KUMPs could prove fruitful. As a simple example of their recent use in practice in the context of road system planning, Nichols (2007) drew up a list of sources of uncertainty facing a new major road project in the concept shaping stage with two purposes in mind. One purpose was to assess appropriate timing for design development in strategic and then detailed terms – land purchase, ground condition assessments, contracting and other key project lifecycle decisions, which is arguably a *very* important KUMP for basic project planning purposes. The other purpose was to use this list to guide concept shaping cost assessments, when lack of a design, final route, knowledge of ground conditions and contracting approach are key sources of uncertainty. Whether or not we choose to decompose cost uncertainty using these categories raises separate questions, as discussed in Chapters 2 and 7. Viewing uncertainty as incomplete knowledge is the key to recognizing these dual purposes and a very helpful perspective for both PUMPs and KUMPs, a notion we attribute to Mike Nichols.

Viewing uncertainty through a performance lens involves a generalization of a modern decision analysis view of uncertainty in 'decision making' mode. Standard textbook decision trees provide a framework for considering successive decision choices with variable outcomes in terms of all relevant measurable attributes. However, we do not want to make any of the restrictive framing assumptions usually associated with decision analysis – such as discrete value outcomes, or attribute measurability, or the attribute 'utility' functions used to maximize 'expected utility'. Nor do we want to build in the kind of restrictive market-based assumptions used for 'real options' (Trigeorgis, 1997) and other approaches built on a decision analysis basis. The reasons should be clear by the end of this book and, for those interested, further exploration can start with Chapman and Ward (2002, ch. 9).

Viewing uncertainty through a knowledge lens might be associated with a generalization of a modern decision analysis view of uncertainty in 'value of information mode'. Standard textbook decision trees provide a framework for evaluating decision choices under conditions of both 'perfect information' and 'imperfect information' about alternative outcome possibilities. However, knowledge is a much more general concept than information, and incomplete knowledge is the concern of PUMPs as well as KUMPs. We do not want to make restrictive assumptions about what we know, what we do not know, and what we need to know – ambiguity is at the heart of the reality we need to cope with – and managing uncertainty has to cope with all aspects of ambiguity. The key aspects of KUMPs and PUMPs addressed in this book do not address the value of knowledge – they just address 'what do we need to know?' for specific PUMP purposes and related specific basic project planning purposes.

Figure 1.3 portrays some key features of this 'two lens perspective' on uncertainty.

Figure 1.3 clearly puts uncertainty at the centre of deciding whether or not we want to continue to develop a project and, if we do, what needs to be done to get to the next lifecycle stage. In this sense project uncertainty management is central to project management, and PUMPs and KUMPs are complementary key components of our recommended perspective.

Our two-lens view of uncertainty could be elaborated to multilevel compound lens perspectives. For example, we could use a 'trust' lens on top of a 'behaviour' lens on top of our 'performance' lens to focus on uncertainty about trust between key parties in terms of behaviour that has implications for project performance. A trust/behaviour/knowledge lens combination would provide a different perspective, but both may be relevant. Zaghloul and Hartman (2003) provide an example of what these kinds of lens combinations can reveal.

Criteria–plan and knowledge–plan relationship structures

When we look at uncertainty through a performance lens for PUMP purposes, to see uncertainty about the achievement of objectives, we have to use 'criteria-plan relationship structures', part of the integrated seven Ws and project lifecycle structure that defines the roots of uncertainty. For example, project capital cost is central to plans for business case purposes. When considering uncertainty about project capital cost, a capital cost item structure is the obvious starting position for sources of uncertainty. Direct estimation of item cost uncertainty may be an appropriate basic source of uncertainty structure for some capital cost items purchased directly – a specific plot of land currently for sale to be used for a new building, for example. Other capital cost items may involve an uncertain quantity that has to be multiplied by an uncertain cost per quantity unit – the amount of steel needed to build a new oil refinery and the cost per ton of steel, for example. Further items may involve resources with an uncertain cost per unit time and an uncertain duration for the activity defining when they are needed – for example, the cost per unit time of a barge for laying offshore pipelines and how long it will take to lay the pipe. This involves

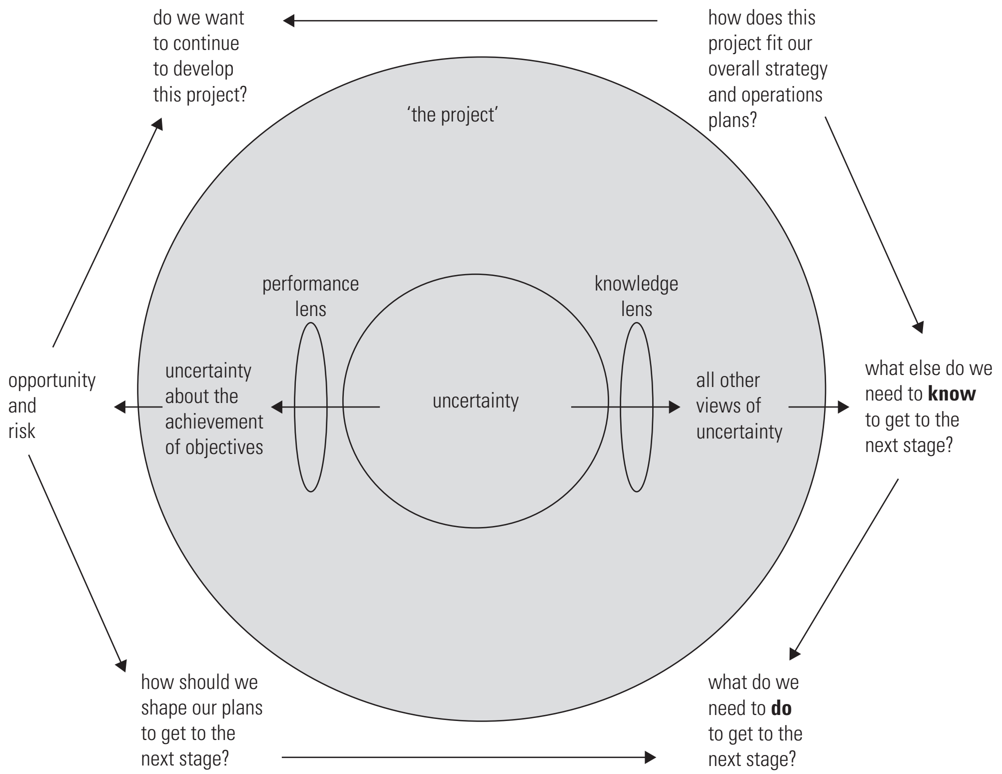

Figure 1.3 The role of the performance lens and the knowledge lens to visualize uncertainty

links between plans for resources and plans for activities. If inflation is a concern, uncertainty about inflation rates needs to be integrated with these planning frameworks, and contractual structures may have important implications. If the cost of the capital tied up during construction is a concern, this depends upon a cost of capital interest rate per unit time, expenditure to date at the end of each relevant time period, the total duration of the construction period, and associated contractual arrangements. A high clarity assessment of capital cost involving components that are duration dependent may have to start by assuming that the primary criterion is duration, and then build on a clear understanding of all relevant capital cost–duration relationships. Capital cost–design and operating cost–design relationships are further examples of criteria–plan relationship structures that may need to be understood. A direct capital cost estimate that leaves these considerations ambiguous may be appropriate at the concept shaping stage of a project, but associated uncertainty should not be overlooked. All relevant plans as defined by the integrated seven Ws and lifecycle structure and all relevant criteria have relationships that need to be understood at a suitable level of clarity.

Shaping project strategy, then shaping project tactics, involves refining base plans and contingency plans. We have to understand the relationships between plans and performance to understand how to shape a project. The criteria–plan relationship structure is a basis for understanding uncertainty in PUMP terms.

When we look at uncertainty through a knowledge lens for KUMP purposes, we use a 'knowledge–plan relationship structure', and what we see may be relevant for PUMP purposes. For example, detailed design for a new highway may have to be done by the prime contractor for its construction, and this may require detailed ground condition surveys, which may not be feasible until the land has been purchased. Planning and executing associated activities is part of the 'what do we need to know?' and 'what do we need to do?' coordination that is a necessary part of basic project planning. Lack of information about ground conditions and detailed design and their relationship with contracting choices is an example of part of the uncertainty that also has to be accommodated in all PUMP analyses early in the lifecycle, whether or not we actually realize it. Failing to see this kind of complexity does not make it go away.

Knowledge–plan relationship structures are also part of the integrated seven Ws and project lifecycle structure, and the way both KUMPs and PUMPs use them needs to be understood at an appropriate level of clarity, acknowledging any ambiguity implied by the chosen level of detail.

Conclusion

Any designated project is a particular reference point in a larger system, affected by the wider system, and with the potential to affect the wider system in turn. Essentially, strategic decisions driven by perceived mismatches between management expectations about future needs and current operational capabilities give rise to project management activity that creates organizational changes, and new or modified assets that in turn have implications for future operational capability and performance. In addition, operational management, corporate management and project management are each influenced by the wider environmental conditions prevailing, and by views about the future operating environment.

Taking a corporate view of enhanced performance, it is important to recognize the extent to which projects are part of a programme of interconnected projects, driven by operations and strategic goals, each requiring management. The desirability of an approach to uncertainty management that addresses the overall system increases dramatically as the interdependency between projects increases.

As well as recognizing the role of a project as part of a larger, corporate picture, it is also important to look inwards, at the detailed internal structure of individual project lifecycles. The management of uncertainty should be an integral part of project management at each stage of the lifecycle, designed to address the pertinent issues at each stage, but cognizant of implications for the following stages of the lifecycle. Many different aspects of uncertainty are involved, from making incomplete knowledge more complete, to getting things done that must be done in order to proceed to the next stage of the project., The scope of the uncertainty that needs to be addressed is at its greatest at the outset, but the depth of analysis should increase as the project progresses towards the execute stage. Prior to each stage, a preliminary analysis of uncertainty, opportunity and risk should guide the first step, but as more details and options are considered in subsequent steps, further analysis should be performed with increasing detail and precision to continuously guide and inform the project management process. Table 1.3 provides a fairly detailed generic lifecycle stage-step framework for doing this.

The value of a *nominal* lifecycle structure at this level of detail might be questioned on three grounds:

- the steps and stages will be difficult to distinguish cleanly in practice;
- in practice some of the steps may not be necessary;
- this level of detail adds complexity, when what is required to be useful in practice is simplification.

For example, it might be argued that some of the later evaluation steps may be regarded as non-existent in practice because the decision to proceed is not usually an issue beyond a certain point. However, it is worth while identifying such steps beforehand, given their potential significance in managing sources of process uncertainty, because many serious sources of project uncertainty are late realizations of unmanaged uncertainty from earlier lifecycle stages, and many organizations spend too much money advancing projects beyond their budget capabilities, often leading to inappropriate project choices. In many projects there is a failure to give sufficient attention to 'go/no-go/maybe' decisions, and to distinguish between efficient *planned* iteration associated with evaluation by the people directly involved, and more debatable *unplanned* iteration which governance evaluation should help to control. Such 'go/no-go/maybe' decisions should involve careful evaluation of uncertainty, both to appreciate the sources of uncertainty inherent in a 'go' decision and the rewards forgone in a 'no-go' decision. Equally important is the need to recognize when a 'maybe' choice should be on the agenda. Many projects appear to involve just one 'go/no-go' decision – at the end of the concept-shaping stage. Yet the large number of projects that run into major problems of cost escalation, time overruns and quality compromises suggests that explicit 'go/no-go/maybe' decision points in later stages would often have been worth while.

A further reason for specifying a detailed step structure for the project lifecycle is to highlight the process of objectives formation. As we will see, the formation and modification of objectives has great significance for uncertainty management, and vice versa. In the early stages of the project lifecycle, objectives and performance criteria are often initially vague for good reasons, but they must be progressively clarified and refined prior to the execution stage. This process needs to be recognized and the implications understood. A situation in which the objectives of a project change imprecisely during the project without proper recognition of the implications of the new situation is particularly risky. From an uncertainty management viewpoint, any changes in objectives and performance criteria at any stage of the lifecycle need to be carefully evaluated for knock-on implications.

The fundamental importance of performance objectives when managing uncertainty warrants careful and detailed consideration of:

- the scope of a project's objectives, including the intended operational performance of the associated asset;
- stakeholders who play a part in shaping these objectives;
- other 'parties' not usually seen as stakeholders who might thwart project objectives (competitors or terrorists for example);
- how different tradeoffs between objectives might be aligned for different parties;
- implemented tradeoffs between these objectives; and
- how all these considerations influence the root sources of uncertainty in any project.

This leads naturally to a need to understand the uncertainty related to the seven Ws and, in particular, the knock-on effects between each of the seven Ws as a project progresses. Consideration of these issues also clarifies some aspects of the 12 stages of the asset lifecycle.

As with the detailed lifecycle structure, the detailed framework provided by the seven Ws framework in Figure 1.2 can be criticized on similar grounds, but defended on comparable grounds. For example, planning relationships and contracts from an early stage in a project can pay huge dividends. Such opportunities are often available but seldom seized effectively because the interaction between parties, contract structures, the rest of the lifecycle, and the rest of the organization, are not clearly understood.

The importance of the four components view of uncertainty (ambiguity, inherent variability, event uncertainty, and systemic uncertainty), and the need to deal with composites of all four at many different levels of composition, may not be immediately apparent, but should become more evident in later chapters.

Similar comments apply to the importance of the performance and knowledge lens views of uncertainty, the implied generalizations of a decision analysis view of uncertainty and the role of criteria–plan and knowledge–plan relationship structures.

All the structures and concepts introduced in this chapter are working assumptions that lay a foundation for the rest of this book. The authors' purpose is not a definition of the best way to view projects and all associated uncertainty, but guidance at a level of detail that avoids, as far as possible, simplifications that might obscure important aspects of the understanding needed in practice, even if very simple approaches are employed.