Environment Systems and Decisions, September 2014, Volume 34, Issue 3, pp 417-424

Protecting Asset Value and Driving Performance with a Dynamic, Risk-Based Contingency

C W Mauelshagen, S J T Pollard*, D Owen[†], S Herndlhofer[†], P Firth[†], J McKenna[†], N Bingley[†] , P Jenson[†]*

**Cranfield University, UK, c.mauelshagen@cranfield.ac.uk, [†]Yorkshire Water Services, UK*

Keywords: Contingency, risk, performance, asset management.

Abstract

We present a risk-based contingency management methodology to mitigate the impact of external risks on asset value and performance. Many asset intensive industries, such as water and energy utilities, are significantly affected by external risks such as extreme weather events. Given that extreme weather events are expected to become more frequent under anthropogenic climate change we believe there is a need for such tools to allow companies to better protect themselves. Our risk-based contingency approach is appropriate for short term business planning and would complement longer term climate change adaptation and mitigation strategies. Our approach offers a risk-based methodology to manage contingency that is explicit and defensible. Critically, our methodology allows contingency to be managed dynamically as risk probabilities and impacts change, creating a mechanism for contingency funds to be periodically released if risk exposure reduces. The long term benefit of contingency that is dynamic and risk-based is to mitigate the impact of external risks and support long term sustainability of the business.

1 Introduction

We believe creating and managing an appropriate contingency is a critical part of asset management. During capital investment planning and delivery, cost, time and quality risks are routinely taken into account when setting contingency. However, uncertainties around on-going operational costs are not often treated with the same rigour. Effective operation and maintenance are critical to efficient asset management, particularly for long-lived assets. For example, human error has a large impact on asset operation (Wu et al. 2009), contributing to significant proportion of the unexpected cost and lost revenue associated with assets (Eti et al. 2006; Le May and Deckker 2009). For industries with assets exposed to the natural environment, for example water utilities and construction, weather can have a large impact on asset performance resulting in significant costs (Taroun 2013). Further as extreme weather events become more frequent (Easterling et al. 2000) it will become increasingly important for companies to better prepare for and manage the impact of extreme weather events both in within-year business planning and as part of long term strategies and investment. In this paper we present a simple and usable methodology to establish and manage such a contingency, that we believe any company could implement with relative ease.

1.1 Role of contingency

The primary approach to managing asset risk is to proactively reduce the likelihood of risk events materialising (control) or reduce the severity of the impact of risk events (mitigation) through the use of barriers (Pollard et al. 2004; Flage 2013). Barriers may be physical, such as retaining walls, or behavioural such as training or standard operating procedures. Where proactive risk management through control or mitigation barriers is not possible or feasible, other risk management options include, risk sharing, risk transfer or simply accepting risk (Hopkins 2008). However, for many asset intensive industries, such as water utilities, assets can be significantly impacted by external risk drivers that are, to a significant degree, beyond the control of the managing company. For example, extreme weather, climate change, the global economy, supply chains and customer behaviour cannot be completely controlled. Many of these uncontrollable, external risks are increasing in both severity and complexity, for example risk due to globalisation of supply chains and anthropogenic climate change (IBM 2007; Rowan et al. 2013). As a result, there can be a significant residual risk left after all reasonable risk controls and mitigations have been put in place. Further, there may be considerable uncertainty around that residual risk. This is particularly true of risks due to climate change (Allen et al. 2000).

This residual risk around the operation of assets can be partially managed through the provision of contingency. A well-managed contingency fund can provide the additional resources required to respond effectively once a risk event has realised to minimise impact on customer service and performance from the perspective of owners, for example shareholders. Where possible it can also provide the additional investment required to scale up proactive risk management measures in response to a suddenly increases risk. Some external risks are cyclical, for example extreme weather risks where some years weather will be benign and others extreme. For these risks, a contingency effectively smooths the impact of extreme events by transferring the financial headroom experienced when risks do not realise to periods when those risks do realise (Figure 1). Financial headroom can be transferred to operational headroom through provision of additional people-hours and equipment as appropriate.

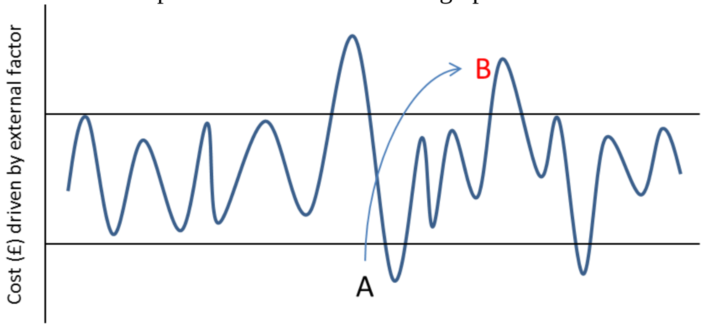

Figure 1: Using a contingency fund to balance higher than expected costs (B) and lower than expected costs (A), thus minimising disruption in operational performance and volatility in financial performance.

1.2 Research aim

The aim of this research was to develop an effective and practicable methodology to provide risk information relevant to setting, managing and using a operational contingency fund. The first step was to establish a set of criteria the contingency methodology would have to fulfil:

- The contingency would have to accurately reflected exposure to unexpected operational costs both in terms of risks (unexpectedly high costs) and opportunities (unexpectedly low costs).
- It would have to be dynamic to reflect the volatile nature of risk drivers such as weather and markets.
- It would have to be able to inform both the provision of contingency but also the release of contingency when it is no longer needed.
- It must be able to reflect a firm's risk appetite, which may change with time and between firms.
- It must support a quantitative assessment and aggregation of risk. But reflecting the common challenge of data availability (Taroun 2013), the model will also be able to use expert judgement of risk.
- Finally, to generate maximum value it must be able to be integrated into business planning processes.

Below, we describe the methodology and process we have developed to meet these criteria. It was developed and trialled in collaboration with a UK combined clean and waste water utility. However, it could, in principle, be applied to any industry where operational costs and performance are significantly affected by external risk drivers.

2 Dynamic risk-based contingency model development

To develop this methodology we worked closely with a UK combined Water and Sewerage Company. This gave us access to data and allowed us to test whether our model provided decision relevant outputs. The utility was typical of its sector, in that it owned and operated a large asset base and was exposed to a wide range of external risks. These included risks due to extreme weather (extreme cold in winter and droughts in summer), changing customer demand and behaviour, regulatory changes, financial markets (ability to raise finance and cost of capital) and input cost inflation (notably energy and construction costs). Risk of unexpected operational costs must be particularly carefully managed in highly regulated utilities, such as our case study, which have to commit to large capital projects with associated outcomes to be delivered for tightly controlled budgets.

2.1 Identification and selection of suitable risks

Risks were identified through the existing risk governance processes and through expert elicitation. Drawing on the company's strategic risk register and interviews with finance managers in each business unit, a comprehensive register of risks and opportunities with an impact on operational cost was developed.

A key outcome of our research was that selecting the range and type of risks to be managed through provision of contingency is a critical step. As we will discuss a central contingency is not appropriate as a management tool for all risks. Through this study we developed a set of guidelines to select risks that are appropriate and feasible to be mitigated through a central contingency (Table 1). In summary, only medium impact and frequency risks (Figure 2) driven by an external risk driver were deemed suitable to be mitigated through the central contingency. What constitutes 'medium' impact and frequency will vary between companies but for this case study it entailed risks with a probability of 10-20% chance of occurring in a year (therefore, with a frequency of 1-2 times a decade) and an impact of £1-5 million. The main rationale behind this (Table 1) is that if a central contingency is used to manage too broad a range of risks, it might compensate for poor operational performance that could be better tackled through a route cause analysis and mitigation of the underlying human, technological or organisation causes. For this reason, central contingency should be limited to mitigating residual risks driven by external factors largely outside of the risk owner's control. More seriously, over-reliance on central contingency as a kind of internal insurance fund might retard efforts to proactively and preventatively manage risk. In summary, a critical step in establishing and managing a central contingency to mitigate the residual risk of asset operation, is determining which risks are appropriate and feasible to be mitigated through a central contingency. Guidelines to help this determination are set out in Table 1.

Risk type	**Appropriate for central contingency**	**Rationale**
Low impact risks	No	Should be within the capability of local managers to manage. Therefore, local managers' responsibility to be sufficiently resilient to small shocks.
High frequency risks	No	Likely to occur every year (multiple times) and therefore, should not be a surprise and should be accounted for in business (as usual) plans.
High impact risks	No	Should be managed preventatively where possible and mitigated through third party insurance were necessary. Would require an unfeasibly large central contingency, therefore share risk with other organisations.
Very high impact risks	No	Impacts are intolerable and risk management should be proactive and preventative using multiple barriers [10].
Risks with internal drivers	No	(Where possible) should be addressed preventatively through route cause of risk (whether it is human error, technological or organisational). Contingency should not compensate for poor performance.
Moderate impact risks	Yes	Beyond the ability of individual managers and business units to absorb. Do not require excessive contingency to be held.
Moderate frequency risks	Yes	Not likely to occur every year, so beyond scope of annual business (as usual) planning.
Risks with external drivers	Yes	Risk drivers are partly or wholly beyond control of organisation, therefore not due to poor performance.

Table 1: Rationale for what range of risks are appropriate and feasible to be mitigated through a central contingency.

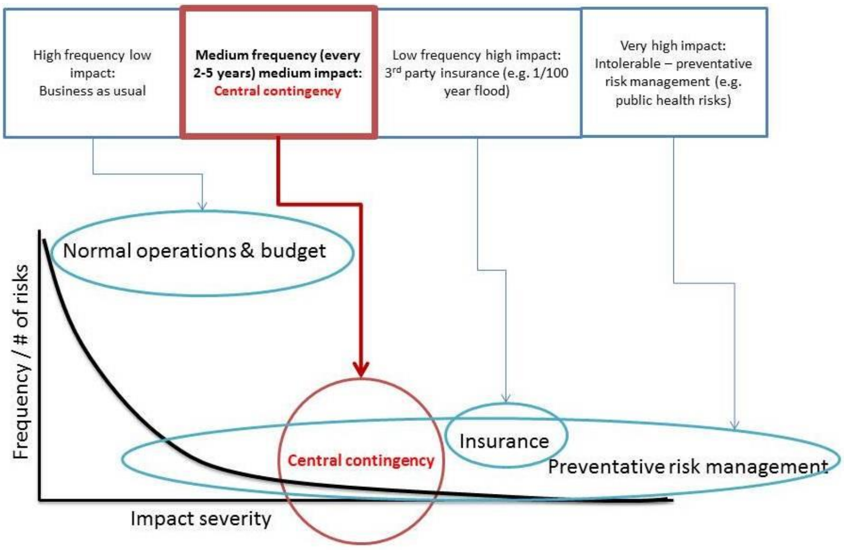

Figure 2: Range of risks, delineated by frequency and impact, appropriate and feasible to be mitigated through a central contingency.

2.2 Methodology to represent risk and uncertainty

Risks were represented within a Microsoft Excel spread sheet with the @Risk version 6.1 add-on for the stochastic and Monte Carlo functions. Risks were expressed as their probability of occurrence and the severity of impact should they occur. We used Bernoulli and Triangular probability density functions to model probability and impact respectively (Figure 3). Bernoulli probability density functions are suitable for modelling a stochastic event that may or may not happen (Rees 2008). We found triangular probability density functions effective for representing the information on risk impact available to us, which was predominantly expert judgement. By asking domain experts in each risk to estimate the best case scenario, most likely case, and worst case scenario we defined a triangular distribution for each risk. The same approach was applied to opportunities with the difference that the impacts on cost were negative (lowering overall cost). If quantitative data were available, or should become available, a different distribution could be fitted or selected, such as a normal or lognormal distribution, and simply substituted for the triangular distribution in the model.

The underling method then used to calculate the dynamic risk-based contingency is a Monte Carlo simulation. A Monte-Carlo analysis involves repeatedly selecting a random variable from stochastic functions within a model or function and solving that model or function. Over a large number of iterations almost all possible outcomes are simulated. These can then be analysed for the range and likelihood of outcomes, and sensitivity of the outcome to input variables.

In this model, the Monte Carlo simulation followed the following steps. For each iteration, a random value was selected from each risk's probability distribution and impact distribution. For each risk the selected probability value and impact value were multiplied and the resulting values summed for all risks. This was repeated for 10,000 iterations to produce a comprehensive range of possible scenarios of the risks modelled, reflecting the frequency of occurrence for each risk and range of impacts. Where risks were known to be related, for example sharing a common risk driver, @Risk allowed their probability of occurrence and/or severities to be correlated in the Monte Carlo.

In order to account for the seasonal variability of risks (particularly weather related risks), the probability of each risk was determined on a month by month basis. Profiling the probability of risks across a year with even a monthly granularity proved challenging due to lack of data and the novelty of many of the risks. To overcome this, risk experts were asked to assess for each month whether their risk(s) had a low, medium or high probability of realising and attribute probabilities to each of those probability categories. As a notional example, the risks due to extreme winter weather might be judged at zero for summer months, low in autumn and spring ($p = 0.05$), and high in winter (December to February) ($p = 0.1$).

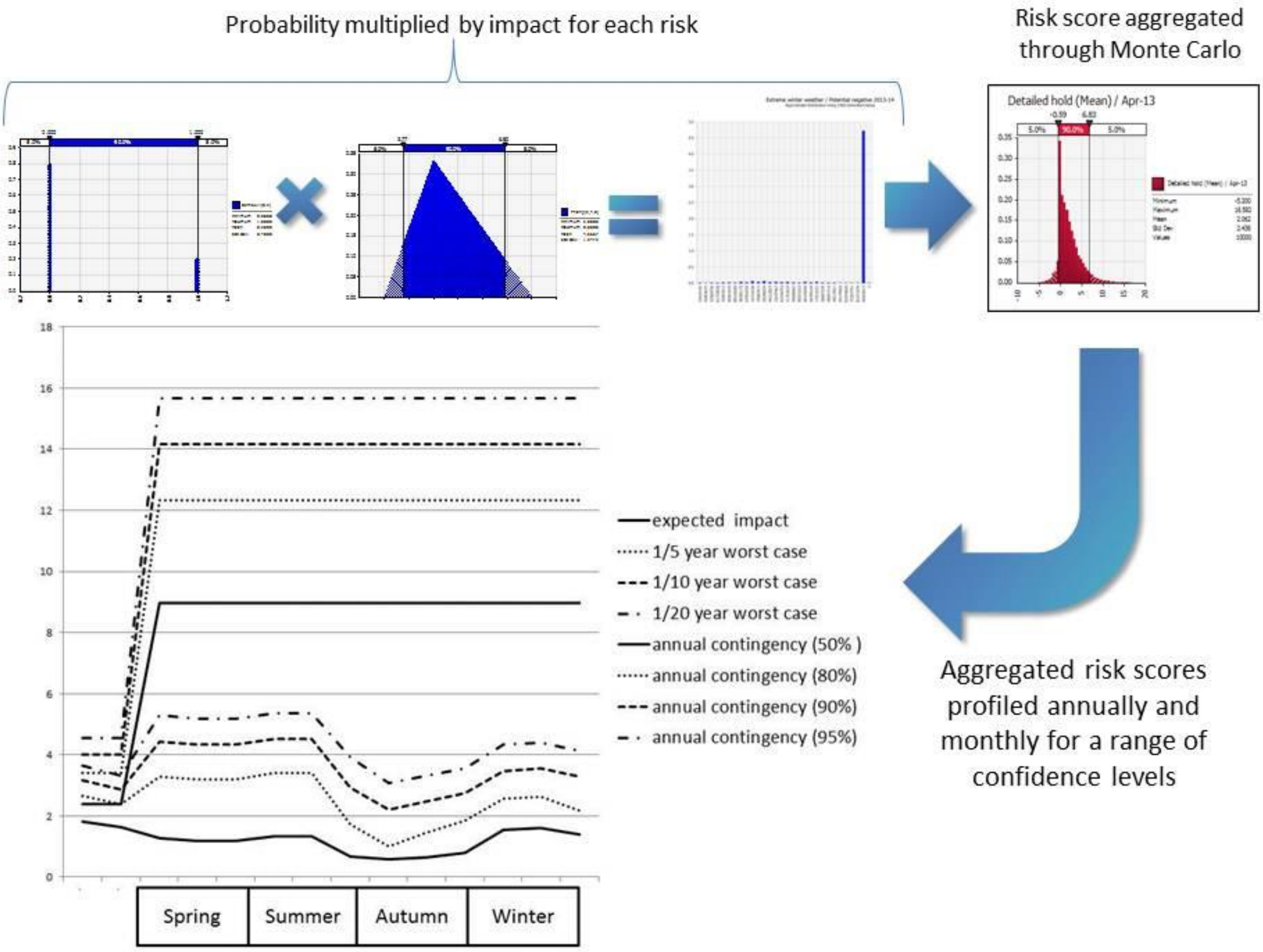

Figure 3: Method to model and aggregate financial risk exposure on a rolling monthly basis in order to determine (and manage) annual contingency required (dates and precise values have been removed for confidentiality).

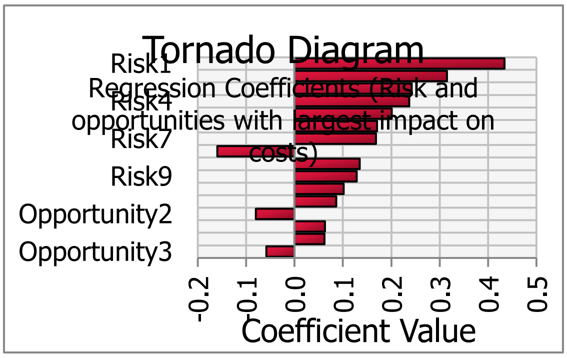

Figure 4: Risks and opportunities with largest impact on financial exposure (unexpected costs).

2.3 Sensitivity analysis

Sensitivity analysis can provide valuable insights into key risk drivers. This functionality is provided by @Risk. The ability to show which risks most drive changes in overall risk indicates where to focus risk management resources. One graphic, the “tornado diagram” (Figure 4), ranks the input risk factors by their impact on the total output mean. This can inform a prioritisation of resource to mitigate risk and ensure that use of contingency is optimised. It is also a useful indicator of the uncertainty associated with each risk or opportunity which can be useful to inform where further data gathering or research is required.

2.4 Selecting risk appetite for contingency

The contingency model produces a range of potential costs (financial impact of realised risks) each with a different probability. This necessitates a decision on the level of residual risk the organisation is willing to take and therefore the level of contingency required. For example, an annual contingency of £10m might be forecast to be sufficient with a confidence level of 90%, i.e. £10m can be expected to be sufficient up to a 1/20 year worst case. Alternatively, the same results might also determine that an annual contingency of £20m would provide sufficient with a 99% confidence, i.e. can be expected to be sufficient for up to a 1/100 year worst case.

Determining the percentile level of risk to use is a direct reflection of an organisation's risk appetite. The instinct of some might be to use the median or mean value as using this value would meet the criteria of being risk neutral. However, this would be an unusually high risk level to take for most organisations, whereby approximately half of the time the contingency would be insufficient. One standard deviation above the mean would provide cover with an 85% confidence level and is often used. For example, an 80% confidence level was used to determine contingency for the on-going $5.25 billion Panama Canal expansion and is judged to be appropriate for capital projects of this magnitude (Alarcón et al. 2011). An annual contingency at the 80% confidence level would be expected to be sufficient four out of five years.

2.5 Managing contingency

One practical constraint on how contingency could be managed are accounting and financial management practices. Because budgets cannot always be carried over from one financial year to another, it would not always be possible to simply bank money in a 'lucky' year when risks were lower or did not materialise, and keep it until an 'unlucky' year. Particularly for low frequency risks, the time value of money would make this unappealing. Instead at the beginning of each year the amount needed to cover an 'unlucky' year to an appropriate level would have to be set aside in the central contingency (Figure 5). Where risks then materialised, the contingency would be used to mitigate the additional costs. If on an annual, quarterly or monthly basis risks did not materialise or were lower than expected, contingency would be returned to investors or reinvested in the business while retaining contingency appropriate to the remaining risk.

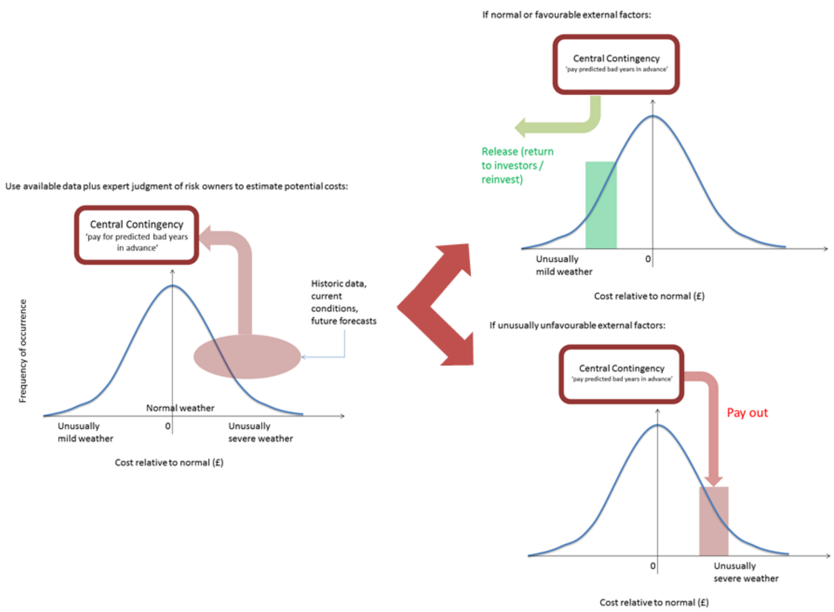

Figure 5: Establishing, using and releasing central contingency to manage external risks such as extreme weather.

In order to ensure that central contingency is based on an up-to-date assessment of risk and is available for shareholder return/reinvestment more often (but without creating an excessive work-load for risk owners and exerts), risks should be re-assessed monthly and contingency adjusted accordingly. Another benefit of monthly risk assessments is ability to dynamically capture the seasonal nature of risk (particularly relevant to weather related risks). As can be seen in the results obtained from our case study of a water utility, risk exposure was highest in summer and winter due to weather related risks (Figure 3) namely too little water and cold weather increasing leakage. The total level of contingency held would typically decline as each year progressed due to a reduction in risk exposure (simply because there is less time for risks to realise and one off risks may already have realised) and through the release of excess contingency at the end of each month, with the option to return or reinvest unused contingency.

The following example (Figure 6) illustrates how contingency managed on a quarterly basis could be used or released: *at the beginning of the year a central contingency of £10m is required. During the first quarter of the year (Q1) approx. £1m is paid out to cover exceptional costs. £9m remains in the contingency pot. At the end of Q1 the risk for the remaining three Quarters is assessed and will require a contingency of £8.5m. Therefore £8.5m is retained in contingency and £0.5m is released for return (to shareholders) or reinvestment in the business. This is repeated for the remaining Quarters until contingency is reduced to zero at the end of the year through use to cover exceptional costs or release.*

A key strength of our contingency method and process is that it provides a clear methodology to release contingency when risk is reduced or is lower than initially expected. For example, at the beginning of a year contingency may be held for the costs due to increased pumping and other measures required in the event of unusually low precipitation in the summer months. If, later in the year this does not occur or is deemed unlikely to occur, the marginal contingency set aside for this risk can be realised and used as deemed appropriate by the business, without impacting the overall risk position of the company. Conversely, by dynamically updating risk on a monthly or quarterly basis any increase in risk can be captured. Increased exposure to risk can be mitigated by providing additional contingency or through other risk management actions such as increased preventative controls and reduction of other risky activities.

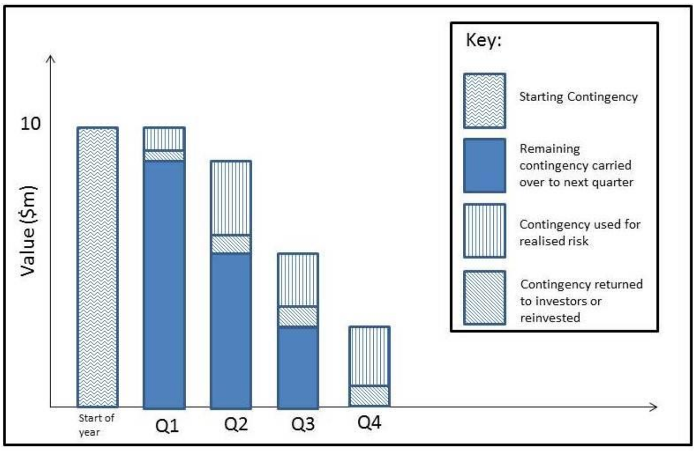

Figure 6: Example annual profile of central contingency where, on a quarterly basis, contingency is either used to mitigate realised risks, returned to shareholders/re-invested in the business, or retained for subsequent quarters.

4 Conclusions and future development

The benefits identified through development of this model, of using a contingency fund to reduce cost and operational volatility due to uncontrollable, external factors are:

- Prevention of existing asset performance being compromised due to unusually high costs driven by external factors.
- Ensuring that when costs are normal or lower than usual contingency funds can be released following an explicit methodology and used appropriately.
- Prevent contingency being appropriated to compensate for poor performance.
- Allow contingency to be optimised for the seasonality of risks (for example, a contingency for winter risks does not have to be held during summer) reducing the overall amount of contingency required without reducing the level of risk covered.
- Provide a robust methodology for better governance of contingency.
- **Altogether, contribute to the sustainability and long term value of the business.**

For many organisations largely uncontrollable external risks already have a significant impact on performance and must be managed. This is particularly true of companies exposed to weather related risks, but are also true of companies exposed to volatile markets and regulatory regimes. Given that weather related risks are likely to become more frequent and severe due to anthropogenic climate change, managing the impact of weather will become an increasingly core competency. We argue that an ability to mitigate the short term cost and performance impact of weather events (and other external risks) through provision of contingency will constitute part of that competency, alongside preventative risk management and long term strategies to build resilience.

Finally, this method for setting and managing contingency is undergoing constant development. A key functionality under development is ability to model the effects of risk drivers on key risks so that future risk exposures can be forecast and explored through ‘what-if’ scenarios and to model risk interactions in greater sophistication. For example, it would be valuable to explore what future climate change scenarios could mean for risks driven by extreme weather. It would also be valuable to assess the knock-on impact of risks, for example if one asset fails what is the reduction in operational capability to deal with subsequent, simultaneous asset failures. This will require modelling the entire value chain including all operational costs and cost drivers. Ultimately the aim is to apply such a probabilistic approach to expected cost and time predictions (i.e. not just unexpected costs as in this model) within business planning. This would serve to integrate risk management more closely with core business and investment planning activities. We view the risk-based contingency methodology presented in this paper, and the processes around it, to be a step towards the ultimate goal of fully integrated risk and cost based business planning, both capital and operational.

References

Alarcón LF, Ashley DB, de Hanily AS, et al. (2011) Risk Planning and Management for the Panama Canal Expansion Program. J Constr Eng Manag 137:762–771. doi: 10.1061/(ASCE)CO.1943-7862.0000317

Allen MR, Stott PA, Mitchell JFB, et al. (2000) Quantifying the uncertainty in forecasts of anthropogenic climate change. Nature 407:617–620. doi: 10.1038/35036559

Easterling DR, Meehl GA, Parmesan C, et al. (2000) Climate Extremes: Observations, Modeling, and Impacts. Science 289:2068–2074. doi: 10.1126/science.289.5487.2068

Eti MC, Ogaji SOT, Probert SD (2006) Reducing the cost of preventive maintenance (PM) through adopting a proactive reliability-focused culture. Appl Energy 83:1235–1248. doi: 10.1016/j.apenergy.2006.01.002

Flage R (2013) On risk reduction principles in the context of maintenance optimisation modelling. Proc Inst Mech Eng Part O J Risk Reliab 227:241–250. doi: 10.1177/1748006X13489954

Hopkins A (2008) Failure to learn: the BP Texas City refinery disaster. CCH Australia, Sydney, N.S.W.

IBM (2007) IBM Research | Technical Paper Search | Harnessing Uncertainty: The Future of Risk Analytics (Search Reports). http://domino.research.ibm.com/library/cyberdig.nsf/papers/B910FD44213574458525743400534 9F4. Accessed 1 May 2013

Le May I, Deckker E (2009) Reducing the risk of failure by better training and education. Eng Fail Anal 16:1153–1162. doi: 10.1016/j.engfailanal.2008.07.006

Pollard SJT, Strutt JE, Macgillivray BH, et al. (2004) Risk Analysis and Management in the Water Utility Sector: A Review of Drivers, Tools and Techniques. Process Saf Environ Prot 82:453–462. doi: 10.1205/psep.82.6.453.53207

Rees M (2008) Financial modelling in practice. Wiley ; John Wiley [distributor], Hoboken, N.J.; Chichester

Rowan E, Evans C, Riley-Gilbert M, et al. (2013) Assessing the Sensitivity of Transportation Assets to Extreme Weather Events and Climate Change.

Taroun A (2013) Towards a better modelling and assessment of construction risk: Insights from a literature review. Int. J. Proj. Manag. In Press:

Wu S, Hrudey S, French S, et al. (2009) A role for human reliability analysis (HRA) in preventing drinking water incidents and securing safe drinking water. Water Res 43:3227–3238. doi: 10.1016/j.watres.2009.04.040