Studying the funding principles for integrating Asset Management in Operations: an empirical research in production companies

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Abstract: The aim of this paper is to investigate Asset Management (AM) implementation as a business process within production systems to contribute to operational excellence. The main fundamentals to be considered to properly implement AM within production companies according to the existing literature and standards are identified and they are: two dimensions – i.e., the asset life cycle (Beginning of Life, Middle of Life, End of Life phases) and the hierarchical level of the asset-control activities (strategic level, tactical level, operational level) – and four funding principles – i.e., life-cycle orientation, system orientation, risk orientation and asset-centric orientation. An empirical investigation is then developed through multiple case-study involving eight production companies in Italy, in order to assess the level of orientation towards those funding principles within production companies as it is nowadays, in order to identify existing gaps and areas for improvements.

Keywords: Asset Management, Life cycle, Decision making, Production systems, Management systems

1. INTRODUCTION

Nowadays, the management of physical assets is recognized as an important contributor to foster value generation for companies (El-Akruti et al. 2013; Maletic et al. 2014; Mitchell 2002; Schuman & Brent 2005). Moreover, the recent publication of the ISO 5500x body of standards on Asset Management (AM) contributed reinforcing the increasing interest on the topic both by industry and academia. Nevertheless, AM as a discipline and business process is still at its early stage within the scientific debate and solutions to support its adoption in different industrial contexts are still under definition.

AM, as it has been evolving during the last years, is considered as a holistic approach. It embraces different kinds of actors that together aim at realizing value by managing assets through coordination and in alignment with the organizational strategy. According to the ISO 55000, 'an asset is an item, thing or entity that has potential or actual value to an organization. The value will vary between different organizations and their stakeholders, and can be tangible or intangible, financial or non-financial' (ISO 55000:2014(E) 2014). Overall, this statement clearly outlines the main purpose of AM, which is to realize value from assets, and its scope of application, generally referred to different types of assets and industrial sectors.

This paper looks at AM within the context of production companies (manufacturing and process industry) to investigate what is its relevance in supporting production systems operations.

The objective of this paper is to identify which are the main fundamental elements to be considered to properly implement AM within production companies according to the existing literature and standards. An empirical investigation is then developed through multiple case-study. The case study enables assessing the level of orientation towards those fundamentals within production companies as it is nowadays; besides, it helps identifying the existing gaps and areas for improvements.

The paper is organized as follows. Section 2 provides information on the methodology that was adopted for this research. In Section 3, the fundamentals for AM integration in Operations in production companies are detailed as they have been defined based on an extensive literature review and discussions with people from industry. Based on that, Section 4 provides a cross-case analysis of the main findings that emerged from the multiple case study development. In particular, for each AM funding principle, the main findings on how it is addressed by the analysed companies are presented. Finally, Section 5 is dedicated to conclusions.

2. METHODOLOGY

This research is based on an extensive literature review and on brainstorming activities and workshops with industrial exponents that allowed identifying and hypothesizing the foundations for implementing the case study. In fact, the synthetization of the foundations of AM is the basis for next research steps and provides indication on how decision-making should be implemented within production companies in order for AM to be integrated in their management system.

Based on that, the case study method was chosen for the scope of this paper. In fact, case study allows exploring evidences and testing the relevance of the postulated concepts according to the retroductive approach's objective (El-Akruti & Dwight 2010). In this research, the implementation of a multiple case study enables investigating the existence / absence of practices oriented towards AM principles in the analyzed production companies. In particular, this study targeted eight production companies in Italy. Medium or big size companies were selected, with medium/high maturity in maintenance management practices (according with the analysis previously implemented through the survey developed by TeSeM observatory (2014-2015) (www.tesem.net), that focuses on understanding the state-of-practice of the technologies and services for maintenance in industry). In fact, it is assumed that only companies with certain maturity in Maintenance management are ready enough to talk about and implement the wider concept of AM. Finally, the selected companies belong to different industrial sectors in order to avoid biases and to cover a broader scope of the production industry.

The data collected from the case studies were analyzed using a uniform approach. The main source of the primary data for this research is a semi structured interview. The chosen unit of analysis is the company from the perspective of the maintenance function / industrial engineering function and a face-to-face semi-structured interview was chosen as the main source for data.

The following Table 1 shows the panel of companies that was selected for this study.

Table 1. Case study: involved companies

Company	Sector	Interviewees
A	Chemical	- Maintenance and technical materials Executive
B	Appliances	- Site Industrial Engineering Manager
C	Steel	- Maintenance Manager
D	Steel	- Technical Director - Maintenance Manager
E	Petrol-Chemical	- Maintenance Manager
F	Machine Tools	- Technical Functions Manager
G	Food & Beverage	- Global Maintenance Director - Real estate and Energy Management
H	Tyre	- Corporate Maintenance Coordinator

The data collected from the case studies were analyzed using a uniform approach. The responses to the interview were interpreted and analyzed from the transcripts, according to the coding technique which is the analytic process of examining data line by line or paragraph by paragraph for significant events, experiences, feelings, and so on, that are then denoted as concepts (Corbin & Strauss 2014).

3. FUNDAMENTALS FOR INTEGRATING AM IN OPERATIONS

An extensive literature review on the recent publications about Asset Management (El-Akruti et al. 2013; Amadi-Echendu & Brown 2010; Schuman & Brent 2005; ISO 55000:2014(E) 2014), but also considering the evolution of such a concept and discipline over the years (Liyanage 2010; Murthy et al. 2002; Tsang 2002; Waeyenbergh & Pintelon 2002; Al-Turki 2011; Crespo Márquez 2007; Taylor 1981; Committee on Terotechnology Great Britain 1975), by keeping the perspective of production companies; allowed defining the fundamentals for integrating AM in Operations. In particular, two main dimensions and four funding principles are defined.

First of all, referring to the management of production asset like production plants, lines or equipment, two main dimensions have to be considered and integrated by the company in order to develop an AM process that can be integrated in Operations. The two dimensions are defined as follows:

i. the asset life cycle; that includes the Beginning of Life (BoL), Middle of Life (MoL), and End of Life phases (EoL) (Ouertani et al. 2008);

ii. the hierarchical level of the asset-control activities; that comprises the strategic, tactical, and operational levels (El-Akruti et al. 2013).

A full integration of the two dimensions is the hearth of AM. Any time a decision is taken about assets, the whole life cycle must be considered analysing what is inherited from the past in term of influencing variables, and how the future will be affected by the decision in case it is taken. At the same time, all three levels of control within the organization need to be involved, ensuring alignment through feedback loops implementation. The ability of a company to implement AM stands in the capability to integrate the two dimensions into a robust and clearly defined AM system in its organization.

Provided the two main dimensions to be considered, i.e. asset life cycle and asset hierarchical control level, four funding principles are then introduced to generate the required substrate for AM implementation. In fact, the success of process execution should depend on how much these principles are incorporated in the process. Four founding principles are considered:

- Life-cycle orientation
- System orientation
- Risk orientation
- Asset-centric orientation

In the following subsections, each funding principle is better detailed.

3.1 Life-cycle orientation

The adoption of life-cycle orientation in the decision-making processes means that the AM process should incorporate long-term objectives and performances to drive decision making. Supporting tools can be adopted by the company to aid the achievement of this objective, such as the LCC (life cycle cost) / TCO (total cost of ownership) (El-Akruti et al. 2015; Roda & Garetti 2014). Moreover, given that the three phases of the life cycle of the assets are different, different organizational functions need to collaborate in the AM process through multi-disciplinary approach, covering all organization's hierarchical levels (El-Akruti & Dwight 2013).

3.2 System orientation

Criticality of the assets at system level is an essential aspect to be considered in order to ensure focusing efforts and resources on the right activities. Indeed, as it is expressed in the ISO 55000: "an asset is defined critical if it has potential to significantly impact on the achievement of the organization's objectives"; thus, the impact on the objectives can be detected only if looking at the systemic dimension.

Industrial assets are, in fact, complex systems composed by different components interrelating among themselves. Such interactions, together with the state of each component, affect the state and performance of the system itself. In order to have a robust AM process, the systemic effect of any local decision has to be considered in decision-making. Finally, it is worth reminding that the final aim is to realize value from the asset system. Holistic consideration of asset system in their entirety and not merely of the individual components is essential to this end (Xu et al. 2013).

3.3 Risk orientation

Together with costs and benefits, the risk of taking a decision needs to be considered. Applying this principle, the AM process should be structured in order to build in risk orientation in decision-making.

The failure of critical assets proved to be the risk that is recognized by companies to have the biggest impact on business (according to the results of the industrial survey on operational risk management (Aberdeen Group 2007)). Being aware of such criticality, leading companies use analytical tools to gain better visibility into the risks within their operations (e.g. to predict when maintenance is needed). Establishing a risk culture and empowering the workforce with the information to be predictive decision-makers is instrumental to achieve Best-in-Class performance' (Aberdeen Group 2007). Moreover a risk-orientation is inevitably connected to tending to the realization of value taking into account likelihood and consequence of fulfilling stakeholders' expectations. A multi-disciplinary approach is required to be able to consider all relevant risk aspects related to AM in a company.

3.4 Asset-centric orientation

The management of assets is dependent on knowledge about the organization's assets, in terms of both current equipment, business role of the assets and future prospects. In other words, asset managers need to have a practical working knowledge of the major assets so to be able to make sound business decisions (Hastings 2009).

Thus, it is advocated that it is necessary for AM implementation to have an asset common database where all the data about each asset and its components are stored together (Al-Najjar & Basim 1996; Kans & Ingwald 2008). The asset database would provide basic reference to information regarding assets' properties, usable for strategic, tactical and operational decisions. Also, tracking of changes during the life cycle of the asset is facilitated by a common data-base, supporting integrating the lifecycle dimension.

4. CROSS CASE STUDY FINDINGS ANALYSIS

The defined funding principles above were used as the basis for studying the actual level of integration of AM in Operations by production companies, and to subsequently understand the main limitations, thus orienting future research on the topic.

Based on the undertaken analysis and coding of the interviews with the companies under study, the findings coming from it are presented hereafter through a cross-cases synthesis. In particular, each funding principle is considered and the orientation towards it of each analysed company is studied.

4.1 Life cycle orientation

As described in Section 3.1, life cycle orientation means: i) promoting an integrated organizational structure in which all the necessary competencies and functions are involved at each stage of the life cycle of the asset; ii) adoption of long-term performance objectives and indicators in managing assets.

As far as the first issue regards, the findings from the case study analysis allowed assessing if companies present a proper level of integration among functions to manage the assets. In particular, by keeping the point of view of the maintenance function, a general trend towards integration emerged from the analysis. Nevertheless, there are still gaps at the organizational level to achieve a complete integrated management of assets, which are as follows.

At the early stage of the life of the asset (Beginning of Life, BOL) - design, construction and commissioning -, the desired condition is to get to closer cooperation among the various functions such as design, purchasing and maintenance. In general, a certain trend towards this direction was detected in all the analysed companies; however, the integration cannot be considered complete within all companies. What clearly emerged from the majority of the cases is the desire of the Maintenance function to have a more active role in the BOL phase.

As for the management of the intermediate stage of the life cycle of the assets (Middle of Life, MOL) – use and maintenance, with possible adjustments by retrofitting / revamping during the life - in general, awareness of the role Maintenance of an “evolved" fundamental function that must work in an integrated manner with the various functions, and in particular with the production function, emerged. Nevertheless, in some cases a certain "sufferance” by the maintenance function is still perceptible that would like to participate more to decision-making, and that instead is often confined to managing assets in terms of reliability and availability in a still partially isolated way.

Looking at the end of life phase of the assets life cycle (End of Life, EOL) - disposal, recycling, reuse, etc. -, it is the phase in which in general there is the lowest level of integration among the functions. In particular, the maintenance function in most of the analysed companies mainly takes executive role, without participating in the decision-making process (re-use, life extension etc.). This leaves open space to achieve better integration.

As for the implementation of Asset Management guided by long-term goals, interesting findings have emerged evaluating the tools and indicators used by companies to support decision making. Below, the evidences that emerged regarding investments on assets are showed.

In the investments assessment, traditional methods are mainly adopted like ROI (Return on Investment), NPV (net present value) and IRR (Internal Rate of Return). Although these indicators theoretically imply the adoption of a long-term vision, in practice in the majority of cases their calculation is done through an accurate assessment of only CAPEX (the costs recognized in the capital of the company, i.e. Capital Expenditures) and by only including a rough estimate of OPEX (operating costs for the year, i.e. Operational Expenditures). In particular, it is evident that the approximate estimate of OPEX is likely to underestimate the impact of the investment decision to the future performance of the asset that can generate inefficiencies and therefore hidden costs.

Few are the cases where the investment assessments (made with the above methods) are flanked by other methods such as the use of a TCO model, the assessment of the satisfaction of the stakeholders, or RAM analysis (Reliability, Availability, Maintainability) for a provisional estimate of industrial plant performance losses.

In general, investments still seem a financial problem, while all the companies recognize the need to increase the contribution of the engineering vision to be integrated with the financial analysis. This hope is based on the need to evaluate the convenience of choices enriching the financial indicators with models capable of synthesizing the technical and operating dimension of industrial assets, with the ultimate goal to obtain adequate performance estimations, which are at the basis of informed financial analyses.

4.2 System orientation

Regarding the system orientation, the case study allowed investigating whether the complexity that characterizes the assets is taken into account in the decision-making processes, given by the fact that industrial assets are typically systems composed of multiple components with their own RAM characteristics, which interact with each other to perform the requested function of the industrial plant.

All analysed cases showed an awareness of the importance of adopting a systemic vision in the system performances analysis, with the ultimate goal to take into account the effect that every local decision inevitably has got at global level. This means, for example, making decisions for improvement for increasing productivity in an industrial plant on the basis of a careful analysis of the criticality of the individual equipment with respect to the function they have for the production flow at system level. Nevertheless, this does not necessarily coincide with the "local" criticality of equipment measured by traditional indicators like OEE (Overall Equipment Effectiveness) - which is by definition "centered" at equipment level.

Although awareness was shown by companies, today analyses keeping the systemic perspective are not implemented in a systematic way. This may be justified by various contingent reasons. In some cases, the asset (as a system) requires the operation of all the equipment (components) for its operation - is the typical case of a system configuration in line / set of equipment, with the limited presence, or absence of inter-operational buffer. In this case, each equipment assumes the same criticality at local and systemic levels, namely the OEE the Equipment would be sufficient to have an accurate approximation of the effect of local problems on systemic performances. In other cases, there is not yet a full integration of tools or engineering techniques, within the reliability and maintenance engineering systems, so to enable that the global effect of local decisions is fully analysed, in fact some companies ae still relying on traditional KPIs like OEE keeping the local perspective. Finally, in other cases, the systemic analysis is restricted to a limited number of decisions in the life cycle, and the use of some specialized engineering techniques but with no systematic approach throughout the life nor fully exploiting the potentials of systemic RAM analysis. In conclusion, system orientation – as a founding principle of Asset Management – generally requires an enrichment of techniques already used in practice through the extensive use of advanced engineering tools, capable of systemic RAM analysis.

4.3 Risk orientation

As far as risk orientation regards, when making decisions related to assets, every company applies all the needed measures present in the relevant legislative framework of the specific sector to reach the level of compliance required for the management of critical risks (related to safety and environmental impact). In this study, the focus was rather on whether and how those operational risks that are under the category of "uncertainty", such as the risk linked to the effect of future behaviour of assets on the expected performance, are managed.

With regard of this issue, the sectorial contingency has an impact on the practices adopted by the different companies. In some sectors, the most capital-intensive ones, ensuring asset integrity is a priority due to its high impact on business. It is the case of the most advanced companies in terms of the systematic integration of typical approaches of RAM analysis and methods for operational risk management in Asset Management. Nevertheless, attention to the performance and operation of the assets is a critical element in all analysed cases.

In relation to the "uncertainty" issue, the aspect that stimulates greater reflection is then if the expected performance of the asset, and any inefficiency expected from its operation, are quantified in terms of cost to support decision-making by companies. In fact, the implementation of reliability analysis of industrial equipment should also become an issue to be included in the evaluation of an asset-related investment. What in general is still missing - as noted previously about life cycle orientation - is an alignment between the system's technical performance measures and financial indicators, which are the ones that are taken into account in the company to make decisions. Engineering analysis should support the final choices, reducing the possibility of operational risk losses in production efficiency, ensuring an informed decision-making process.

4.4 Asset-centric Orientation

The adoption of an asset-centric management approach appeared to be influenced by the sectors of the companies. In the most capital intensive sectors, the role of the assets and their performance is definitely recognized as central to ensure the production and the achievement of business objectives. It follows the high emphasis on ensuring clear ownership of the asset.

In general, in all cases the relevance of the definition of a clear ownership of assets to ensure control and commitment to Asset Management is recognized. The various analysed companies, while proving to have all shared the need for a clear ownership, have made different organizational decisions. In some cases a centralized ownership at the level of maintenance / technical direction functions has been chosen for different systems; in other cases the ownership was instead given to an executive belonging to the top management board.

In terms of information systems, in order to support an asset-centric management approach, maintenance information systems are seen with a central role. In general, the information maintenance systems are still partially integrated with other enterprise information systems and the need to move towards the definition of a better system, in which different kind of data (technical and economical) related to assets are collected and analysed in an integrated manner, is recognized. Overall, this is considered an enabling element for effective implementation of Asset Management.

4.5 Concluding Remarks

To conclude, it is worth remarking that the case study was developed by considering companies belonging to different industrial sectors to have a general overview and assessment on AM integration in production companies. Even if the companies selected for the case study development are companies with high level of maturity in terms of Maintenance Management, when widening up the perspective over Asset Management, gaps to be filled in have been identified. None of the companies resulted to fully incorporate the four funding principles for AM integration (i.e. life cycle orientation, system orientation, risk orientation and asset-centric orientation). Life cycle orientation is the principle that more companies are looking at in order to tend towards it (re-organization, testing of new tools etc.), while system orientation is still quite weak in all companies.

Moreover, it is worth noticing that the gaps that have been identified regarding the level of integration of the Asset Management in the companies not only are due to contingent reasons (industry, type of assets to manage etc.) but also to the low development level of the necessary technologies / methodologies, for example, the availability of a standard model for Total Cost of Ownership to support the decision-making process or the availability of performance indicators at system level.

5. CONCLUSIONS

Work is still required both in research and practice in order to tailor Asset Management in the production companies' context as a business process within Operations.

Companies have to get more and more aware of the importance of addressing Asset Management by reflecting the four funding principles and by accordingly structuring an Asset Management system. Moreover, mechanisms have to be introduced so that the decision-making process within such system is faced through a life cycle perspective and through alignment among the strategic, tactic and operative control levels. Only by adopting these measures, sustainable value creation from assets can be ensured.

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