Decision Making Situations Define Data Requirements in Fleet Asset Management

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Abstract: Large amounts of data are increasingly gathered in order to support decision making processes in asset management. The challenge is how best to utilise the large amounts of fragmented and unorganised data sets to benefit decision making, also at fleet level. It is therefore important to be able to utilize and combine all the relevant data, both technical and economic, to create new business knowledge to support effective decision making especially within diverse situations. It is also important to acknowledge that different types of data are required in different decision making context. A review of the literature has shown that decision making situations are usually categorized according to the decision making levels, namely strategic, tactical and operational. In addition, they can be classified according to the amount of time used in decision making. For example, two situations can be compared: 1) optimization decision where a large amount of time and consideration is used to determine an optimum solution, and 2) decisions that need to be made instantly. Fleet management of industrial assets suffers from a lack of asset management strategies in order to ensure the correct data is collected, analysed and used to inform critical business decisions with regard to fleet management. In this paper we categorize the decision making process within certain situation and propose a new framework to identify fleet decision making situations.

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1 Introduction

Automated decision making is increasing due to large and often detailed amounts of available data. This is not just an issue within manufacturing organisations; recently this problem has been identified within asset management. New technologies including advanced sensor arrays, advanced analytics and cloud computing enable the development of new approaches to collect, analyse and utilize data to improve decision making within fleet asset management. The term fleet can be described as "a population of similar entities" (Tywoniak et al. 2008). Often the term fleet refers to equipment provider's installed base of units in customer sites around the world, including machinery and equipment, such as cranes, trucks, and paper machines. It is important to identify which use of the term fleet is appropriate for each research. Therefore we suggest that the concept of 'fleet' can be broadened on demand to describe different kind of fleet. In this paper we regard the fleet as "*a population of similar physical assets"* (machinery, equipment, vehicles and spare parts). Fleet may include even thousands of assets and they generate valuable data that could be utilized to fleet management.

Fleet management is an important area of research and several authors including (Mishra et al. 2013; Hounsell et al. 2012) discuss this topic in detail. Furthermore little consideration is given to the whole-life management, and the data required to manage and maintain a fleet of vehicles (Knowles and Baglee 2015). The trend in asset management has changed due to introduction of advanced technologies including eMaintenance and condition based maintenance (CBM), both of which have been discussed in the academic literature. Due to the large amounts of data available it can be argued that the required data has not fully been captured and data from historic systems is often challenging to obtain, therefore the necessary data should be identified and collected in order to be utilized more effectively in the decision making process. More effective use of data in decision making makes possible the management of asset fleets. Fleet asset management has still not been sufficiently researched and increasing understanding of fleet management and different fleet decision making situations is highly important.

The objective of this study is to increase an understanding of fleet asset management, fleet decision making situations and to identify the key data required in order to make accurate decisions. The main research question of this paper is: *What kind of decision making situations are related to enhancing fleet asset management?* This question is supported by two sub questions: 1) how are various fleet decision making situations categorized in literature? 2) what decision making situations are identified by industrial practitioners?

In this paper, we utilize design science approach as we aim at building a theoretical framework for practical managerial purposes. The design science approach aims at developing a construction, a model or a method in order to solve a problem (van Aken 2004). In design science research process, the following steps are included: identification of the problem, development of the solution (design), demonstration of the solution and validation. In this paper, we deal with the first phases of design science process, as we identify the problem and the need for a solution; in addition, we propose a framework based upon a literature review and supportive insights from industry practitioners. Insights from industry practitioners are collected in workshop organized by a research program dealing with the service solutions for fleet management. Insights are gathered from representatives of ten companies. Further testing and development of proposed framework are executed later in future research.

2 Literature Review

Fleet management techniques have been studied in the literature with regards to vehicle fleet management (Mishra et al. 2013; Hounsell et al. 2012) and fleet-wide asset health management (Voisin et al. 2013). The literature has presented a number of different fleet management systems, tools, and models which have been developed for a number of different decision-making situations. For example, Antuñano and Dessureault (2011) have developed a real-time fleet cost tool and Andersen et al. (2009) present an optimization model that improves the integration of vehicle management and service network design. Knowles and Baglee (2015) have proposed an asset management strategy for vehicle fleets based upon the use of pre-installed vehicle telematics systems which offer an opportunity for operators to continuously monitor the performance and effectiveness of their vehicles.

Optimal fleet management requires all relevant fleet data is available between stakeholders in industrial network which may consist of a large number of players, including equipment providers, customers, and service providers. This is now possible with Internet of Things (IoT) enabling advanced technologies, which help to gather and share large amounts of new data more easily between business partners. These new possibilities bring the concept of the ‘industrial ecosystem’ into discussion. We define the industrial ecosystem as an industrial network combined with IoT, where the ecosystem consists of companies, their assets and data which all are connected by the Internet. Availability of data gathered in ecosystem needs to be uncomplicated in order to get all the relevant data to decision making in order to enhance fleet management. To better understand the problem related to fleet decision making, the current academic literature has been reviewed to gain an insight as to how decision making situations have been categorized and what fleet decision making situations have been already designed, developed and implemented. It can be argued that there is no comprehensive framework which allow categorizing decisions making situations and takes into consideration multiple dimensions at time, such as fleet perspective. One commonly used approach is to divide decision making situations based on the level at which they are made, i.e. operational, tactical, and strategic levels. This will allow the user to separate everyday routine decisions from decisions with longer-term effects on the whole organization. Thus, the division into short and long-term decisions have also been addressed in literature. In addition, decision making situations have been categorized based on the level of uncertainty and risk. Due to the development of a number of innovative technologies the division into human and machine decision making is covered extensively within the literature (Porter and Heppelmann 2014; Davenport and Harris 2005). In asset management, Sun et al. (2008) present the classification of decision making situations using relevant time scale as criteria. They separate decisions with time scale varying from several years to the decisions that need to be done when an event occurs. Consequently, there are several ways and perspectives to observe the categorization of decision making situations but none of them takes into consideration the perspectives of fleet decision making.

Classifying fleet decision making situations is not widely discussed in literature and framework to analyse or structure fleet decision making are at best limited. As table 1 shows, fleet management is somewhat discussed in latest academic research and there is a need to better understand the subject. When reviewing the literature, it can be noticed that fleet management problems presented in literature can be separated into four groups of decision making situations: reactive, real-time, proactive, and strategic decisions. This categorization is a conclusion from literature concerning asset management decisions and fleet management.

Table 1 Categorizing fleet decision making situations, literature review.

Category of decision making situation	Decision making situation
Reactive decisions • Decisions after the event occurs • Detailed technical data and cost analysis usually cannot be conducted	Corrective maintenance, fault diagnosis and corrective actions based on data from multiple similar assets (Sardar et al. 2006)
Real-time decisions • Fast reaction, aiming to act real time • Technical, real-time data	Real-time accident handling (Ngai et al. 2012), Real-time bus fleet management (Hounsell et al. 2012), Dynamic fleet management problem (Shi et al. 2014)
Proactive decisions • Developing predictions and plans: actions before something happens • History and life-cycle data, including technical and economic data	Fleet-wide diagnostic and prognostic assessment, proactive monitoring (Voisin et al. 2013), Optimized resource utilization (Andersen et al. 2012; Mishra et al. 2013), Optimizing reliability, availability and maintainability of fleet, Fleet cost management (Antuñano and Dessureault 2011)
Strategic decisions • Long-term strategic decisions • Plenty of time and consideration can be used • History and life-cycle data, emphasis on economic data	Replacement investments and strategy (Richardson et al. 2013)

Therefore, we can identify two extremes in the categorization of fleet decision making situations based on the time scale in which the decisions are done. The available time essentially affects to the nature of data and information that can be used in decision making situations. In other words, in reactive decisions which need to be made after an event occurs, detailed technical data and cost analysis usually cannot be conducted (Sun et al. 2008). Due to advanced technologies the trend is moving toward real-time decisions, where the available time is limited but the constantly monitored real-time technical data enable to make decisions even in real time. External forces and uncertainty, for example customer demand (Shi et al. 2014), are typical for real-time decisions but also for proactive decisions. The opposite is strategic decisions where plenty of time can be used and history and life-cycle data, both technical and economic data, are usually needed. Decision making situations can also vary according to the life cycle phase of the assets they are related to. It can also be noticed that maintenance-related decisions, representing the operation and maintenance phase decisions, and replace investment decisions, representing the end-of-life phase decisions, may take place for different levels of the system hierarchy.

3 Fleet Decision Identification Framework

Based on the observations from literature review and supportive insights from industry practitioners, a framework for helping to identify fleet decision making situations is proposed. The framework utilizes the categorisation of fleet decision making situations made based on literature in table 1. The main observations related to Fleet Decision Identification framework (figure 1) are that usage of time varies between different types of decisions, which also affect data requirements. Secondly, there are different fleet decision making situations in every phase of asset life-cycle. Therefore, the framework aims to bring multiple dimension together when categorizing fleet decision making situations. These dimensions are life-cycle perspective, time scale, and asset hierarchy (from unit level to fleet level). Fleet level also include the ecosystem aspect to the decision making as data sources from different parties of ecosystem are needed in fleet based decision making.

In figure 1, the first box illustrates decision making situations at unit level trough the life cycle of asset. The second box represents the decision making situations at fleet level where data from the ecosystem and other units can be used. The decision making situations are quite similar both at unit and fleet level, but there is more data available for fleet decision making situations. This is expected to enable more accurate predictions and optimizing models as supporting data is collected from other similar assets and it can be used to make fleet level decisions. Fleet level makes possible, for example, to develop resource and capacity utilization as performance data of all assets in the fleet can be analysed. Consequently, fleet data can be utilized in diverse optimizing decision making situations in order to improve asset management.

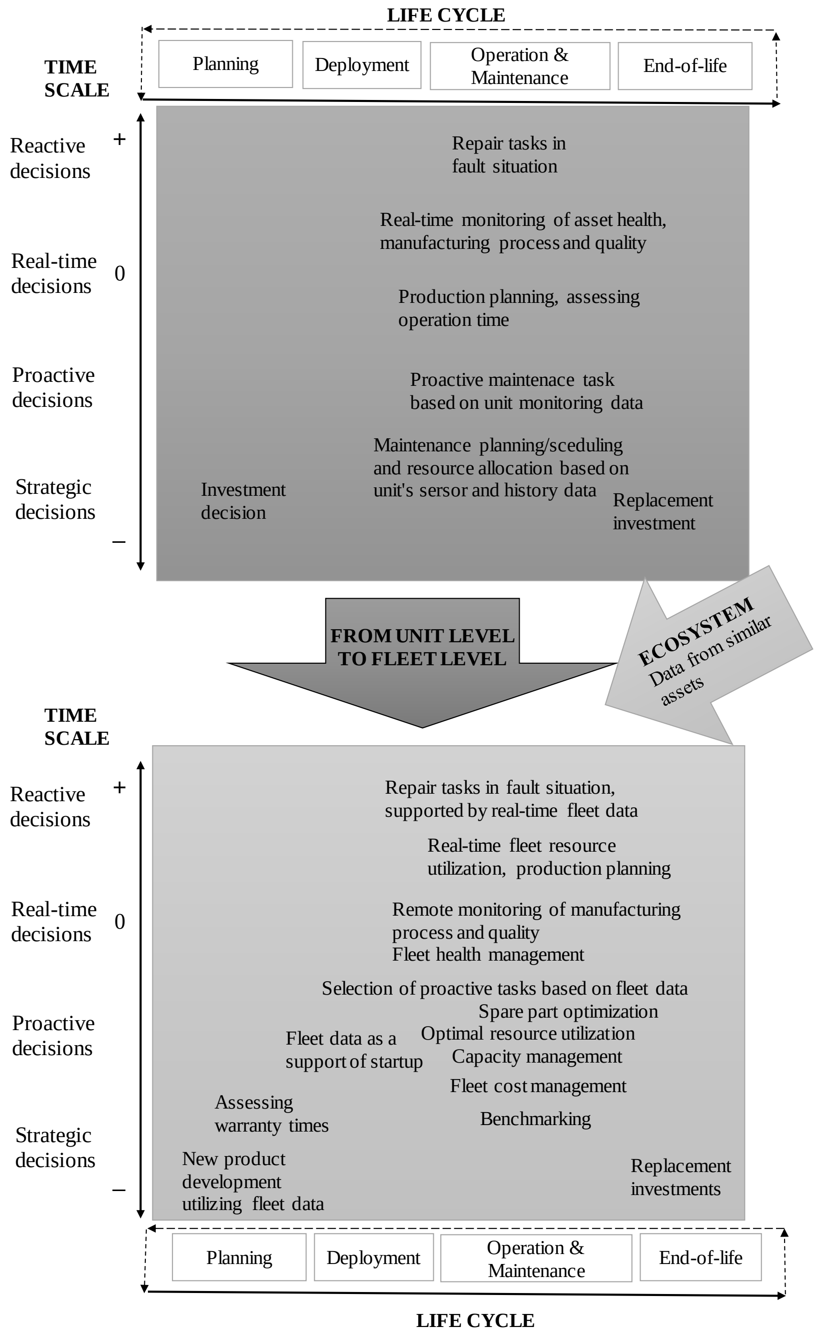

Figure 1 Fleet Decision Identification framework.

4 Conclusion

Researching fleet management is becoming relevant as business practitioners are facing continuous pressure to manage their assets more efficiently. The results of this research extend current understanding of different fleet decision making situations and work as a basis for better fleet management. The Fleet Decision Identification framework helps researcher and practitioners to identify various fleet decision making situations through the whole life-cycle of assets and therefore helps to understand the significance of ecosystem behind the fleet decisions as the data needs to be gathered from different sources in ecosystem. A benefit is a replacement investment which occurs only once in a unit's life-cycle, but these replacement investment decisions become significant if those decisions can be made perceiving the whole fleet. In addition, increasingly gathered data, technologies, and analytics enable to take advantage of the data in decision making, compared to previously when it was hard to utilize both technical and economic data in decision making. If the amount of automated decisions is pursued to increase, fleet data might enable scale advantage and mass tailoring of fleet services in future. This research acts as a basis for further research which will highlight the problem of how fleet based life-cycle data can be turned into business knowledge in fleet decision making situations. The proposed Fleet Decision Identification framework will be developed further and future research will focus on evaluating information network more precisely in certain fleet decision making context.

Acknowledgements

The authors gratefully acknowledge the Finnish Metals and Engineering Competence Cluster (FIMECC) for organizing Service Solutions for Fleet Management program (S4Fleet), the Finnish Funding Agency for Technology and Innovation for funding the program and the companies involved in the research.

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