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Practical Implementation of an Asset Management System According to ISO 55001. A Future Direction in the Cloud & IoT Paradigm

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1. Abstract

This contribution describes a general process according to the main topics of the ISO 55001 requirements, answering questions related to the reason or to implement or not an asset management system. With that purpose, some tools are briefly depicted, underlining the importance of having a proper knowledge of the plant taxonomy, in order to perform later a Criticality Analysis. Once detected the most and the less critical items according to the business interests and goals, each asset is evaluated and analyzed according to different methodologies. These methodologies provide results and data that will constitute the management plan for each asset. As a result, in the application of these methodologies, large amount of information and big data are usually compiled, being useful the integration of feasible Cloud and IoT technologies. Finally, connections to risk standards and uncertainty references, as well as to intangible asset management are commented together with some conclusions.

Keywords: Asset, Cloud, Organization Factors, IoT, Maintenance, Reliability, Risk, Standardization, Uncertainty.

2. Introduction

Standardization can be considered a process to implement generic best practices in organizations. Together with other benefits, the different standards are generally intended to improve business policies reducing risks and uncertainties in work procedures (Crespo et Al. 2018). Among the standards, ISO 55001 provides a series of requirements that seek the improvement of decision-making on assets management, reducing costs, enhancing operations quality, as well as increasing business profitability and users' satisfaction among other advantages. Standards are typically generic since they must be useful for a wide range of organizations. Therefore, this contribution is intended to summarize specific tools and methods, providing solutions for the reliability and risk management of complex systems (Zio & Coit, 2019).

Usually, the implementation of a management system based on ISO 55000 refers to industrial physical assets. That is, machines, test equipment, laboratory devices... all those items necessary for the production process. Obviously, the value realized by the asset will depend on the organization and may change throughout its useful life. The concept of value does not only refer to value from an economic point of view. Today, responsible companies extend

this concept to the field of social, environmental, etc.

Besides effective and well-known maintenance management models (Crespo 2006), this document starts responding some preliminary question that any organization wonders at the beginning of an implementation process (Crespo et Al. 2019): what must be considered a physical asset? How is linked the asset accountability value included in a financial balance, with the TOTEX? (The total expenditure related to an asset), why should the company invest in implementing an Asset Management System? After providing some first answers, this contribution is focus on explaining tools that are useful to implement in a practical way. Finally, connections to risk standards and uncertainty references (Aven, 2012) are commented together with some conclusions. In that final section, some remarks are also commented about the possibility to apply the ISO 55001 principles to an intangible asset management system.

3. Preliminary questions and answers

When an organization is initiating the implementation of an Asset Management process, usually appears some hesitations about what an asset really is. Since this word is widely used in accountability area, there are sometimes some misunderstandings on what should be assumed as "asset". According to the international accounting standards, a balance sheet includes a column related to "Assets" which refers to company goods and rights, and a column related to "Liabilities" which refers to debts and obligations. Liability is organized in terms of enforceability, and Asset column is organized in terms of liquidity. This Asset column includes current assets (cash, inventories, loans to clients…) and non-current or fixed assets which considers intangible assets (like copyrights), properties (like buildings, terrains…), as well as plants and equipment (machines, systems…). Hence, it is possible to ask what a physical asset is then. Those machines or equipment included in the fixed asset part of a financial balance sheet is, in other words, the physical assets of the company.

3.1 How is linked the physical asset with the accountability concept?

The accountability value included for such line of the balance refers to the monetary value invested on such machine. It is basically linked with the acquisition cost, which is reduced every year by the corresponding depreciated cost. There is no monetary disbursement connected to such depreciated cost. Apart from that, there is the concept of total cost of the asset ownership, which refers to all those costs that the Asset may incur during its completely useful life cycle, once the item has been acquired. Complementary to this concept, there is also the term total value of the asset ownership, which refers in this case to the profits that can be earned by the assets during its whole lifecycle. The key point with all this clarification is that once the machine is totally depreciated (from the accountability viewpoint), the asset on the contrary is usually able of course to keep on providing value and it may incur naturally in different cost (for operation, maintenance, etc.). These costs do imply a monetary disbursement. Hence, it is possible to ask what the total life cycle cost of an asset is then. It will be the sum of the CAPEX, represented by the acquisition cost (and linked with the value included in the balance sheet), plus the OPEX, represented by the sum of installation and commissioning costs, O&M costs, …, plus disposal cost (or minus the asset remaining value). This life cycle cost is also known as TOTEX.

3.2 Why should a company invest in implementing an AM System?

Besides these first questions, an organization intended to implement an Asset Management Process usually wonder reasons to invest resources in that task. Usually, there is a list of theoretical benefit that can be summarized in aspects like better investment decision; increased efficiency to deliver; achievement of intended outcome; increased quality; better risk / opportunities management; enhanced reputation / social responsibility; etc. All these aspects are certainly profiting items gathered from the implementation of an Asset Management Systems, but they are not sufficiently tangible as desired by a board of directors. In order to make more practical and convincible the arguments, here below are some examples in order to justify the implementation effort:

- In reference to investments, an appropriate Asset Management System helps to compare assets and, consequently, is a good tool that supports the decision on what to buy, what to renew, or what to keep on maintaining.

- In reference to assurance policies, an exhaustive Asset Management System helps to control the assets, mainly those considered critical, to increase the knowledge on them and, consequently, to receive bonus or discounts from the assurance companies, reducing the corresponding expenses or increasing the corresponding allowance.

- In reference to the supply chain management, and connected to the first bullet, data compiled can be considered as an additional factor (besides purchasing cost, quality and delivery time) to decide the purchase of an item or service to one provider front other bidders.

4. Practical clarification on asset management concept

Asset management is usually understood as “those coordinated activities of an organization to realize value from its assets”. Sometime, this definition is not enough to convince the different levels of an organization about the implementation of such a management system. Therefore, it is useful to set question in order to understand how the organization is managing its asset. For instance:

- What is the Asset Inventory?
- Who is responsible of the Assets?
- How important are these Assets for the Company?
- How will these Assets behave?
- Are the resources assigned efficiently for each asset?
- What is the Assets performance?
- How much will the assets cost during their whole life cycle?
- How are the Assets linked to the business goals?

In general, Asset Management responds these questions and take decisions according to data. Among the previous questions, one of the most important and strategic question is the last

one related to the link to the business goals. In order to create value, organizations can establish different types of strategies. Economically, strategies of companies are basically focused on obtaining a benefit, whether short or long term. Understanding that the benefit follows this formula profit = revenues – expenses, strategies can be materialized in objectives that will be aimed at, for example:

- In order to increase revenue or increase customer value (they would be growth strategies) or
- In order to improve cost structure and increase asset utilization (they would be productivity strategies)

From the perspective of physical assets, what should a machine do for the organization to increase revenue? It will be interesting that, when the machine is necessary, it fails little. That means to have high reliability. Likewise, what should a machine do for the organization to reduce costs? It will be interesting that the operation and maintenance costs are low. In order to do this, downtimes must be reduced. That means in this sense, it is interesting that the asset has a high maintainability. In short, the above concepts are encompassed by the term availability that considers a high average operating time (linked to reliability) and a low repair time (linked to maintainability). In other words, the creation of value implies business general objectives to which, there are objectives in the management of assets that must be aligned. For that purpose, it is needed to follow those processes established in the company for such asset management. Aligned with the objectives of the company, the objectives of asset management should be, for example:

- Improve quality, reliability and availability
- Be more cost efficient
- Extend the service life etc.

An important aspect in asset management is the concept of maintenance, since it has a very important function throughout the life cycle of machines. According to ISO 13306, maintenance is considered as those activities focused on reducing failures. For this purpose, two types of maintenance can be distinguished, one applied before a failure (event in which the asset loses the conditions to fulfill its function) and prevent it from taking place (preventive), or after it (corrective) for restoring the equipment to conditions in which it fulfills its required function. The rest of the subdivisions comply with different criteria. For example, the corrective can be done immediately or deferred and even programmed. Preventive maintenance has been subdivided into on condition or systematic, depending on whether it is carried out based on the conditions observed in the equipment or based on a series of predetermined measures of its use respectively. Taking ISO 13306 on maintenance terminology as a reference, the predictive maintenance would be a type of condition-based maintenance. Condition-based maintenance includes the Detection, Diagnosis and Prognosis of failures using, generally, data-mining techniques. Therefore, detecting or diagnosing are equally relevant to predictng.

Maintenance and asset management are related, but they must be distinguished. Generally, maintenance is understood as those activities aimed at reducing faults and keeping the operation of a machine. This is therefore a operative activity with a short / medium term vision. Asset management adds a more strategic and long-term vision, since it considers

activities that will be carried out throughout the asset life cycle. This includes, therefore, economic aspects such as the possibility of new investments, extensions of useful life, replacements, etc. as well as operational aspects. That means, decision-making may change, if the operational context varies, as well as logistics aspects of spare parts management, training, subcontracting, etc. In other words, asset management has a greater scope than maintenance, both in time horizons and in organization areas.

5. Practical view on ISO 55000 family of standards

The family of standards ISO 55000 is constituted by three norms:

- ISO 55000: which refers to terminology and principles
- ISO 55001: which refers to the requirements
- ISO 55002: which includes guidelines for the implementation?

This family of standards is structured on a 'Plan-Do-Check-Act cycle' basis. It is basically a Deming Cycle, similar to the one applied for the ISO 9000. According to this cycle, value is added by creating alignment from the 'context' element through to the 'improvement' element. However, this system cannot work isolated – it must be integrated with other management systems within the business. How must this standard be focused on a company? All these aspects shall be translated into a series of processes and procedures of the company. For sure, many procedures already exist in every company, although they must be updated considering now this new vision on asset management. Other procedures will need probably to be new. In any case, it is important to review the whole body of documents in order to assure that Asset Management is incorporated into the business policies, strategies, plans and processes. That means, in other word, to apply a Gap Analysis to the company procedures system.

Once the company is decided to implement an Asset Management System according to the ISO 55000, it will require as inputs, the knowledge of the business context and interest parties, the identified risk and opportunities, as well as other aspects like the business management policies, legal requirements and the asset inventory. With these inputs, the proposed asset management process will be a cyclical management framework, where the main tools are:

- Criticality Analysis (applied to the asset inventory at a specific taxonomy level)
- Reliability Centered Maintenance (as part of the asset operation and maintenance)
- RAM Analysis (useful as indicators for the asset performance)
- Root Cause Analysis of Failures (applied to improve knowledge on incidents and non-conformities)
- Life Cycle Cost Analysis (needed for capex / opex decisions)

As outputs, the company shall obtain a management plan for each asset that will be more exhaustive for those assets considered as critical. These outputs must be linked to those company procedures related to continuous improvement, management review, investments procedure, etc. Possible collaborative projects on this field are of course all those related to

find support from the new technologies application, in particular IoT in order to automatize as much as possible the data compilation, and Cloud tools in order to facilitate the remote connectivity and the data transmission and storage.

6. Review of tools for the asset management system

6.1 Asset Inventory and Criticality Analysis

This methodology shall enable a prioritization in the assets inventory:

- To reduce resources where they are less needed (non-critical assets)
- For improvements in routine maintenance plans
- To assign resources where they should be more targeted, even with a contingency plan (critical assets)

First, the company must have an asset inventory for each manufacturing center, which is a list of all the assets used by such factory (owned or leased). In order to make the list, it will be needed to define previously the intervention level. This level will depend on each manufacturing center, where such center should define the list referred to the level in which the maintenance plans are applied. There is a standard (ISO 14224), which is generally used for its clarity when defining taxonomy and levels, although it is for the petrochemical field. The taxonomy may range assets from the most general classification (the industry or the business line), to the most concrete (as the components or parts). It is usually structured in the form of a tree, in a parent-child relationship between levels. Systems or equipment unit (level 6 or 5 of the ISO 14224 classification) commonly makes the assets inventory.

Once the asset inventory is known, the Criticality analysis is performed. The criticality of an asset is an indication of how important it is for the business in terms of realizing value. Since the criticality in terms of value is difficult to measure, what is applied is the calculation of the dual problem: That is to say, criticality will be a measure of the worst-case impact that the failure of the asset could have on the business. This methodology would consist, for instance, the product of the frequency of a failure (or a factor that refers to the greater or lesser occurrence of a failure event), multiplied by the consequence of this failure (which may refer to the costs generated by the failure or a factor of the greater or lesser effect that this failure event has). The different factors require a consensus among experts, constituted by the Asset Management Team. Among the factors, usually Safety is enhanced in front of the other ones (operational impact, maintenance cost …). Once applied this analysis, the list of assets can be ranked (as a Pareto's graphic), where there will be non-critical, medium, and critical assets.

6.2 Process for non-critical assets

In the non-critical assets, an increment in the frequency of failures does not lead to drastic changes in their criticality. The frequency of its revisions in the maintenance plan can be modified, without affecting the operational availability of the plant. What to do with these non-critical assets? They must be studied by a cost-risk-benefit analysis considering that, sometimes, the necessity of such non-critical assets may be due to legal reasons. In any case, these actions allow the company to get early savings (early quick wins):

- Removal of unnecessary maintenance activities for the asset
- Cost savings on preventive maintenance activities for the asset
- Assessment of criticality status change, resulting from modifications to preventive maintenance activities

On the other extreme of the Pareto's graphic, the critical assets appear. With these items, it is recommended to perform an RCM analysis (Reliability Centered Maintenance). It allows us to know the root cause of the problems, the possible weaknesses of the assets and thus, to allocate the necessary resources. Therefore, these assets will follow the following sections.

6.3 Process for critical assets

Those elements with high criticality deserve a deeper and exhaustive treatment. The methodologies suggested for these assets are (among other possible ones):

- RCM (Reliability Centered Maintenance): This tool is a kind of FMEA versioned to physical assets. With this methodology, failure modes and their effects are analyzed, and current maintenance policies are improved. In order to apply properly this analysis, a multidisciplinary team is needed where the areas of Operations, Maintenance and Occupational, Health and Safety (OHS) are at least represented.

- RAM (Reliability, Availability and Maintainability): These parameters or metrics are calculated in order to get information about the asset performance. They are useful, for example, on work progress, labor rate assessment, etc. In order to obtain these results, it is necessary to gather data such as Operating and Repair Times

- LCC (Life cycle Cost): The total cost of the asset is estimated during its useful life. It is similar to an EAC (Estimation at Completion analysis), where possible deviations can be observed or decisions if the useful life should be extended, if the asset should be replaced, etc. can be taken.

The fact of estimating the cost throughout the life cycle allows comparing, for example, different options to know which machine can be more or less convenient when deciding on an investment. In the case of an asset in function, calculating the incurred cost (similar to an ITD, Incurred to Date) and estimating the cost until its completion (similar to the ETC, Estimation To Completion), can provide a useful knowledge as to:

- cost deviations (if the asset is incurring more or less costs than planned),
- if extending the asset useful life (considering the extra cost) may be interesting
- if the replacement of an already amortized asset may be a good choice

After the application of this practical process, a management plan is obtained for each asset. It usually includes a summary that compiles the main results of all the above-mentioned analyses as well as a decision sheet that the asset management team proposes. These possible actions shall be reported to the senior managing board in order to decide for instance:

- Discard the asset,
- Reduce maintenance
- Maintain the current level of maintenance
- Reduce Repair Time
- Increase maintenance
- Replace the asset
- Etc.

7. Intelligent asset management focused on CloudIoT

Intelligent asset monitoring enabled by CloudIoT means comprises aware and integrated units that may run as a "single strategic system". That enables entities and companies to transform digitally their operations. Now with CloudIoT, they have become a single smart solution. Therefore, it offers many advantages in comparison to traditional solutions. This transformational technology may change the way of doing things and disrupts consequently business processes. Intelligent asset monitoring (enabled by CloudIoT) achieves to perform everything that traditional solutions can do, allowing additionally to know where the asset is located, what the asset condition is, the asset lifecycle management, control of processes, etc., including also intelligence to automated workflows, alert timing, data insights, dynamic asset monitoring, predictive maintenance, cross-domain analytics, and real-time visibility. Intelligent asset management generally comprises the following aspects:

- Tracking of remote asset
- Asset Condition Monitoring
- Asset life cycle management
- Automation of asset workflow
- Predictive Asset Maintenance

There can be many derivative solutions or variations of these in order to make CloudIot specific to an industry or a business process (Saraubon et al. 2019). Intelligent asset management applications in various industries can be found, for example, in logistics (Ponis et al. 2020), healthcare industry (Lee et al., 2015), or railway sector (Sarkar et al. 2020).

Most companies that have high-cap assets on their facilities or spread across different locations have many issues to solve. Such as assets with poor health, excessive maintenance costs, high mean time to repair, ineffective performance, etc. CloudIoT focused on intelligent asset management may offer a more holistic approach to asset control rather than a module-based approach. CloudIoT provides to asset management the right visibility for organizations to overcome these challenges. The main advantage of CloudIoT is the capability to access domain data and seamlessly integrate it with a unified solution so that management has the knowledge to make the right decision. CloudIoT solutions may bring the inherent value of automation, innovation and digital transformation.

Traditional alternatives provided a lot of data but lacked information. There was a great deal of human involvement, offline data, iterations, etc. The time delay made many reactive activities or excessive of preventive tasks.

CloudIoT solutions may connect however machines with people, with processes and systems in ways never seen before. This makes automation easier. Human intervention is required only for decision making in the place of performing routinely tasks. The main advantage of intelligent asset monitoring is the automation of all this. Thus, one increases accuracy, reduces costs, improves process efficiency, and eliminates non-compliance. Physical checks, routine tasks and regular monitoring can be drastically reduced and can now be performed based on the condition and actual use of the asset.

The possibilities of providing innovative added value with intelligent asset management are endless. Data analytics aids in real-time or near-real-time decision making with the help of machine learning techniques and other advanced intelligent tools. Data from multiple machines embedded with information on product usage can reveal new insights that have never been seen before. This enabled management to find innovative decisions and solutions to meet the common challenges that their company has faced for many years.

8. Conclusions and future research lines

At the beginning of this document, the physical assets and the asset management concept were linked to the business goals through the introduction of some accountability concepts and the definition of profits as the results of the difference between revenues and expenses. Another way to see the effect of asset management in the business goals is by using economic ratios such as ROIC (Return on Invested Capital). This is the percentage obtained by dividing the result of the net operation profit after taxes (NOPAT), by the invested capital.

Among the elements that would be part of the Net Operating Profit can be found:

- Improvements in OHS, Operations and Maintenance, as well as in processes
- Reductions in labor and storage rates for spare parts and tools
- Applications of Lean techniques, continuous improvement, good practices
- Among the elements that would be part of Invested Capital can be found:
- Disposal of obsolete or unused equipment, optimizing inventory
- Improvements in investments and resource allocation
- Meeting performance requirements, reduction of downtimes

Together with this, new challenges appear for the integration of Cloud and IoT tools in order to simplify the handling of the big data generated by all this set of methodologies. The new industrial scenarios require the application of concurrent engineering concepts where IoT present useful advantages as, for instance, when it is intended to implement such a management system as the one depicted in this chapter. In few words, this document contributes to justify the advantages of implementing an asset management system and describes in a practical way a general process according to the main topics of the ISO 55001 requirements. Nevertheless, future lines may deal with intangible asset management system, according to ISO 55001. In particular, the knowledge management as those activities needed to realize value from the knowhow and the human resources of a company. For this case, it will be needed the application as well of the standard ISO 30401, which refers to the

requirements for implementing a knowledge management system.

Finalizing, companies in the digital age are transforming to combine products and services in unique ways to offer their products as a service. A CloudIoT solution focused on intelligent asset management is the key to incorporating new lines of service or new business models in organizations and companies. Traditionally, a company's physical assets, once seen as a cost or burden on the balance sheet, can now be managed effectively to generate additional revenue. With more data, control and vision, a company can observe trends in which they can identify new market opportunities. Capitalizing on those opportunities can generate more revenue for the business.

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