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Risks of extreme and rare events in Asset Management

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ABSTRACT

Modern companies operate in a complex business and operational environment, which generates new types of risks that were relatively unknown just a few decades ago (e.g. cyber security), and creates favorable conditions for the emerging of extreme and rare events that may seriously perturb the current and long-term performance of enterprises. Current practices generally neglect taking into account those risks. Analyzing and managing them through traditional methods has recently shown to be less efficient. Advice and input from technical experts, strategic planners or knowledgeable managers may be insufficient or too narrowly focused to adequately manage the complexity of the systems and structures in a constantly changing and barely predictable environment. It is generally due to a lack of knowledge regarding the type and range of uncertainties, the nature of interconnections, the level of complexity, as well as our low ability to predict future events. Consequently, enterprises need alternative and enhanced methods and tools in order to better understand and model the complex business and operational environment and the associated risks.

This paper proposes a high level Risk-Informed Decision-Making framework in Asset Management that integrates risks extreme and rare events as part of an overall risk assessment and management activity. The research focuses on the methodology aimed at identifying, assessing and managing those risks in Asset Management. We believe that this approach may support organizations in becoming companies more resilient and robust in a changing and complex environment. We expose two case studies that demonstrate the applicability of the proposed model.

1. Introduction

Globalization and strong competition are part of a typical operational and business environment. The ability of enterprises to create and implement innovative concepts is decisive to meet the demands regarding competitiveness, and to ensure their operations and further development.

During the last decades, Asset Management (AsM) and Business Continuity Management (BCM) have become prevalent approaches among successful organizations as effective tools allowing to deliver value from assets and ensure the sustainability of the business and its operations (Komljenovic et al., 2015; Torabi et al., 2014). The positive evolution of AsM practices, experience and knowledge led to the publication of a new International Standard on AsM, the ISO 55000 (ISO, 2014a). The BCM is an approach used by organizations as an effective precautionary tool aiming at mitigating the consequences of disasters, and making them more resilient against disruptions. Good practices are enacted in an International Standard (ISO, 2012). The business continuity represents the capability of an organization to continue delivering products or services at acceptable predefined levels following disruptive incidents (ISO, 2012; Torabi et al., 2014). Business Impact Analysis (BIA) and Risk Assessment (RA) are the steps in BCM which identify the components of a system and try to define plans to ensure the continuity of the business's critical functions (determined in BIA) in emergency situations (determined in RA) (Torabi et al., 2014). Hence, there are overlapping areas between AsM and BCM. The main focus of the current paper is on AsM, and the BCM concept will be used to support analysis in the former when required (e.g. a less studied issue in AsM relates to emergency situations following various disruptive events or their combination).

AsM is sometimes stereotyped as being upon maintenance and reliability. However, it covers much more than those two areas. The ISO Standard provides the following definition of AsM: *Coordinated activity of an organization to realize value from assets* (ISO, 2014a). The same Standard defines an asset *as an item, thing or entity that has potential or actual value to an organization.*

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As per best practices, AsM should not only focus on the asset itself, but also on the value that it can deliver to the organization. It involves the balancing of costs, benefits, opportunities and risks against the desired performance of the assets, in order to achieve the organizational objectives. This balancing activity often involves the consideration of different timeframes and geospatial scales. AsM interacts with virtually all the functions of an organization, and focuses on the total business impact (The Institute of Asset Management, 2015).

Enterprises operate in a business and operational environment characterized by significant complexities and intrinsic uncertainties[1] (Komljenovic et al., 2015). The risk represents the effect of uncertainties on objectives (ISO, 2009; Aven and Aven, 2015). This environment has also produced new types of risks that were relatively unknown just a few decades ago (e.g. cyber security), and created favorable conditions for the emerging of extreme and rare events[2] that may seriously perturb the current and long-term performance of enterprises.

Analyzing and managing those risks within AsM through traditional methods has recently shown to be less efficient. Advice and input from technical experts, strategic planners or knowledgeable managers may be insufficient or too narrowly focused to adequately manage the complexity of the systems and structures in a constantly changing and barely predictable environment (Glouberman and Zimmerman, 2002; Rzevski and Skobelev, 2014). It is generally due to a lack of knowledge regarding the type and range of uncertainties, the nature of interconnections, the level of complexity, as well as our low ability to predict future events (Aven, 2015a,b, 2014; Chopra and Khanna, 2015; Leveson, 2011; Makridakis et al., 2009; Makridakis and Taleb, 2009a,b; Miller, 2010; OECD, 2011; Orrell and McSharry, 2009; Paté-Cornell, 2012; Taleb, 2005, 2010, 2012).

Considering that AsM is an organization's long-term activity, forecasting all relevant influential factors of their business and operational environment is vital for practically all technical and business decisions. The forecasting represents a key part of risk assessment/management (RA&M) and sound decision-making in AsM. Our understanding is that it should also consider the risks of extreme and rare events (E&RE) as part of an overall risk assessment and management activity in AsM (ISO, 2014b,c, 2009). Consequently, assessing and managing risks of E&RE in AsM becomes vital. However, there are almost no significant research works related to RA&M of ER&E in Asset Management, despite the importance of this topic (Komljenovic and Abdul-Nour, 2015). Consequently, enterprises need alternatives and enhanced methods and tools in order to better understand and model the complex business and operational environment in AsM, and its associated risks.

The present study aims at developing a holistic approach for the identification, characterization and treatment of the risks of extreme and rare events in Asset Management that takes into account a complex business and operational environment.

The remainder of the paper is organized as follows: Section 2 provides a comprehensive literature review; Section 3 depicts the methodology of decision-making in AsM, and an approach regarding the risk assessment of extreme and rare events in Asset Management; Section 4 presents two case studies which illustrate the proposed methodology. The paper ends with conclusions and outlines future research works.

2. Literature review

The development of the methodology involves several domains of expertise such as Asset Management, the analysis of the risks of extreme and rare events, and the theory of complexity. The review presented below summarizes some important contributions in these areas.

2.1. Asset Management

The concept of Asset Management is emerging as a 'mainstream' expectation for competent organizations, and it is a relatively young discipline. It has generated significant interest across various industries and is still maturing (El-Akruti et al., 2013; The Institute of Asset Management, 2015). The Standard ISO 55000 mentioned above represents an industry-wide consensus in this area and being implemented.

The nuclear power industry has invested significant efforts in elaborating Asset Management approaches and methods tailored to its needs and particularities. It developed the Nuclear Asset Management (NAM) process aiming to make operational, resource allocation, and risk management decisions at all levels of a nuclear generation business to maximize the nuclear power plant value to stakeholders, while maintaining the public and plant staff safety (EPRI, 2007). The nuclear power industry also elaborated Risk-Informed Asset Management (RIAM), which is a composite financial/engineering method complementary to NAM that uses a risk management approach to support long-term equipment planning and investment decisions at the corporate, fleet, plant, system or equipment levels of nuclear power organizations (EPRI, 2005, 2002).

Some other specific AsM processes were also elaborated. The petrochemical industry has developed its AsM since late 1980s (El-Akruti et al., 2013; The Institute of Asset Management, 2015). Power generation, transmission and distribution utilities produced their specific AsM (Adoghe et al., 2013; Bollinger and Dijkema, 2016; Catrinu and Nordgard, 2011; Dashti and Yousefi, 2013; Schneider et al., 2006). The field of infrastructure management has been using AsM for many years (Bale et al., 2015; Bush et al., 2014; Dornan, 2002; Nikolic and Dijkema, 2010; Osman, 2012; Younis and Knight, 2014). The transportation industry also carried out works in this area (Ballis and Dimitriou, 2010; Dornan, 2002). The mining industry is starting to elaborate approaches related to Asset Management as well, but it is at initial stages (Azapagic and Perdan, 2010; Komljenovic et al., 2015; Komljenovic, 2007).

2.2. Extreme and rare events

The impact and risks related to E&RE have gained growing interest in the recent years. "Black Swan" or rare and surprising

[1] There are two types of uncertainty in engineering (Kumamoto, 2007; US NRC, 2013):

–Aleatory uncertainty: This type of uncertainty arises when an event occurs randomly. This uncertainty can be expressed in terms of probability or frequency. A random equipment failure is a typical example of an aleatory uncertainty. This type of failure is defined as a failure occurring at a predictable rate, but at an unpredictable (i.e. random) time.

–Epistemic uncertainty: This type of uncertainty has been referred to as a state-of-knowledge uncertainty. There are three types of epistemic uncertainties: parameter, model, and completeness uncertainty. Epistemic uncertainties arise when we make statistical inferences from data and/or from incompleteness in the collective state of knowledge. Epistemic uncertainties relate to the degree of belief that an analyst has in the representativeness or validity of a model and in its predictions. ISO notes that the uncertainty is the state, even potential, of information related to the understanding or the knowledge of an event, its consequences, or its likelihood (ISO, 2009).

[2] Extreme and rare events include, but are not limited to, natural disasters, financial and market crashes, pandemics, major failures of critical assets, major industrial accidents, prolonged shortage of power/energy supply, political changes, unrest and instability, armed conflicts or terrorist attacks, radical changes in a regulatory framework, extremely negative treatment in mass-media creating an unfavorable business environment, major legal pursuits, payment defaults or loss of major customers, etc.