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Mapping the multi-faceted: Determinants of uncertainty in safety-critical projects

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Abstract

Project managers tasked with delivering safety-critical projects must demonstrate care, competence and confidence right from the earliest stages of project inception, when levels of uncertainty can be very high. Based on interviews with 30 project management practitioners in civil nuclear and aerospace sectors, this paper builds on work by Saunders et al. (2015), who posited the Uncertainty Kaleidoscope as a framework for identifying uncertainties.

Our findings are that the six determinants of project uncertainty are similar across both civil nuclear and aerospace projects. The most commonly mentioned determinant of project uncertainty was the Environment, followed by Complexity, Capability and Information. The impact of Time on project uncertainty and Individual perceptions of uncertainty were mentioned less frequently by respondents.

Our key contribution is to validate the Uncertainty Kaleidoscope over a larger data set, thereby enriching our understanding of the sources of project uncertainty in these two important and highly-consequential project environments.

Keywords: Project uncertainty; Safety-critical; Large-scale projects

1. Introduction

Large scale engineering projects are central to modern society. Without them there would be no reliable infrastructure, iconic buildings or inspiring Olympic Stadia. However, one of the myriad challenges facing these projects is how to adequately identify and manage project risks, uncertainties and complexities in order to minimise the potential for failure (PMI, 2013). In safety-critical projects – where safety is of paramount importance and where the hazards that must be controlled can harm the environment, personnel, or the public (Wears, 2012) – the delivery of safe and reliable projects is an absolute imperative. Here project objectives such as schedule and cost are always subordinate to the absolute priority afforded to safety (Kettunun et al., 2007; Saunders, 2015). In safety-critical projects individuals must bear the burden for projects, whose timescales are often long, budgets vast and technical complexity high, and where the consequences of failure may be catastrophic (Reiman and Oedewald, 2009). Irrespective of whether the project is to safely decommission nuclear reactors or design the next generation civil airliners, the project landscape will be dominated by regulatory requirements and the need to be in control at all times (Hollnagel et al., 2006; Laporte and Thomas, 1995). Identifying the sources of, and influences on, uncertainty in these safety-critical projects is an essential task for the project management practitioner throughout the project lifecycle.

Uncertainty in its broadest sense is a state of unknowing — where an individual does not have full knowledge of the facts about a particular situation (Perminova et al., 2008). Uncertainty pervades our daily lives and has been studied through the lens of several academic disciplines from economics, psychology and mathematics to philosophy (see for instance Bammer and Smithson, 2009; Osman, 2010). In the context of projects,

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the APM defines project uncertainty as "a state of incomplete knowledge about a proposition. Usually associated with risk, both threats and opportunities" (Association of Project Management, 2006, p. 6). The extant literature on the management of project uncertainty provides us with a number of definitions of project uncertainty, including differentiating it from project risk (Grote, 2015; Hillson, 2002; Sanderson, 2012; Chapman and Ward, 2011); discusses how uncertainty arises in projects (Atkinson et al., 2006; Cleden, 2009; Martinsuo et al., 2014; Saunders et al., 2015; Ward and Chapman, 2003; Winch, 2010) and proffers a variety of approaches to managing project uncertainty (Atkinson et al., 2006; Browning, 2014; Cleden, 2009; Hillson, 2002; Loch et al., 2006; Martinsuo et al., 2014; Perminova et al., 2008; Saunders et al., 2015; Vidal, 2015).

However there are no major studies of uncertainty in safety-critical projects, other than a small exploratory study by Saunders et al. (2015). Given the centrality of safety-critical industries to modern life, and recent calls in the project management literature to replicate rather than reinvent project management research (Horner Reich et al., 2013), our aim here is to refine and validate the earlier exploratory study (Saunders et al., 2015) on a larger and more purposefully selected data set. This will enrich our understanding of the sources of, and influences on project uncertainty in these highly-consequential project environments.

Our analysis is based on semi-structured interviews with 30 project management practitioners on nine large scale projects in civil nuclear and aerospace industries in the United Kingdom. It addresses three key research questions:

RQ1: Whether and how the Uncertainty Kaleidoscope (the previously posited framework for conceptualising the determinants of project uncertainty by Saunders et al., 2015) will evolve after refinement and validation on a larger study of safety-critical projects?
RQ2: What are the commonalities in the determinants of uncertainty between civil nuclear and civil aerospace sectors and across different project types (new build/new product introduction (NPI) versus maintenance projects)?
RQ 3: What are the differences in the determinants of uncertainty between civil nuclear and civil aerospace sectors and across different project types (new build/new product introduction (NPI) versus maintenance projects)?

Validating and refining the Uncertainty Kaleidoscope over a much larger data set will provide project management practitioners with a framework to identify project uncertainties, thereby reducing the emergence of 'unknowns' that may delay project implementation, add additional costs and reduce stakeholder confidence in the project delivery team. It is important to note that this particular study is limited to the context of safety-critical projects, as this is consistent with the earlier exploratory study that we are seeking to validate. We acknowledge that the uncertainty kaleidoscope may have wider application across a range of project sectors, but this empirical work lies outside the scope of this paper.

2. Literature review

2.1. Uncertainty is a multi-faceted concept

Uncertainty is a concept that is rich, evocative and loaded with meaning. Uncertainty can conjure up fear and trepidation, or alert one to future opportunities that can be explored, depending on the perspective taken. An entrepreneur may look favourably on uncertainties within a particular market which he can exploit. In contrast, a project manager may fear the consequences of an uncertain future generated by an organisational restructure. What is clear from these two examples is that "uncertainty" is neither a simple nor inconsequential term. Instead it is a multi-faceted concept; one that has been studied across a broad range of intellectual disciplines. To the mathematical mind, uncertainty may imply probabilities of outcome (Attewell, 2009); to the psychologist the debate centres on the extent to which uncertainty is an objective or subjective phenomenon (Head, 1967; Kahnemann and Tversky, 1982; March and Simon, 1958), and to the business executive the presence of future uncertainties underlies most strategic decisions (cf. Harrison, 1992; Porter, 1980; Sutcliffe and Zaheer, 1998).

Within the domain of project management a number of scholars have articulated the possible sources of uncertainties in projects. Complexity arising from product requirements, the technology choices made or the variety of actors involved in the project is one such source of uncertainty (Cleden 2009; Martinsuo et al., 2014; Winch, 2010). Weick (1995) lists information load (the volume of ambiguous information that must be processed) and turbulence (the rate at which project facts change and the randomness of their timing and direction of change) as two further sources of uncertainty. Uncertainty may also arise due to factors in the external environment, for example, institutional decision making processes, or from external market or competitor actions (Aaltonen, 2011; Winch, 2010). A final source of project uncertainty arises at an individual level: for example, different personality types may view uncertainty very differently (Madsen and Pries-Heje, 2009), with uncertainty being seen as a subjective phenomenon (Head, 1967; Perminova et al., 2008).

Chapman and Ward (2011) argue that uncertainty arises through each of 7 W's of projects (who the various parties involved are, what they wish to achieve, what the shape of the final project deliverable is, how the project delivery mechanism is set up, what key resources are required to execute the plans, when do the key project events have to take place and finally where will the project take place). Other scholars categorise the sources of uncertainty; for example into environmental, organisational, technical and resources (Colarelli O'Connor and Rice, 2013); into stakeholders, external context, organisational context and management processes (Lechler et al., 2014) or in terms of the inherent properties of a project (complexity, complicatedness, dynamism and interconnectedness) (Ramesh and Browning 2014). Chapman and Ward (2011) acknowledge that many of these sources are not independent of one another, and that their interaction with one another can lead to sizeable impacts on projects.