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Evaluation of the Lifetime Impact Identification Analysis: Two tests in a changeable context

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ABSTRACT

Asset Life Cycle Management aims to maximize the value realized from physical assets over their complete lifetime. Over the years, the operation and maintenance of the assets must continually be adapted to changes in goals and context. In an earlier publication, we proposed the Lifetime Impact Identification Analysis to identify such changes. This paper tests this method through an application at two different companies. The method proved to result in a shared and integral overview of long-term challenges and opportunities for the asset, based on experts discussing the asset's future from a technical, economic, compliance, commercial and organizational perspective.

Introduction

Manufacturing is dependent on the safe and reliable functioning of countless physical assets: production lines, chemical plants, trucks and aircraft for transportation, infrastructure for people, freight and energy, etcetera. Physical assets typically have lifetimes of several decades. Therefore, assets designed and built decades ago still fulfil vital functions in manufacturing, as well as in society at large. However, with the passing of the years, many important changes happen that affect the assets. Regulations change, customers acquire new tastes, technology progresses, societal norms become increasingly tight and the skills in the workforce evolve. Additionally, the organization itself may change, for example by focusing on new markets or changing its manufacturing strategy from cost leadership to differentiation. Moreover, a company may have changed its perception of maintenance, from a necessary evil to a profit centre [1]. In the Asset Management literature, many authors recognize the impact of change in Asset Management, which they describe as happening at an ever-increasing pace (e.g. [2,3,4]).

These changes in the operating environment of the asset may have far-reaching implications for the operation and maintenance of the assets. Assets may need to be adapted to fulfil new requirements or demands, or may even become obsolete. As physical assets often represent large sums of money and changing them is time-consuming and costly [5] – if possible at all – these changes should be considered in Asset Management. The scientific literature on Asset Management argues that the complete life cycle of an asset should be taken into account to maximize the value realized from the exploitation of the asset (e.g. [6,7]), which is even more emphasized in the concept of Asset Life Cycle Management [8]. The need to adopt a 'life cycle approach' is also acknowledged by the recent ISO standard on Asset Management [9].

However, existing methods for Asset (Life Cycle) Management do not explicitly consider changes in the operating environment of the assets, nor do they offer clear guidance or tools to effectively manage assets over their complete life cycles. Therefore, we have developed a method to identify the changes in the operating environment of the asset relevant to Asset Life Cycle Management (ALCM): the Lifetime Impact Identification Analysis (LIIA) [10]. The objective of this paper is to test this newly developed method in practice. The test will be carried out by an implementation of the LIIA in two different settings: at a Dutch electricity network operator (Liander) and a Danish operator of an offshore windfarm (Vattenfall).

The next section will introduce the LIIA and its underlying generative mechanisms. Then, the methodology used for the development and test of the LIIA will be presented: the Design Science methodology. The Design Science methodology prescribes the test of a method in practice, to allow further refinement of the

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solution design. Therefore, we have implemented the LIIA in two different companies, and evaluated the method critically. The outcomes of the LIIA and its evaluation will be discussed thoroughly. We will conclude with a conclusion, including topics for further research and implications for practitioners.

The Lifetime Impact Identification Analysis (LIIA)

The Lifetime Impact Identification Analysis (LIIA) has been developed based on a case study of ALCM in practice in a changing context as well as on the literature. We have reported its development in a previous publication in this issue [10]. Nevertheless, we will briefly introduce the LIIA in this paper as well, to allow for a full understanding of the LIIA before we will report on the tests we have carried out.

The starting point of the LIIA is the notion that assets are only valuable to their owner as long as they contribute to the objective of the owner. Therefore, in ALCM the focus should lie on the preservation of the value creation potential of the asset. Value may be operationalized in different ways, depending on the situation. For example, in terms of profits, in terms of social value or in terms of customer satisfaction.

During the life cycle of the asset, changes may happen that affect the value creation potential of the asset. We have termed these lifetime impacts: "probable (technical and non-technical) events or trends that may have a positive or negative influence on the value creation through the use of the asset in the intermediate or long term" [10]. Positive impacts can be innovations or cost savings, negative impacts can be the obsolescence of certain components or a new regulation requiring additional safety systems. These lifetime impacts can be compared with failure modes in Reliability Centred Maintenance (RCM) [11,12]. Just as the identification of failure modes in RCM allows a designer to change the design or develop a suitable maintenance instruction, the identification of lifetime impacts in ALCM allows the Asset Manager to take timely measures to prevent negative lifetime impacts and to reap the full benefits of positive lifetime impacts.

The LIIA consists of five steps (see Table 1), with at the centre the expert session. The outcome of the LIIA is the Lifetime Impact Report (LIR), which represents all the information collected in the LIIA in a structured way. This report discusses the value created from the use of the asset from a long-term perspective, focusing on the (strategic) objectives the owner has with the asset, its current performance and the lifetime impacts that may affect the value created with the asset.

As ALCM is a multidisciplinary practice [7,8,10], impacts on the asset may range from very different backgrounds. These are captured by the acronym TECC: technical, economic, compliance and commercial. To identify all relevant lifetime impacts, each of these four perspectives is discussed separately in the expert session.

The LIIA has been developed based on three generative mechanism that underlie the method. These generative mechanisms were based on the literature, as initial solutions to three challenges identified in a case study on ALCM in practice [10]. The three challenges and the initial solutions to these are presented in Table 2, as well as the main references for each of the three generative mechanisms. The initial solutions are presented according to the CIMO-logic: in a certain context (C), a particular intervention (I) sets a specific mechanism (M) into motion, which leads to an outcome (O). These three generative mechanisms are important when we test the model, as these are the foundational building blocks of the model. If these mechanisms turn out to work in practice, that does not only indicate that the model build on these mechanisms works, but also that these mechanisms may be used in different applications. As such, the test of generative mechanisms is a contribution to scientific knowledge as well [13].

Methodology

The development of the Lifetime Impact Identification Analysis (LIIA) was guided by the Design Science methodology [14]. Typically, the Design Science methodology consists four phases: (1) the exploration of the problem; (2) the search for initial solutions for the problem; (3) the development of a solution; and (4) the test of the solution [15]. In our previous publication [10], we reported on the first three phases. Therefore, this paper will focus on the test of the solution design: the LIIA. Fig. 1 shows the four phases of the research.

To test the LIIA, we implemented the method in practice. To increase the generalizability of the test, we selected two different case companies for the test. The first implementation of the LIIA was carried out at Liander, the largest Dutch distribution network operator, responsible for the safe and reliable distribution of electricity and gas. As the LIIA was developed based on the exploration of the problems faced by Liander, it may be expected that the LIIA will suit their needs. Therefore, the second test was carried out at a very different company as a contrasting case [10], namely Vattenfall Wind Power. The specific case was one of the offshore wind farms they operate in Denmark. This is a useful contrasting case, because Vattenfall is a different company, based in a different country, working in a different sector, and operating very different assets. Compared with Liander, the number of assets in the wind industry is much lower (dozens vs. hundreds or thousands) while the (replacement) costs per asset are much higher (tens to hundreds of thousands vs. millions). Wind turbine generators (WTGs) are equipped with sensors and real-time data streaming, whereas most Liander assets are not, especially not in low and medium voltage. Additionally, the expected lifetimes of WTGs are 20 years, rather than 40 years at Liander. Because of these differences, this second case is a useful way to establish the generalizability of the LIIA method to a different industry. If the outcomes of the method are the same, this would indicate that

Table 1
A short explanation of the five steps of the LIIA [10].

Step	Description
1. Asset selection	Selection of the asset(s) to consider in the LIIA, as well as the scope and depth of the analysis.
2. Collection of general asset data	Collection of all available data and information on the asset, to prepare for the expert session. The main goal is to achieve a good understanding of the asset(s), their performance and the changes that may lie ahead.
3. Expert session(s)	Discussion of experts from different backgrounds, based on the information from step 2 and their expertise, to identify the lifetime impacts they consider relevant for the asset. In the discussion, explicit and tacit knowledge is combined to develop a shared understanding of the asset's future. Four different perspectives on the asset are considered: technical, economic, compliance and commercial (TECC).
4. Writing the Lifetime Impact Report (LIR)	Writing a report based on the information collected in the previous steps. The report presents the objectives of the asset owner, the asset's performance and the lifetime impacts identified in a structured way.
5. Evaluation	Evaluation of the LIR with the relevant experts, allowing to validate and refine the conclusions of the LIR.