Three key elements of Physical Asset Management

Dr Barend W Botha
Senior Lecturer, Department of Mechanical Engineering Science
Aucklandpark Campus, University of Johannesburg, PO Box 524, Auckland Park, 2006
bwbotha@uj.ac.za

Abstract. *Physical asset management is commonly associated with the benefit created by managing mechanical equipment during operation more effectively to reduce life cycle cost. It is therefore often associated with the potential of condition monitoring and maintenance engineering for reducing maintenance cost due to the success that these engineering disciplines have had in doing so. However, physical asset management has much more to it than simply managing maintenance activities or even reducing maintenance cost. It is about balancing performance, risk and cost associated with an asset over its whole life to achieve an optimum solution to the business opportunity at hand.*

Introduction

Asset Management is not a new concept. Many of the principles have been used for many years to manage capital equipment. However, changes in the nature of the equipment and the operating environment have made asset management more important than ever before (Komonen 2013). Effective implementation will, however, require an integrated approach.

Asset management excellence is about finding a balance between performance, risk and cost to achieve an optimum solution (Brown 2004). Due to the short term benefit, the traditional approach to Physical Asset Management (PAM) focused more on maintenance and maintenance optimization of equipment in service, i.e. on maintaining equipment in operation, resulting in a boom in especially the field of condition monitoring and vibration analysis. However, the importance of design decisions on post-commissioning costs raises the question as to the key elements impacting on the effective management of equipment.

Table 1 shows a summary of the research done by Victor Rudenno on 95 mining projects in 33 countries suggesting that less than 20 percent of the overall life cycle cost is spent by the time of commissioning (Rudenno 2012). This means that more than 80% is spent during operations and decommissioning. This logically supports the drive to find ways to reduce maintenance costs. One effective way is to improve maintenance efficiency through condition monitoring resulting in savings being realized relatively quickly.

Table 1 : Life Cycle Cost Example (Mining) (Rudenno 2012)

Total Cost Component Example			
Cost Component	**Open Cut**	**Underground**	**Treatment Plant**
Capital Cost as % of Total LCC	15%	14%	19%
Operational Cost as % of Total LCC	85%	86%	81%

However, as shown in Figure 1, the study also indicates that around 90% of the life cycle cost is already committed at commissioning. This means that the 80% spent after commissioning (maintenance and operations) is a result of design decisions made during development, i.e. before commissioning.

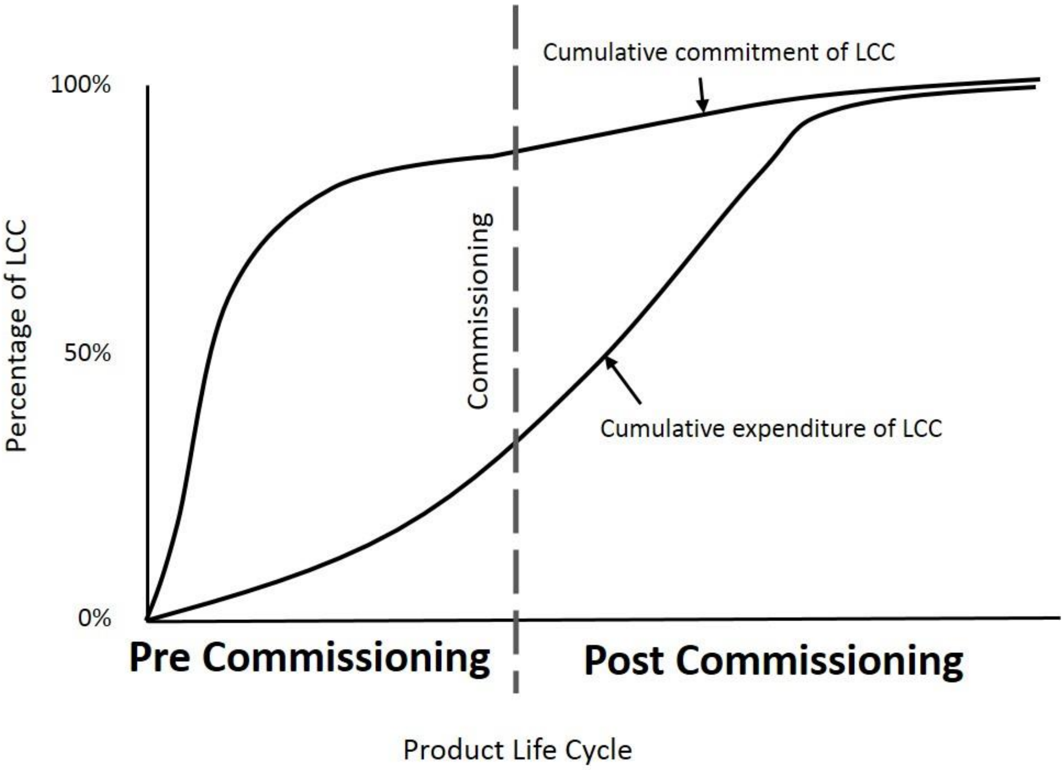

Figure 1 : Life Cycle Cost Commitment (adapted from AS 4360 (AMC))

However, the decision to spend more on development to save on maintenance cost or deciding between replacing or repairing is often driven by business decisions such as the anticipated operating period, available investment capital and ultimate business goal. As industry is realizing the negative impact of the traditional firefighting approach to maintenance it is increasingly moving towards an integrated maintenance strategy (Alves 2010) which acknowledges that maintenance activities should not be performed in isolation, but should also consider the impact on business. As an example replacing truck tail lights with LED lights during maintenance actions at five times the cost while the life expectancy is only three times may seem as a poor decision from a maintenance point of view. Considering that such a replacement removes the truck from service for a day to do the repair, and ignoring other benefits, the higher revenue potential due to the reduced down-time resulting from the extended use far outweighs the higher cost of the LED light making the decision to replace highly beneficial from a business point of view. If the aim is to reduce maintenance cost then the lights would not be replaced.

Based on the above, managing equipment effectively therefore is vital in achieving business goals. The Institute for Asset Management therefore defines Asset Management as the art and science of making the right decisions and optimizing the delivery of value (IAM). Kari Komonen of the European Federation of National Maintenance Societies defines it as “the optimal life cycle management of physical assets to sustainably achieve the stated business objectives” thus confirming the need for an integrated approach throughout the company to improve overall performance.

The information gained suggest the three key elements for effective asset management to be that of Organizational Management (related to the organizational strategy and goals), Design Management and Maintenance Management. Each of these fields include numerous other fields of which only a few is indicated in Figure 2 for perspective. Unfortunately many of these fields are often considered in isolation and/or proclaimed to be the missing link in effective Asset Management.

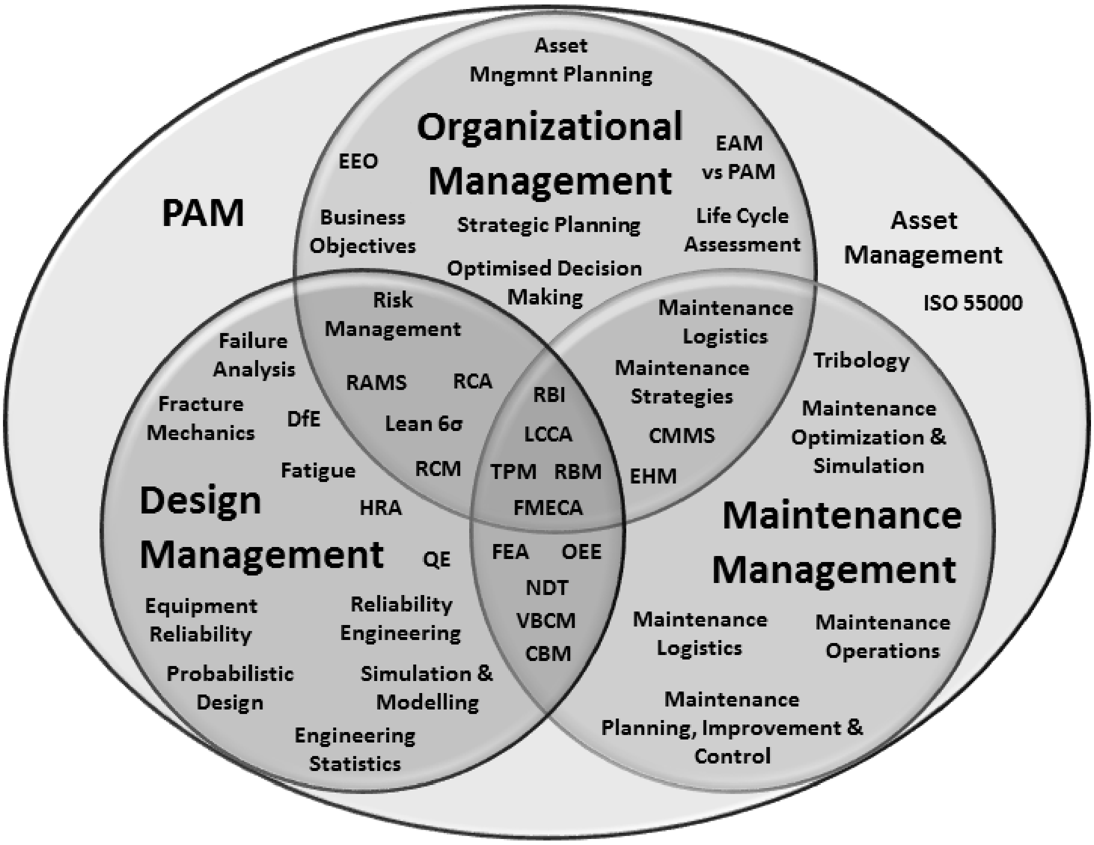

Figure 2 : Key elements of Physical Asset Management

Maintenance Management

Physical asset management has the aim of reducing the life cycle cost through effective equipment management. This means that the equipment performance should be evaluated and managed in the overall context of the business case supporting the concept of integrated maintenance planning. Suitable maintenance strategies and decisions therefore needs to form an integral part of the business strategy in supporting the business case by reducing the life cycle cost after commissioning for the anticipated duration of the project. Way too often companies operate an autonomous maintenance department that needs to meet an ever decreasing maintenance budget. As the maintenance personnel is measured against their budget their focus is driven to reduce maintenance cost without considering the impact on the bigger picture and overall life cycle cost associated with the asset. The downtime cost often does not reflect in the calculations or feedback although it generally runs orders higher than the direct maintenance cost (Mobley 2008).

Effective maintenance management therefore includes all the activities required for retaining or restoring equipment to the specified operable condition to achieve its maximum useful life (BusinessDictionary). It includes the identification of suitable maintenance strategies and application of various technologies and techniques to effectively manage assets to reduce downtime and limit maintenance cost. The focus is to prevent unplanned, unnecessary or lengthy outages, reducing spare part stock, predicting expected life and extending useful life. This has sparked a flurry in monitoring of equipment during operation and has seen creative technologies coming forward measuring various types of data simply because it can. Companies subsequently often over estimate the value of a proposed condition monitoring systems but only realize this after spending exuberant amounts of money and not achieving the anticipated returns. This then results in unfair negative emotions towards the specific technology or even condition monitoring in general. However, without a solid maintenance management program aimed at moving from firefighting to preventive maintenance to eventually proactive maintenance the chances are that the ROI will be low or even negative (Moriarty 2015).

When considering condition monitoring as part of the maintenance management strategy it is important to first identify the information required to make informed decisions at the different operational levels and then select the appropriate technique to effectively obtain this measurements. The focus should therefore be on the ability to identify and capture the required information rather than using selective information from an exhaustive array of measurements captured by often expensive systems. Once again, the decisions and subsequently the required information are often governed by the business strategy.

Design Management

Although valuable in reducing operating cost, focusing on maintenance activities only is like administering antibiotics for a recurring infection. Although not cheap, the cost of the antibiotics is far less than the loss incurred if the person has to be booked off. However, it merely addresses the symptoms and not the cause and subsequently the cost becomes a repetitive cost in itself. Similarly maintenance originates from "unreliability" inherent in the equipment due to decisions made during the design and/or manufacturing process. As long as this error is not corrected there will always be a need for the same, often expensive, maintenance cost irrespective of the monitoring technique applied. Monitoring therefore informs you when the problem is eminent, but does not address the problem not to reoccur.

The Design Management Institute defines design management as the link between design and business (DMI). Best then states that design management focuses on the effective management of resources, processes, procedures and projects (Best). Considering this together with the role of the decisions in asset management the author defines design management in a traditional engineering environment as being related to*:*

The effective application of management and design activities, methods and skills necessary to optimize and manage the design process to deliver the most suitable solution, meeting business objectives and customer requirements within predefined constraints in a technically defendable and sustainable manner for the intended life of the asset.

Realizing that in practice there are numerous aspects included in design management it is important to note that it includes both the traditional detailed design tools such as Finite Element Analysis, Computational Fluid Dynamics and Simulation and modelling, as well as the systems engineering methodologies used to improve the design process such as Design Reviews, Failure Mode and Effect Analysis, Root Cause Analysis, Reliability Centered Maintenance, Fault Tree Analysis, decision making, Requirements analysis, Reliability Engineering (including RAMS), Probabilistic design, Risk management, Life Cycle Cost Analysis, Lean, six sigma, and many more. The aim is to use the tools traditionally associated with systems engineering to determine the most suitable solution supporting the business goals.

One important tool in Design Management is Reliability Engineering which includes all the activities to ensure that the specified reliability is maintained for as long as possible during the specified period of useful life despite the varying operating conditions. Reliability, on the other hand, is defined as the probability of meeting a specified performance under specific conditions for a predefined period of time. It therefore, in essence, is a design parameter. It is merely a figure applicable to a specific set of conditions and cannot be improved once the design has been finalized. As the equipment is seldom operated at the exact conditions the value is often not achieved. Reliability engineering, however, entails the activities or process to improve the probability of meeting and maintaining the required reliability throughout the life by improving the design. It utilizes various systems engineering and statistical tools during primarily the development or pre-commissioning phase and is instrumental in how the item will perform under conditions different to the exact conditions specified. The reliability is therefore generally a requirement specified by the customer while the design team is responsible for determining the most suitable process to ensure that the requirement is met for the specified conditions and duration.

A major contributor to inefficient asset utilization is the misalignment between the economic and technical requirements and expected useful life (Komonen 2013). Delayed gratification, uncertainty and lack of funding often drives the decision as to how much will be spent during the development phase in order to improve this alignment. This often results in less time being spent and cheaper equipment being used resulting in lower equipment reliability and subsequently lower operational availability. The reduced availability and associated downtime generally results in significantly higher operational costs than investing the time to improve the design. In an attempt to increase availability figures the equipment reliability is often specified unrealistically high resulting in high equipment cost. Applying reliability engineering principles early during the design phase will consider alternative configurations as well as maintainability as options to improve availability. Changing the design of an existing layout might be costly and not recoverable within the remaining lifetime of the plant. However, the potential savings may justify some additional effort and cost in selecting more suitable equipment or layout if replacement of existing equipment is eminent anyway. Care should therefore be taken not to accept an unrealistically high value for equipment reliability before alternatives have been investigated.

Another misconception is that reliability is an indicator of quality. Although there might be some relation to quality as perceived by a third party, quality is the satisfaction of customer requirements and nothing more (or less) (Beard 2014). The customer will typically specify the required reliability (nominal value) as a design parameter. Depending on the specific application this may include a relatively low value. Meeting this requirement to within the specified tolerance will then, contrary to common belief, actually imply high quality although the reliability might be low.

Based on the above Design Management needs to consider the potential impact of design decisions on the life cycle cost of the equipment and its intended operating environment. Justification to spend the additional time is generally based on experience of the said impact on operations. It is therefore essential to create a line of communication to feed potential for improvement identified during operations back into the design process. It also underlines the importance of collaborative design reviews between the development and the operations teams.

The aim of PAM is to maximize the potential or actual value of equipment to an organization (Komonen 2013). This is achieved by minimizing the life cycle cost over the intended life time of the equipment. However, as shown Figure 1, life cycle cost is largely determined through the decisions made during the development phase and subsequently supports the importance of applying reliability engineering principles during design in order to result in a product with a reduced post-commissioning and overall life cycle cost. However, changing the business strategy half way through the project, e.g. deciding to extend the life of the plant significantly or operating under significantly different conditions, will not only impact the validity of the suitable solution, but could even reverse the previously economic viability of the business case. In order to increase the value of design management is important that the relevant engineering principles be applied to as mature business cases as possible. This means that the first priority should be to clear all uncertainties as far as possible before interactively applying the principles to find the most suitable equipment selection.

Organizational Management

Business strategy can generally be defined as the business activities and decisions that will enable an organization to achieve its objectives and maximize shareholder value. It should be governed by various inputs with the aim of balancing the costs of capital, operations, maintenance and replacement to income potential perceived. These costs can, however, be influenced significantly by managing equipment more effectively. Management consultant Daryl Mather emphasizes this in his article on "The Strategic importance of asset management" stating that asset management is even more heavily driven by corporate requirements and objectives than any other management initiative (Mather 2003). This is closely followed by corporate culture and attitude.

Corporate culture is driven by the leadership (Schein 2004) with a strong relation between ethical cultures and organizational success. This underlines the importance of identifying the right leadership to embrace the necessary principles in order to achieve success. To successfully implement the concepts of asset management there is no room for inflated egos. Leadership needs to acknowledge the value that employees can bring in their knowledge area when promoting collaborative participation at all levels. They need to accept that their purpose is merely to coordinate the efforts and not to defend their position or knowledge against that of the employees. However, employees need to experience that the culture comes from within the leadership and is not merely window dressing for self enhancement. If not managed correctly, employees will become resistant to participate thus nullifying the whole aim of the effort.

The second important aspect is that of resource management. In order to achieve success it is important to identify the necessary resources to support collaborative participation at all levels, developing the necessary competencies and skills, improving processes and most importantly developing the next level of leadership.

Strategy management is driven by business objectives, be it short term or long term. This includes both corporate as well as project related objectives. Corporate objectives include objectives related to maximizing shareholder value and vision and subsequently drive the culture within the company e.g. maximizing profit, turnover, performance or customer satisfaction. Finding the balance is essential as it generally serves as basis for project execution. Although governed by corporate objectives, project objectives focus on meeting stakeholder requirements. Stakeholders include everyone with a vested interest in the project, i.e. participants, customer, suppliers and shareholders. Shareholders generally have an indirect interest in projects as the project has to support the corporate objectives to maximize shareholder value. Strategic management therefore includes much more than planning maintenance and has a direct impact on design decisions ultimately driving the resulting maintenance plans. It includes maintenance strategy, engineering strategies, anticipated corporate and project life spans, corporate and project risk management, resource requirements and many more.

Integration

The lack of integration is referred to siloing. This can be between departments, teams, disciplines or subcontractors, but generally is a result of a mindset fostered by different management styles to the detriment of the company. These management styles are developed at academic institutions where the various parties are often conveyed a skewed vision of the importance of their specialty rather than the importance of all the parties contributing to the success of cross-functional projects. Some of the many serious consequences to engineering companies include wasted time, poor design decisions and lost revenue (Gleeson). This is aggravated by the global trend of rewarding individual performance for meeting silo goals. Novkov indicates that it is not the silos of expertise per se that is an issue, but the silo-mentality (Novkov). The challenge is to get the different silos of expertise to interact effectively to the benefit of the project and the company. This, however, requires management guidance. Auburn University developed a two-year minor in Business-Engineering-Technology to impart teamwork skills across the Business-Engineering interface with graduates showing measurably better teamwork skills over peers (Swamidass).

As discussed the three circles indicated are not independent. Decisions in each are influenced by information gained in the other. Important for managing assets effectively over their life-time is therefore to consider the three elements in isolation or silos as is commonly done when the departments are measured individually against increasingly unrealistic metrics. The importance of integrating maintenance with corporate strategy is confirmed by KPMG indicating Asset Management to be a new strategic discipline (KPMG). Daniël Pairon, Global Head of KPMG Asset Management indicates experience to have proven that strategic asset management has financial and non-financial benefits realizing maintenance savings of up to 15% and savings on investment replacements of up to 20% through aligning activities and tactical processes, procedures and support resources to create value in a sustainable way. ISO 55000 was developed in an attempt to bring clarity to how organizations can utilize strategic asset management in achieving their organizational goals (GFMAM) by managing the value drivers of performance, cost and risk.

Important, however, is to note that, although interactive, all three circles are not equally weighted throughout the life of the equipment. During the early development phase the interaction between Organizational Management and Design Management governs in determining the correct solution to satisfy strategic goals and customer requirements. However, this cannot be done in isolation as the design is influenced by maintenance requirements and impacts reliability and maintainability and subsequently availability. During the detail design phase in a stronger interaction develops between design management and maintenance management as the focus shifts to meeting the required performance. Optimizing the design while continuously keeping the goals and requirements throughout the life cycle of the asset in mind. Once in operation the interaction between maintenance management and organizational management dominates in meeting project and organizational performance figures while feedback is given to design management functions to improve future designs and decisions.

Although weighted differently it is important to note that effective asset management requires interaction between all three areas throughout the whole life cycle. In order to effectively integrate it is important to at all times keep the overall picture in mind and align apply systems engineering principles in simplifying the bigger picture into smaller, more manageable problems. The shifting in weight results in a dynamic environment requiring effective management and clear goals.

Based on the above it is important to work towards an interactive process to improve the design to meet the business objective and ultimately reduce the maintenance required and associated downtime over the life time of the asset. True integrated asset management therefore no longer shifts the operational responsibility to the operator only. It requires feedback during the design process as to business objectives, maintenance issues, performance issues and potential risks, i.e. addressing the holistic picture of improved asset management. It therefore needs the contribution from everyone involved to get the process under control to identify the correct equipment during the design phase or before replacing equipment on existing plants. A bolted flange to ease access to a bearing to reduce replacement time may result in a slightly higher capital cost, but the downtime is significantly reduced. At a $ 1000 per hour (Shimel, 2015) this outweighs the additional cost of the flange by orders of magnitude.

Conclusion

As discussed, Asset Management entails far more than merely improving maintenance through the implementation of a condition monitoring system. It consists of two sets of activities with distinctly different aims interacting with each other to support business objectives. The traditional approach focuses on the operational improvement of existing systems to reduce life cycle cost resulting from the system that was installed, i.e. post-commissioning. However, the biggest savings can be realized in the development or pre-commissioning phase where equipment is selected. The post-commission activities, however, result in short term savings whereas post-commissioning result in higher but delayed savings.

In short, maintenance engineering is about reaching the end at the lowest possible cost, but working with "whatever hand you have been dealt" after commissioning. Design Management is about designing with the end in mind by manipulating the design as good as possible to ensure "the best possible hand". Organizational Management is about determining how much you are prepared to spend to find (and achieve) the optimum solution. Maximizing value of assets therefore requires an integrated approach throughout the life cycle of the asset.

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Biography

Dr Botha, a professional engineer with ECSA, started his career as Systems Engineer at Denel in 1992 after obtaining both his B. Eng (Mech) and M. Eng (Mech) from the University of Pretoria. He joined North-West University in 1995 as senior lecturer until 2008. In parallel he acted as consultant to PBMR and quality manager at M-Tech Industrial. He completed his Ph.D. in Engineering at the NWU in 2003. In 2008 he joined PBMR full time as Senior Systems Engineer. After the closing of PBMR he joined the University of Pretoria in 2010 lecturing in Reliability Engineering, Reliability Based Maintenance and Mechanical Design. In November 2013 he joined SNC-Lavalin as Design Manager. In 2015 he joined the University of Johannesburg in Mechanical Engineering. In parallel he is also presenting Engineering Systems Management and Reliability Management in the Postgraduate School of Engineering Management. His current research focus is on engineering systems management, design management and optimization, operational excellence and related fields.

Keywords

Operational Excellence, Design management, Asset Management