MANG6143 Project Risk Management

Performance Uncertainty Management Processes - PUMPs

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1 The PUMP Approach to Uncertainty and Underlying Complexity Management

The phrasing "uncertainty and underlying complexity management" has been specifically selected as the title of this section to contrast with the risk management title of the course as a whole. Traditional views of risk management offer a limited scope and an incomplete picture. Often the focus is event uncertainty reflecting the standard dictionary definition of risk: *a hazard, chance of bad consequences, exposure to mischance* (Stevenson and Waite, 2011). This approach does not address the whole of the uncertainty affecting the project, and in the worst case can lead to failed delivery of project objectives. The Performance Uncertainty Management Process (PUMP) framework encourages departure from the event-centric approach advocated by best practice, to consider all corporate, operational and planning sources of uncertainty. This expanded perspective allows the capture of ambiguity uncertainty, inherent variability, systematic uncertainty, as well as event uncertainty. Utilising the PUMP framework shifts the focus of risk management towards the achievement of opportunity efficiency and risk efficiency, through the vehicle of uncertainty management.

Procedures ensure consistency and quality is maintained throughout repeated applications. A good procedure is designed to be simple, repeatable and transparent. However, this cannot be a uniform approach. Some high complexity, high uncertainty projects require sophisticated, tailored procedures. The PUMP framework supports this concept through PUMP packs; a set of PUMPs tailored to specific projects and project lifecycle stages.

1.1 The Project Lifecycle Context

A traditional four stage view of the asset/change lifecycle is a useful starting point to consider the scope of a project. The four stages are conceptualize, planning, execution and delivery (E&D) and Utilization. As explained, effective uncertainty management requires a macro-view of the entire project to capture the different aspects of uncertainty. This leads to an elaboration of the lifecycle to incorporate 12 stages, each emphasizing a different management purpose. There is discussion as to the usefulness of such high clarity in the lifecycle, however it provokes in-depth consideration of all types of uncertainty (Ward and Chapman, 1995). Both views are shown in figure 1.

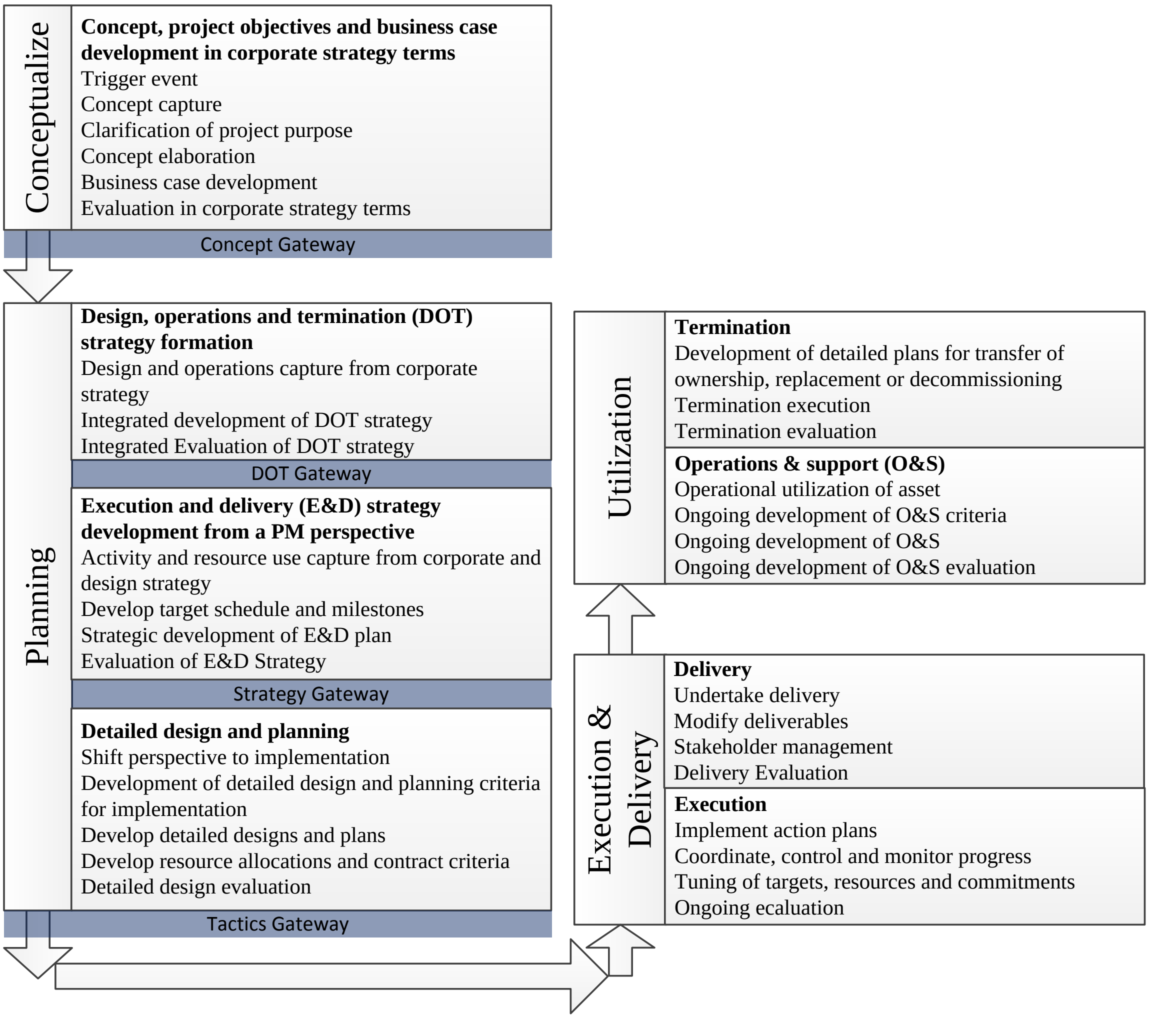


Figure 1: Twelve-stage asset/change lifecycle - adapted from Chapman and Ward (2011)

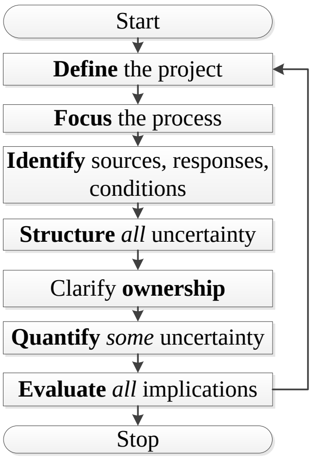
The planning stage of the traditional lifecycle is expanded to three shaping stages and three governance stages. The E&D strategy shaping stage takes a form more familiar in traditional project management. The activity and resource requirements are derived from the corporate strategy and the design, operations and termination (DOT) strategy. This stage considers aspects of the project execution and asks how the asset/change will be delivered? Schedule derivation takes place in the

E&D stage, including the reconciliation of corporate expectation and real-world plausibility. Integrated evaluation is vital to ensuring only viable projects proceed to later more expensive stages of the lifecycle. This paper is concerned with PUMPs tailored to this lifecycle stage.

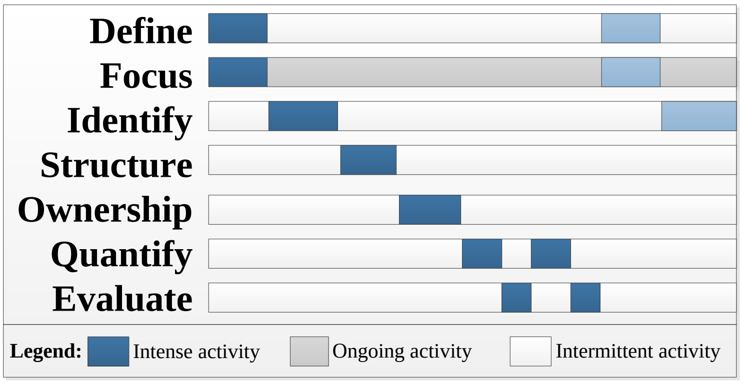
1.2 PUMP Overview

The PUMP approach was developed through the assimilation of other industrial risk processes, building upon the best practice approaches from project management bodies. The process was developed by Acres International Management Services for BP and first implemented on the Magnus offshore North Sea project in 1976. Chapman (1979) published the process as SCERT (Synergistic Contingency Evaluation and Review Technique) and the technique has since been used in a variety of high profile projects for BP, National Power and the Highways Agency. The process has been refined and assimilated into a complete framework suitable for a variety of clarity requirements.

The PUMP process is a seven stage iterative cycle as shown in figure 1. A linear 'right first time' approach is not a clarity efficient methodology. A version of Pareto's principle, sometimes called the 80:20 rule (Sanders, 1992), empirically states that 20% of the issues causes 80% of the problems. The first iteration of the PUMP is a high level sweep to identify the key areas of concern. Subsequent iterations focus on these issues until a sufficient level of clarity is achieved. This allows the achievement of clarity efficiency, by minimising time spent on unnecessary detail while achieving the required level of understanding.



(a) Flowchart visualisation

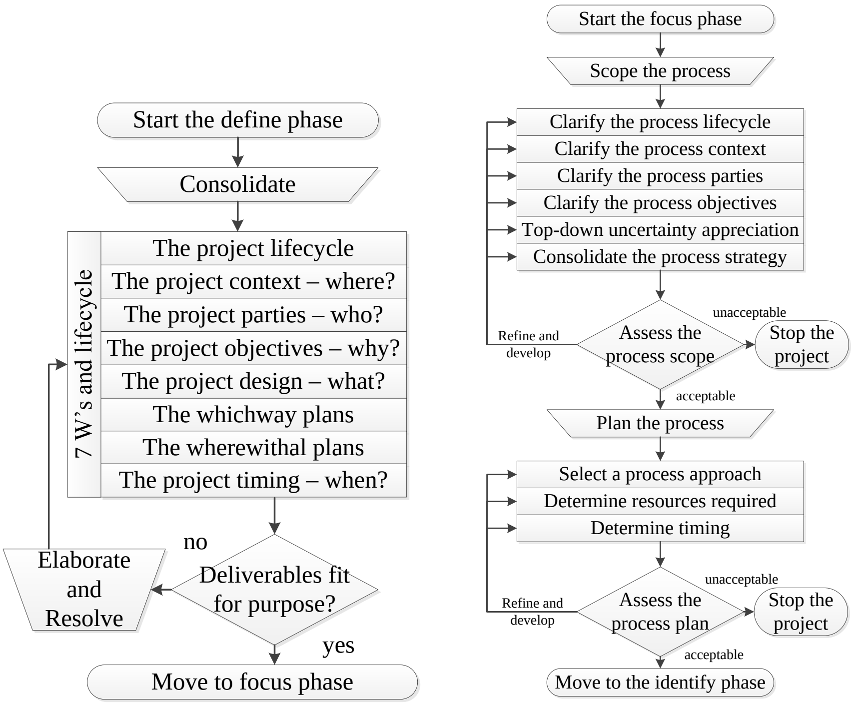


(b) Gantt chart visualisation

Figure 2: The generic PUMP process - adapted from Chapman and Ward (2011)

The initiating phase of the generic PUMP is the **define** phase. This phase defines and develops an understanding of the project as a basis to ask the right questions in subsequent phases. It features high level context capture and approach development at a strategic level. There are two key activities in this phase; consolidate and elaborate as shown in figure 3(a). A useful framework for adequately addressing these issues is the 7W's: where, who, why, what, whichway, wherewithal, when? Using the 7W's to consolidate the existing information, then sub-iterating in order to sufficiently define the project is a useful method to complete this phase. The phase is complete when the project deliverables are fit for purpose.

The **focus** phase involves scoping the level of analysis required during the E&D shaping lifecycle stage. During this phase, the generic PUMP is tailored to the specific requirements of the project at hand as captured from the corporate context. This phase is closely coupled with the define phase. The aim is to achieve clarity efficiency by stating all working assumptions at an early stage. The phase ends when the scope, strategy and plan for the tailored PUMP process is fit for purpose.



(a) Define phase process (b) Focus phase process

Figure 3: Phase process flowcharts - adapted from Chapman and Ward (2011)

The identification of all sources of uncertainty, relevant response options and conditions is undertaken in the **identify** phase. This phase has key distinguishing features that are vital to achieve clarity efficiency and to understand all relevant uncertainty and underlying complexity. This is considered in detail in section 2.

Following the identification of sources of uncertainty, responses and conditions, an understanding of their relative importance is qualitatively established in the **structure** phase. This phase contributes to the clarity efficient nature of PUMPs, by maximising the effort expended on issues of perceived importance. Responses should also be considered, as early identification of powerful general responses means less effort is required to deal with specific responses. Source-response diagrams, decision tress and influence diagrams are useful tools for this phase. Failure to deal with underlying complexity, assumptions, interdependencies and detail could endanger the success of the project. Seemingly small details missed in the structure phase represent systematic uncertainty that could lead to later threats or missed opportunities. Other key activities are shown in figure 5.

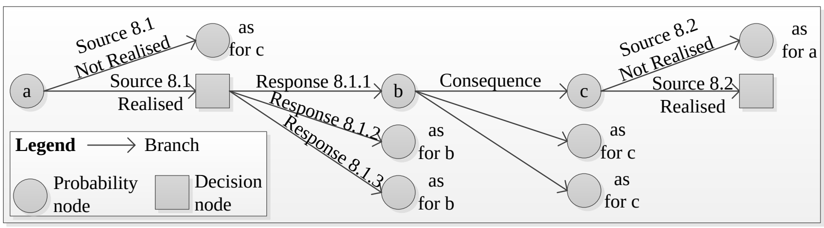


Figure 4: Partial example probability/decision tree - adapted from Chapman (1979)

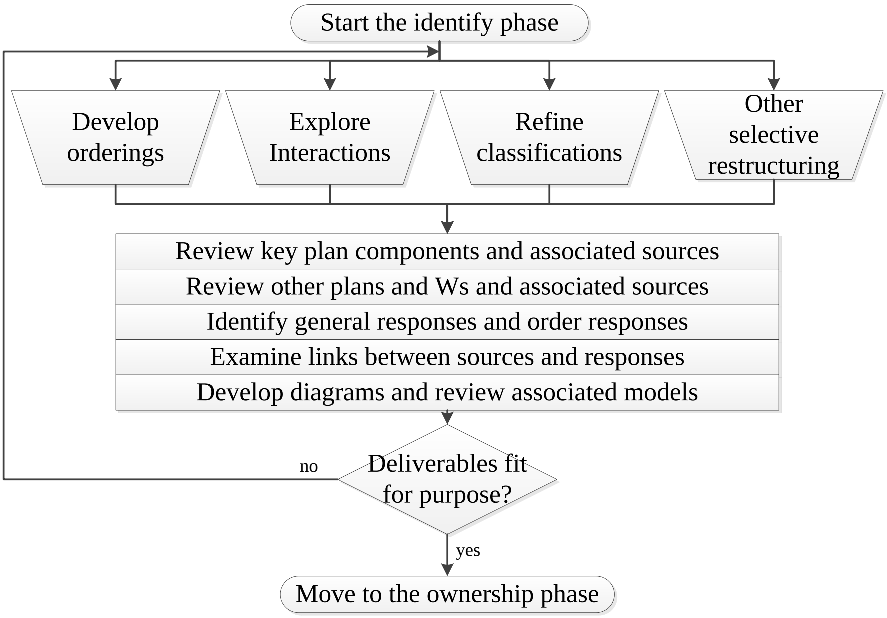


Figure 5: Structure phase process - adapted from Chapman and Ward (2011)

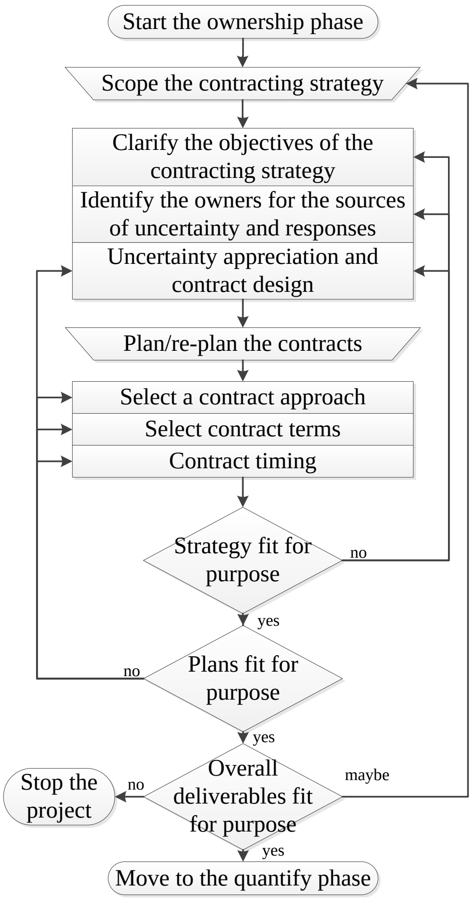
The clarify **ownership** phase allocates financial and managerial responsibility for relevant sources of uncertainty. In reality, all sources are allocated to a party whether explicitly or by default. The key activities of this stage include developing a contracting strategy, distinguishing ownership and allocating responsibility. The aim of the phase is a win-win outcome for all contractual parties, so that client and contractor objectives are aligned.

The key deliverable of the **Quantify** phase is an informed basis for making critical project decisions in the pursuit of opportunity efficiency. Clarity efficiency is achieved by sizing the data on the first iteration and decomposing to subsequent levels of detail where necessary in further iterations. Probability impact grid (PIG) approaches are widespread in industry. PIGs suffer from subjective interpretation of measuring terms (Merkhofer, 1987), a failure to address uncertainty of other than event uncertainty and granular quantisation of sources (Cox, 2008). Where objective data is available, probabilistic density functions should be utilised. It would be foolish to disregard the expertise of experienced personnel; subjective probabilities provide a method of using this information in the absence of objective data. The SRI technique published by Spetzler and Stal Von Holstein (1975) provides a framework for probability elicitation. There are some complexities discussed by Merkhofer (1987), including strategic misrepresentation (Flyvbjerg et al., 2003) and it remains an inexact science.

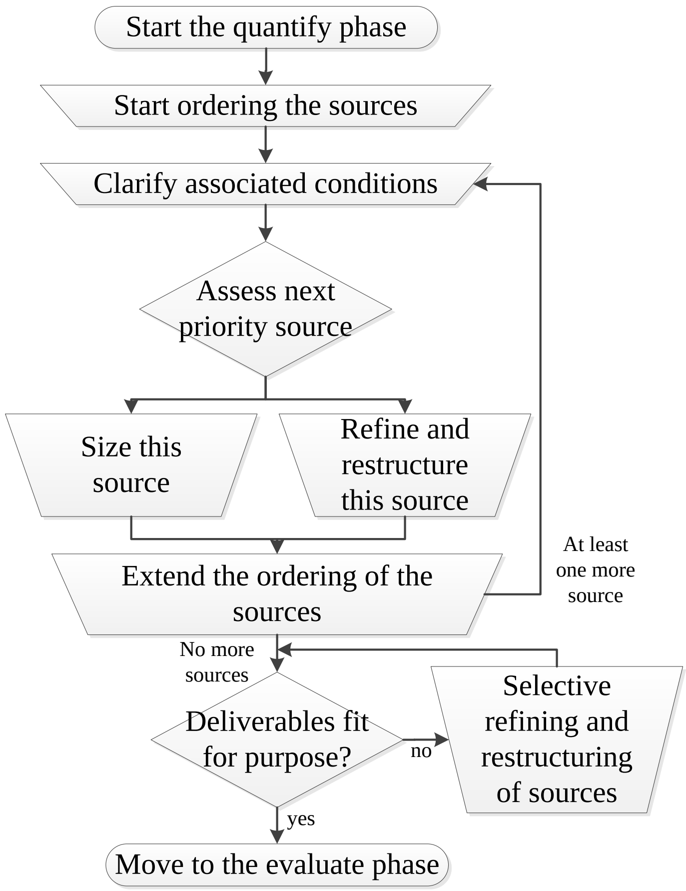
The **evaluate** phase involves synthesizing the results of the quantify phase and assessing the statistical significance of results. This phase is critical to the successful application of the PUMP process, and consolidates much of the understanding of uncertainty. This phase is considered in detail in section 3.

1.3 The Clarity Efficient Approach to Opportunity Efficiency

This section has given a brief overview of a high clarity PUMP for the E&D strategy shaping phase, except for the identify and evaluate phases considered later. Several recurring themes throughout all PUMP phases have been illustrated including the pursuit of clarity efficiency, flexibility and a holistic approach to uncertainty management to achieve opportunity efficiency. The following sections will consider the Identify and Evaluate phases in detail.

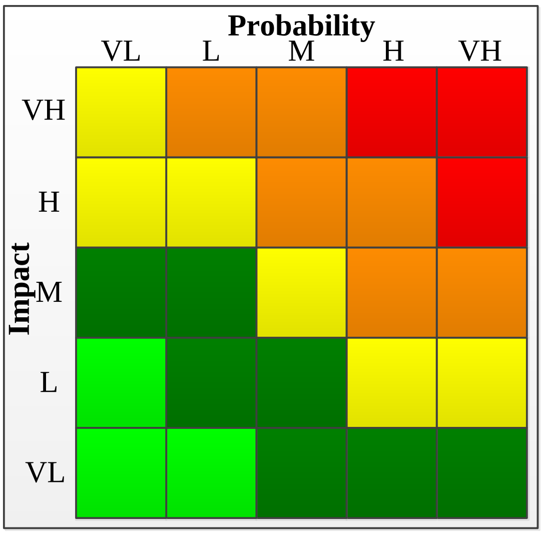


(a) Ownership phase process

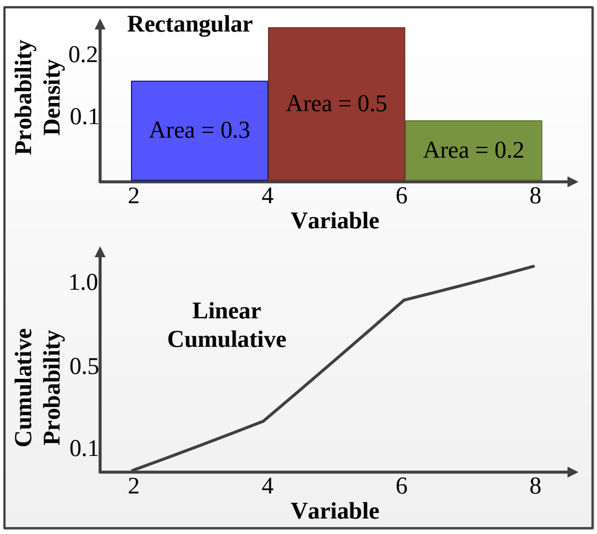


(b) Quantify phase process

Figure 6: Phase process flowcharts - adapted from Chapman and Ward (2011)



(a) Example 5x5 pig approach - adapted from Cox (2008)



(b) Example methods for developing probability density functions - adapted from Chapman and Ward (2011)

Figure 7: Potential approaches to the quantification of data

2 Identify *All* the Relevant Sources of Uncertainty

The identify phase is common through several risk management methodologies, including PUMPs. However, there is a marked removal from common practice in the PUMP approach resulting in an iterative, holistic, inherently creative methodology to identify all relevant sources of uncertainty, possible response options, assumptions, conditions and second-order sources. This encourages the consideration of all types of uncertainty to a relevant degree of detail thus achieving clarity efficiency.

Common practice approaches such as the Project Risk Management (PRM) framework prescribed by the Project Management Institute (PMI, 2013) are linear processes whereby all relevant risk events must be identified at an early stage. The identification of response options is left until later in the linear process and decoupled from the identification of the sources themselves. Assumptions and conditions are also decoupled, since unbiased estimation is not a formal goal of the process. This approach does not optimise clarity efficiency and powerful general responses are often not realised until a much later stage. The complexity relating to secondary sources of uncertainty due to the consequences of response options is not considered. Moreover, a dangerous false sense of security can be created through such approaches where linearity obscures the underlying complexity which may ultimately endanger the achievement of project objectives.

Within the PUMP framework, the identification of sources of uncertainty and possible response options are closely coupled. Considering possible response options as new sources are identified increases the chances of developing powerful general responses that are critical to the delivery of clarity efficiency. Moreover, unidentified responses contribute to ambiguity uncertainty. On some occasions the consequences of the response can lead to secondary sources which may also require consideration. The identify phase allows an enlightened reshaping of relevant base plans and contingency plans as required.

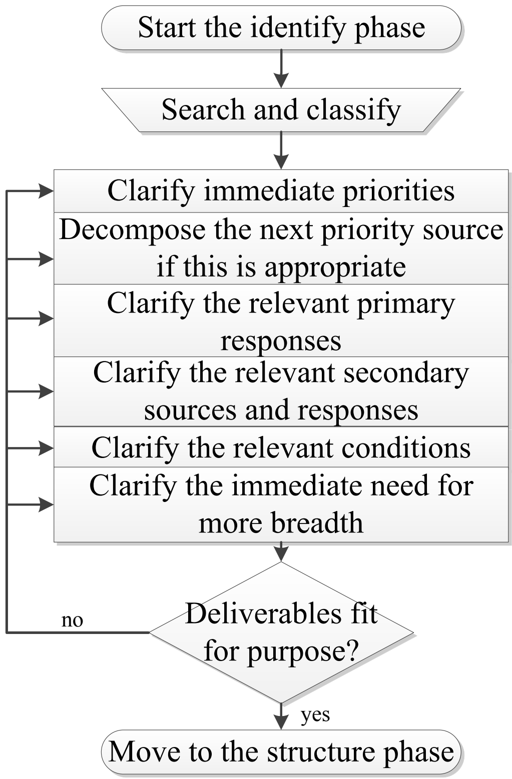


Figure 8: Identify Phase Process - adapted from Chapman and Ward (2011)

The process has two main features. The **search** task involves finding all relevant sources responses and conditions. The **classify** task provides a suitable structure where sources have been aggregated or decomposed as necessary upon which further analysis can proceed. The process is shown in figure 8. The keyword in the process is 'relevant'. The skill of the risk practitioner is in seeing where maintaining strategic level composite sources or decomposing to further levels of detail is useful.

The search for relevant response options is addressed in step 2 of figure 8. An informal assessment of each response option is required which is usually easiest when the uncertainty types are viewed as a general composite. The search for possible responses is simple at face value. Following the identification of a source of uncertainty, it is frequently obvious how one would immediately respond. However, a more considered systematic approach may uncover opportunities that are not immediately apparent, particularly for sources that are particularly significant or complex.

The PMI (2013) advocates four generic response types; avoid, transfer, mitigate and accept. Figure 9 shows eleven generic response options that Chapman and Ward (2011) assimilate from literature. The mind-map format indicates that this is by no means a complete list of responses, but a trigger for the consideration of diverse response options. In reality, many responses fall into several categories. The aim of using such tools in this step is to maximise opportunity efficiency through robust early response development and a qualitative understanding of the consequences. This enables important sources of risk inefficiency to be designed out and provides a clarity efficient methodology for capturing opportunities.

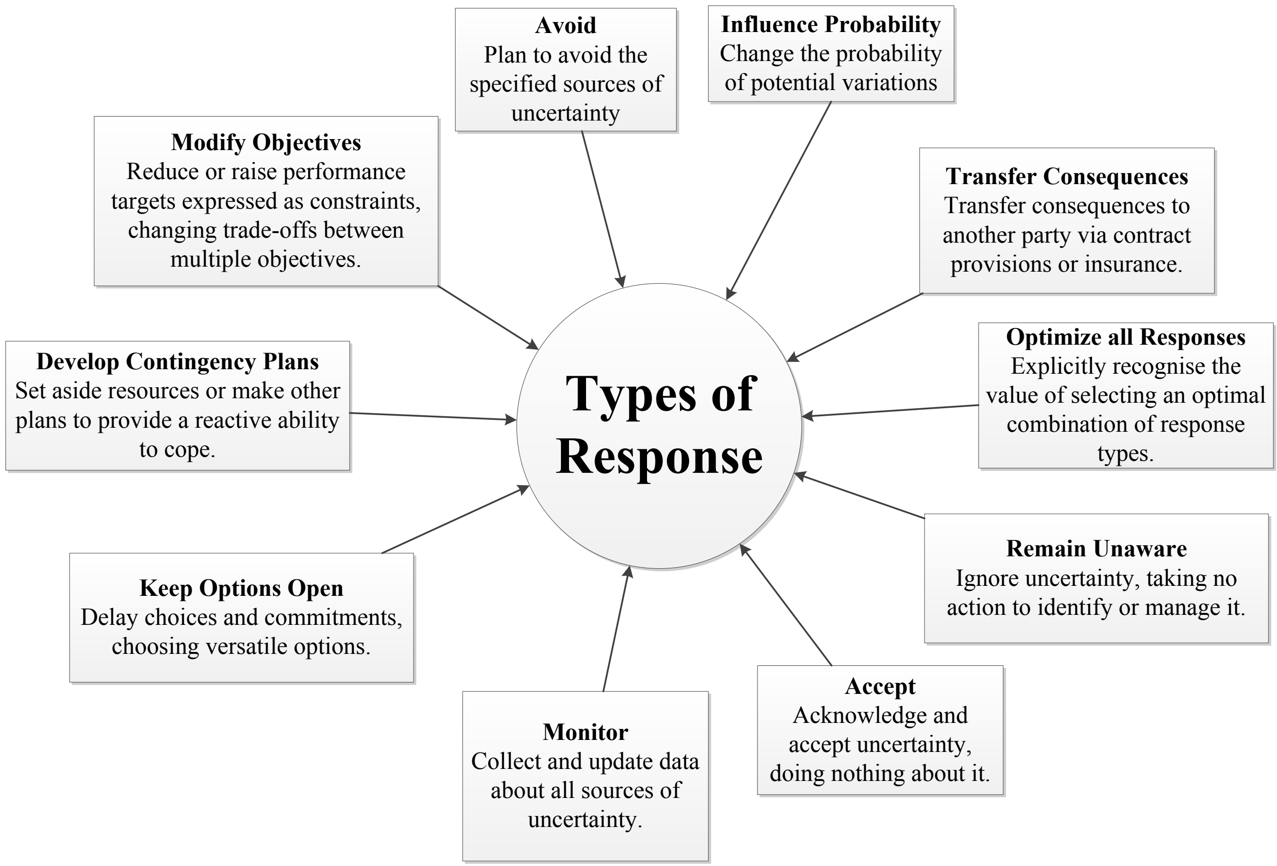


Figure 9: Generic response types - adapted from Chapman and Ward (2011)

For the identify phase to be effective, creativity must be embraced and encouraged. Identification can be undertaken by an individual or by a team of practitioners. The most straightforward approaches are 'pondering' techniques using a simple blank sheet of paper. While this could prove too simple and limited for some projects, it should not be dismissed as a starting point. Brainstorming is another familiar technique used to harness creativity. When used with groups with particularly keen understanding of the project at hand, or those with applicable prior experience, brainstorming can provide important responses. Synectics (Gordon, 1961) and decision-conferencing techniques (Finlay and Marples, 1991) are alternative techniques for problem-solving with groups of people. List based approaches could also prove useful as checklists to ensure the creative process has considered viable alternatives before moving on. Encouraging creative solutions and harnessing the relevant experience and expertise in a clarity efficient manor is key to realising powerful general response options and uncovering key opportunities.

Special consideration of the identify phase has been given in this report, since when operating in a high clarity context, identification can require significant effort. However, given an understanding of the process and of the project at hand, it is arguably one of the simplest phases in the PUMP framework. Simplification for lower levels of clarity is possible, providing the balance between clarity efficiency and holistic consideration is maintained. Clarity efficiency remains the key principle. The identify phase must ensure an adequate level of decomposition is performed for important sources, while higher level aggregates are utilised for those less important. The common practice approach offers only a glimpse of the total uncertainty, often missing key opportunities and the underlying complexities of sources identified. The PUMP approach to identification gives the widest possible appreciation of uncertainty as early as practicable in the process, which allows risk efficiency and most importantly opportunity efficiency to be achieved.

3 Evaluate *All* the Relevant Implications

The evaluate phase is the pivotal phase of the PUMP process and plays a critical role in consolidating understanding and controlling PUMP iterations. The phase involves collating all of the insight and results gained during previous phases into a coherent and comprehensive narrative understanding of the uncertainty involved and the response options available in a clarity efficient manner. An intuitive understanding of statistical and causal dependence is required to adequately understand the implications of underlying, often-complex relationships. Following result synthesis, the results must be presented in the most clarity efficient format, usually using diagrams, to allow interpretation of their practical meaning. This section is not a complete summary of the evaluate phase, but considers some of the tools available for efficient delivery of the phase objectives in some detail, with further areas of consideration in Chapman and Ward (2011).

The phase deliverables may be a simple list of priority sources and responses at early project stages. This may be developed further to diagnose issues and suggested revisions to base plans so that specific sources of risk inefficiency are avoided, and to ensure opportunities are captured. There are five 'modes' of operation of the phase, shown in figure 10.

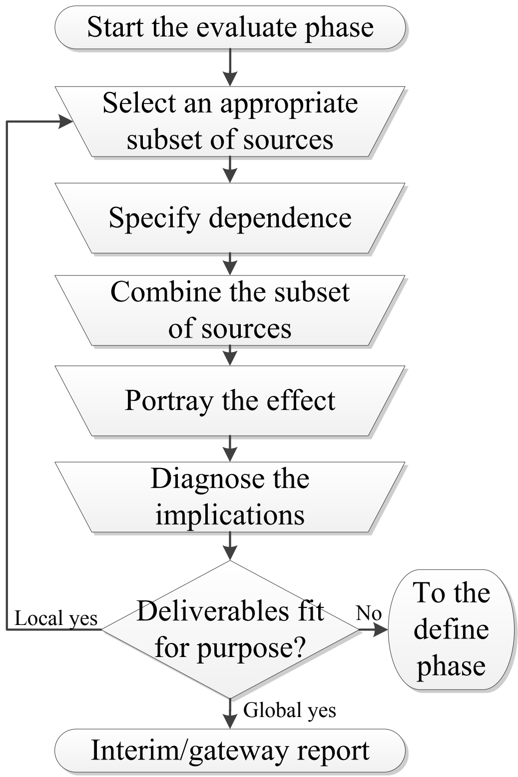


Figure 10: Evaluate Phase Process - adapted from Chapman and Ward (2011)

Specifying dependence is an important mode of the phase. To simplify the approach, many practioners following common practice may assume independence between sources. This is an extremely dangerous assumption, and any formal analysis based on this on a non-evidential basis should be immediately discounted. Falsely assuming independence paints an optimistic picture of the circumstances by ignoring the knock-on effects of underlying complexity. This can be compounded by over-simplified computational tools that aim to make calculations easier, and by a managerial preference for limited variability. Positive dependence is a more reasonable assumption, making a more conservative, robust assessment of the impacts. In high-clarity contexts, complex statistical and causal dependencies may require more sophisticated modelling approaches to adequately understand the full implications.

The dangers of making false dependency assumptions is shown in the contrast between independent and positive correlation in figure 11. Two identical probability functions are combined by addition, showing the difference caused by dependence assumptions. Any dependence relation between 0-100% can be achieved by linear interpolation between the two curves.

Cost (£k) a,b	Probability
8	0.2
10	0.5
12	0.3

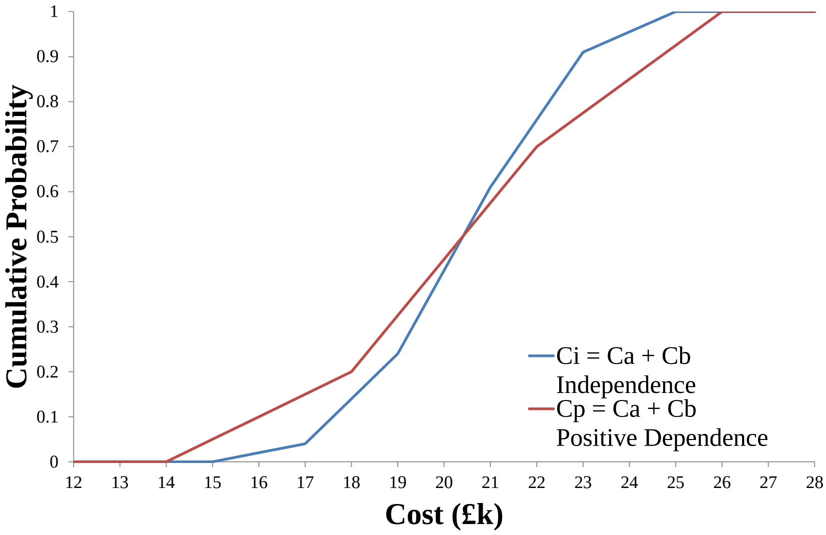
(a) C_a and C_b probability density functions are identical

Cost (£k) i	Computation	Probability
16	0.2x0.2	0.04
18	0.2x0.5 + 0.5x0.2	0.20
20	0.2x0.3 + 0.5x0.5 + 0.3x0.2	0.37
22	0.5x0.3 + 0.3x0.5	0.30
24	0.3x0.3	0.09

(b) $C_i = C_a + C_b$ probability density function assuming independence

Cost (£k) p	Probability
16	0.2
20	0.5
24	0.3

(c) $C_p = C_a + C_b$ probability density function assuming positive correlation



(d) Cumulative probability distributions for the addition of C_a and C_b

Figure 11: The impacts of independent and positive dependence assumptions - adapted from Chapman and Ward (2011)

Another key mode of the phase is to portray the effects. The story that has been developed throughout the analysis must be conveyed in the most clarity efficient manner to be of any practical value to the project organisation. Sensitivity diagrams are an important tool for conveying and explaining uncertainty. The common phrase "a picture is worth a thousand words" is relevant here. A sensitivity diagram gives the audience the required information in a non-threatening easy-to-grasp format so that interpretation can take place and issues raised can be resolved.

The sensitivity diagram in figure 12 shows the collation of six sources associated with a geotechnical investigation project in preparation for the construction of a power station. A diagram of this type may be required for each activity in a network. The gap between each curve portrays the effect of the labelled source. The final source "personnel Availability for Processing" is clearly the most important source in this example, and more effort can be given to addressing this as required. The ordering of the sources are important, so that any causal and statistical dependence is portrayed by adjacency of sources. A maximum of around six sources should be displayed on the diagram to ensure the meaning remains clear. Less important sources can be combined so that only the most relevant aspects of the story are shown.

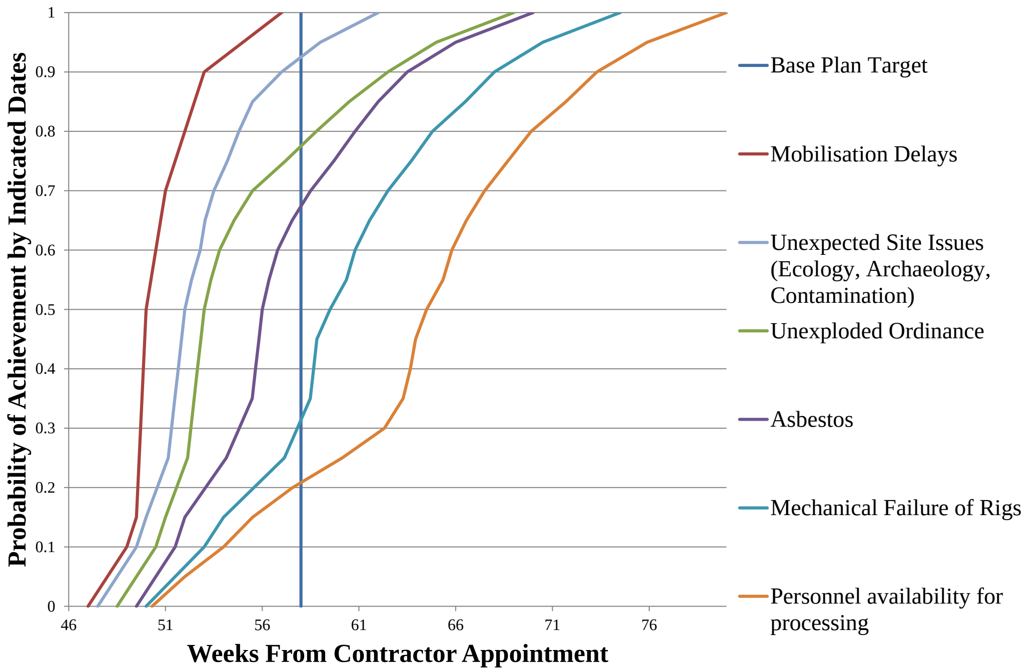


Figure 12: Sensitivity diagram for geotechnical investigations completion date - adapted from Chapman and Ward (2011) & Hopkinson et al. (2008)

It may be useful to expand a sensitivity diagram where schedules are concerned. This can help develop a project strategy that includes realistic milestones and help identify contingency requirements (Hopkinson et al., 2008). Uncertainty can be decomposed through a number of project milestones and contracting activities, as in figure 13. This can be displayed alongside a Gantt chart to portray the schedule implications if this adds to understanding (Hopkinson et al., 2008).

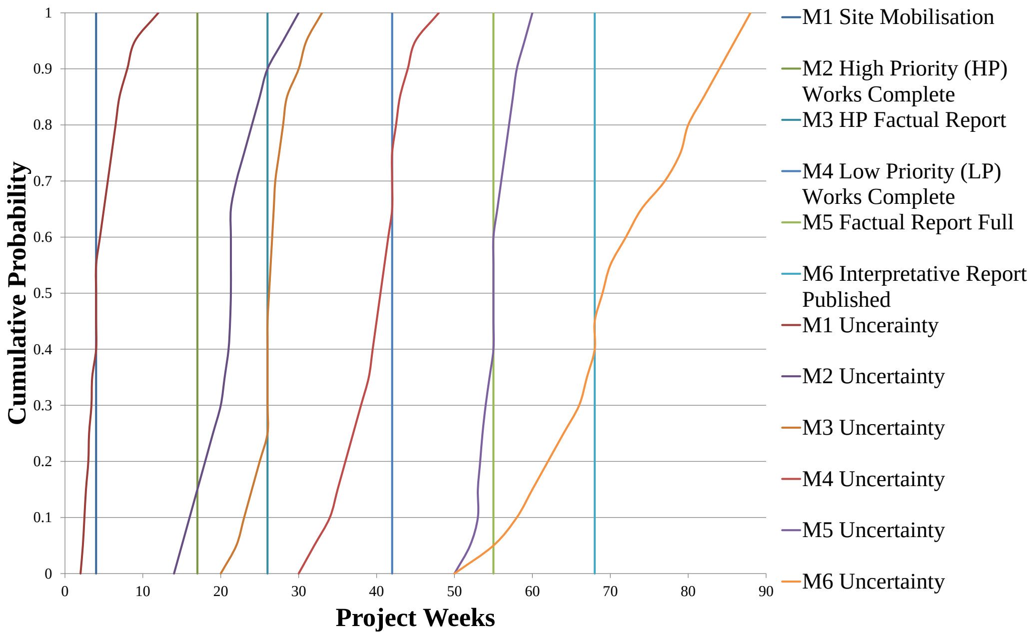


Figure 13: Schedule sensitivity diagram - adapted from Hopkinson et al. (2008) & Chapman and Ward (2011)

There are alternative forms of sensitivity diagram which may be useful for presenting uncertainty when there are several different parameters involved. One of these is the tornado diagram, as shown in figure 14, a common output from Monte Carlo simulation programs. Each parameter is varied in turn whilst the others are held at a constant expected value. The sources are then portrayed in order of significance.

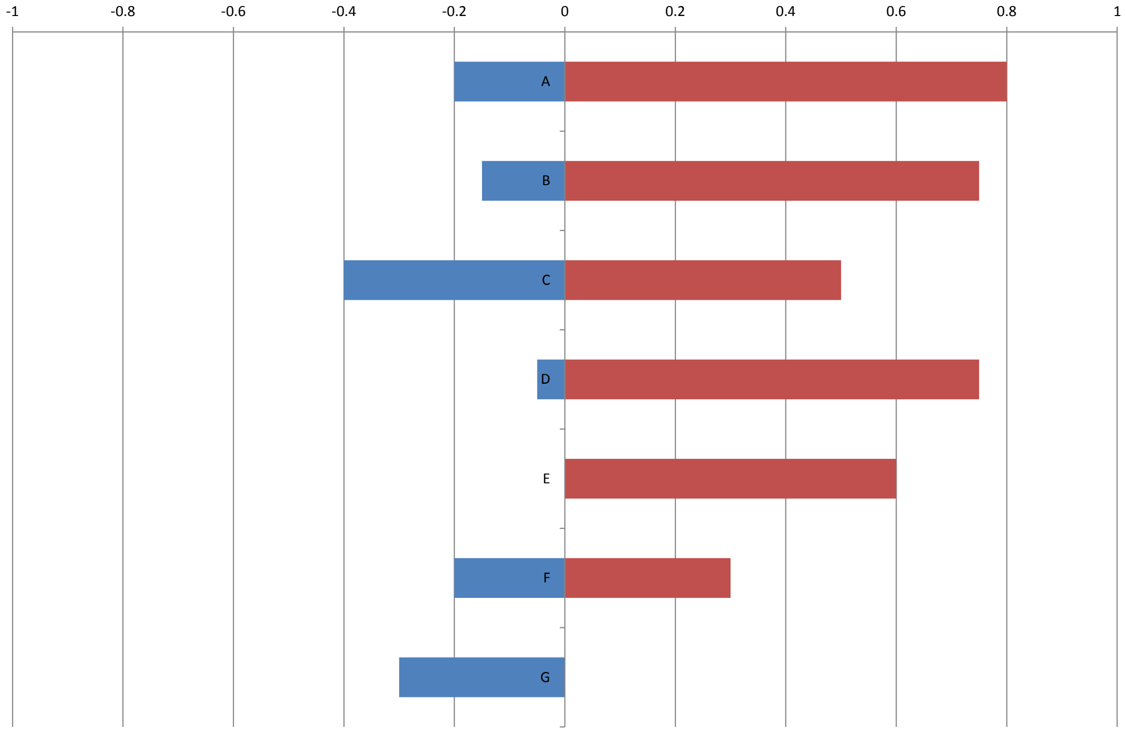


Figure 14: Tornado diagram - adapted from Hopkinson et al. (2008)

The evaluate phase is key to the successful implementation of an iterative process. Iteration is one of the key sources of clarity efficiency which is harnessed through the PUMP approach and the reason for special focus on the evaluate phase in this report. It is essential that on the first pass of the PUMP that only a rough sizing of all relevant sources is undertaken. The aim is not to achieve an accurate probability estimate for all sources; this is not clarity efficient and means time is not spent optimally. The first pass should result in a simple order-of-magnitude picture of the importance of the sources so that successive iterations can refine the most important sources where useful.

Informed, effective and efficient decision taking is the key deliverable so that opportunity efficiency can be maximised. The evaluate phase consolidates the outputs from the other phases for presentation and interpretation. Attention must be paid to how dependency and assumptions are dealt with during this phase. Any analysis that does not adequately consider these factors should be discounted. The use of a nested structure of sensitivity diagrams together with decision diagrams (Chapman and Ward, 2011) highlights the trade-offs between sources. This interpretation of the portrayed uncertainty culminates in the effective shaping of base plans and project strategy so that risk inefficiency is minimised while opportunity efficiency is maximised.

4 Concluding Remarks

Risk management processes have evolved hugely in recent years. Best practice approaches are increasingly harnessing the concepts of opportunity efficiency and clarity efficiency rather than rigid, linear, event-centric methodologies of the past (APM, 2012). However, the PUMP approach remains a forerunner to best practice in the focus on opportunity, an encompassing perspective of uncertainty and in the attention to tackling underlying complexity and assumptions. This is achieved while increasing the clarity efficiency of the overall process. Personally, I have discovered and understood many principles that have shifted my perspective of risk to a holistic appreciation of uncertainty, enriching my career as an engineer and resulting in the maximisation of success in future projects.

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Appendices

A Acknowledgements

This work builds on the ideas in Chapman and Ward (2011). The work is not referenced unless there is direct quotation or adaption from the text. However, it remains the main source for this report and it's influence is kindly acknowledged.