Physical Asset Management Systems Concepts

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PHYSICAL ASSET MANAGEMENT SYSTEMS CONCEPTS

1. SUMMARY OF HISTORICAL BACKGROUND

Maintenance, or the execution of certain tasks to keep implements in working order, had its origins in the early times when rough wooden and stone tools were made.

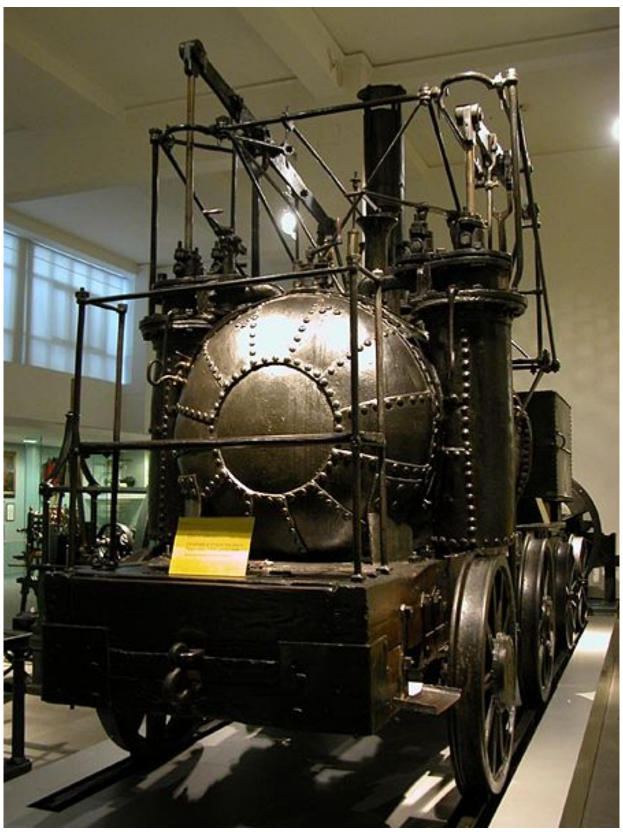
Maintaining those tools required nothing more than very rudimentary skill.

In the later part of the 1700s there occurred a transition in parts of Great Britain's previously manual-labour-based economy towards machine-based manufacturing. It started with the mechanisation of the textile industries, the development of iron-making techniques and the increased use of refined coal. Trade expansion was enabled by the introduction of canals, improved roads and railways. The introduction of steam power (fuelled primarily by coal) and powered machinery (mainly in textile manufacturing) underpinned the dramatic increases in production capacity.

It is specifically the double-acting Watt steam engine, developed during 1763 and 1775, that is regarded as the driving force behind the industrial revolution.

These early steam engines were atmospheric engines, and the development of high-pressure steam engines started with Richard Trevithick, from around 1800.

Below is a picture of “Puffing Billy”, built by around 1814.



Picture 1: Puffing Billy (Science Museum, London)

Steam pressures started to exceed 145 pounds per square inch, which brought about the need for increased safety awareness, resulting in periodic inspections to assess general condition and integrity.

Maintenance became more prominent during the industrial revolution, and advanced quickly way beyond the mere sharpening of stone or wooden tools. The equipment manufactured during the industrial revolution were crude and rudimentary in comparison to today's equipment, and intended to last for a lifetime. Patterns of wear and deterioration were simple, and rates of wear were predictable. It was indeed possible for an artisan to understand these equipment so well that he knew exactly how long specific components would last. Of course unexpected failures occurred, as manufacturing techniques, quality standards and especially metallurgy were not well developed. Few of these machines were built, and it was common to build these according to the customers' needs – standardization in terms of parts was not the rule. Maintenance of these equipment relied heavily on the skill of the artisan. He had to rebuild parts, and often had to manufacture parts from only a sample. It is for these reasons that the old blacksmith was a sought-after and prominent person.

Of course the industrial revolution brought some very sophisticated equipment about, for example printing presses and the Jacquard weaving mill. These machines were examples of mechanical geniality, and were manufactured with great skill and precision. Maintaining these machines required exceptional skill from the artisans.

The industrial revolution period contributed very little to the discipline of Maintenance Management, or Physical Asset Management as we know it today. Management involved only the "people management" and a certain degree of quality control.

Successful maintenance relied on **skill**.

Mass production during the first half of the twentieth century meant more intense competition, the need to decrease operating cost in order to increase profit, and the need to extend the life of production equipment while production pressure increased. Larger volumes had to be produced at lower cost to stay in business. Equipment became larger, faster, more automated and more complex. The capital required to set up or expand a plant increased, and the plants were required to produce more reliable (fewer interruptions) and for longer periods.

During the first half of the twentieth century, needs beyond artisan skill developed. To execute maintenance tasks quicker, more effective and correctly, a high level of technical knowledge was required. Demands for parts standardization, availability of replacement parts, and a high degree of interchangeability was growing.

Successful maintenance relied on **skill and technical knowledge**.

From 1945 onwards, there was internationally a sharp increase in the demand for energy. This included commodities like coal, electricity, oil and fuel. The capturing of German scientists by the Americans and Russians led to the space race, with the success of the various space programs heavily dependant upon reliable operation of equipment for given periods.

Failure prevention became critical to ensure continued output and reduce cost and losses. Economic viability of a plant became dependant on the capability to have a good idea of when failures were expected to occur, and to prevent it by doing the relevant maintenance during off-peak periods.

The relative cost of maintenance became significant, and attempts were made to contain it by better management skills. Time and method studies to set standards and compare labour performance flourished.

Maintenance during the latter half of the twentieth was characterized by a need for skill, technical knowledge, and **preventive and planning capabilities**.

Since the 1960's, the concept of "Reliability Centered Maintenance" (RCM) was initiated by the "Federal Aviation Agency" in the US. An initial investigation was done to determine the feasibility of frequent, fixed frequency rebuilding of aircraft components. This investigation resulted in some startling findings:

a. Frequent, fixed frequency rebuilding had no significant effect on aircraft reliability (there are exceptions).

b. For a significant percentage of component types, preventive maintenance can not be applied successfully.

In the author's opinion, these findings resulted in the awareness of the need for a "total approach" to maintenance – in other words, what the most appropriate mixture of maintenance types for a given equipment type, in a given operating context, is. This "most appropriate mixture of maintenance types" is often called the "maintenance strategy".

It became apparent to both maintenance practitioners and industry leaders that the maintenance required, and the cost thereof, over the lifecycle of the asset is largely a function of design. Equipment is designed to perform a specified function at a specified rate, while maintenance is all about preserving the capability of the equipment to perform such function.

Therefore, some groundbreaking work done since the 1960's laid the foundation for the maintenance approach that took us into the twenty-first century – **approaching maintenance holistically, with a high dependence on systemization**.

2. INTRODUCTION TO PHYSICAL ASSET MANAGEMENT

Since the early 1970's there has been an increasing awareness that the traditional view of maintenance as a "necessary evil" is shortsighted and indeed limiting. A focus shift started to take place, from spending maintenance Rands on preventive, detective and corrective activities towards "design for maintainability". This focus shift gave rise to the development of asset lifecycle models like **Terotechnology,** the **EUT (Eindhoven University of Technology)** model, and many more. All of these positioned the business of maintenance as a sub-set of a more comprehensive "lifecycle economic management of assets". It is the combination of management, financial, engineering, and other practices applied to physical assets such as plant, machinery, equipment, buildings and structures in pursuit of lowest lifecycle cost.

The current state of the art is as follows:

1. Maintenance and its management is regarded as a sub-set of a larger system of “Physical Asset Management”.

2. Various sub-systems of Physical Asset Management have matured and became well-entrenched, notably Reliability-Centered Maintenance (RCM), Total Productive Maintenance (TPM) and Total Quality Management (TQM). TQM has its origins in a 1951 publication by Armand Feigenbaum, and has since developed into a comprehensive business management methodology which spans all organizational segments.

3. It is recognized that a single, standardized model will pull all the diverse ends of Physical Asset Management together. Much thinking has lately gone into this.

4. The British Standards Institution (BSI) has just released the first major revision of its “PAS 55”, a Publicly Available Standard aimed at the optimized management of physical assets. This PAS is available from the Southern African Maintenance Association (SAMA), and is a good “superior reference” for all maintenance practitioners and physical asset managers.

5. The holistic approach to maintenance and its management, which gave rise to the concepts of Physical Asset Management, relies heavily on well-designed, well-implemented and well-used information systems. This in turn forces standardization, and the need to describe our business of Physical Asset Management clearly and exactly – systems analysts and software designers must be able to understand our needs.

3. PHYSICAL ASSET MANAGEMENT: A SYSTEMATIC APPROACH

To put Physical Asset Management into its correct slot within the broader business management environment, we must first consider the overall picture. The model shown below illustrates the salient elements of establishing and operating a business:

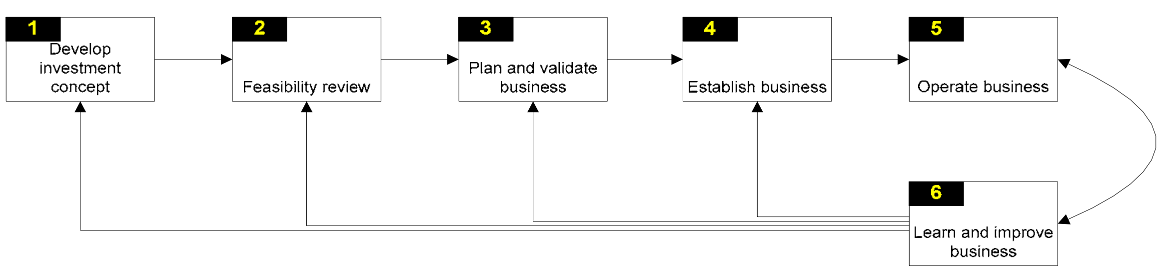


Diagram 1: Establishing and operating a business

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If the elements of the “traditional” Physical Asset Lifecycle Model are mapped to diagram 1, in other words we approach the traditional asset lifecycle with a business mindset; the following very interesting points arise:

a) Acquisitioning: We purchase function and capacity, but we get with it a lifetime of maintenance requirements and the associated cost. This cost, together with the expected availability and reliability, will play a significant role in the success of our business venture for many years to come. Business feasibility studies cannot be done without an objective understanding of future availability, reliability, skills requirements, technology requirements, and software systems requirements. These in turn will have a profound effect on the organization structure, roles, ongoing training, and ongoing contracting of specialist service providers.

b) Installation and commissioning: Considerations like accessibility, special lifting and hoisting equipment, transportation etc need to be well-understood, as these bring about more cost, more maintenance, more administration, and more facilities. If we expect deterioration to start at the moment of start-up, we must have a clear understanding of the imminent maintenance requirements. In other words, commissioning the equipment without a formal, realistic maintenance strategy and the associated requirements is no longer a realistic option.

c) Operation: All the elements of the "total approach" come together during this stage in the asset lifecycle. The key questions here are:

    - Are we performing all maintenance tasks in a quality manner?
    - Are skill levels appropriate?
    - Are replacement parts available just in time?
    - Do our artisans have access to the required technical knowledge?
    - Are we continually learning, and using this knowledge to improve the maintenance strategies?
    - Do all of the above contribute to the expected / desired levels of availability and reliability, with a high level of predictability of cost?
    - Are we preserving the integrity and value of the asset base, thereby looking after the capital invested by the investors?

    The next chapter is devoted to this topic.

d) Replacement, disposal: The cycle starts anew, but we can be certain that technology has progressed substantially. The ever-shortening innovation cycles have a profound effect on skills required, training, engineering expertise and the availability of such expertise to artisans, possible outsourcing etc. Various technology directions therefore need to be reviewed.

The diagram below provides a Physical Asset Management view on the establishing and operating of a business.

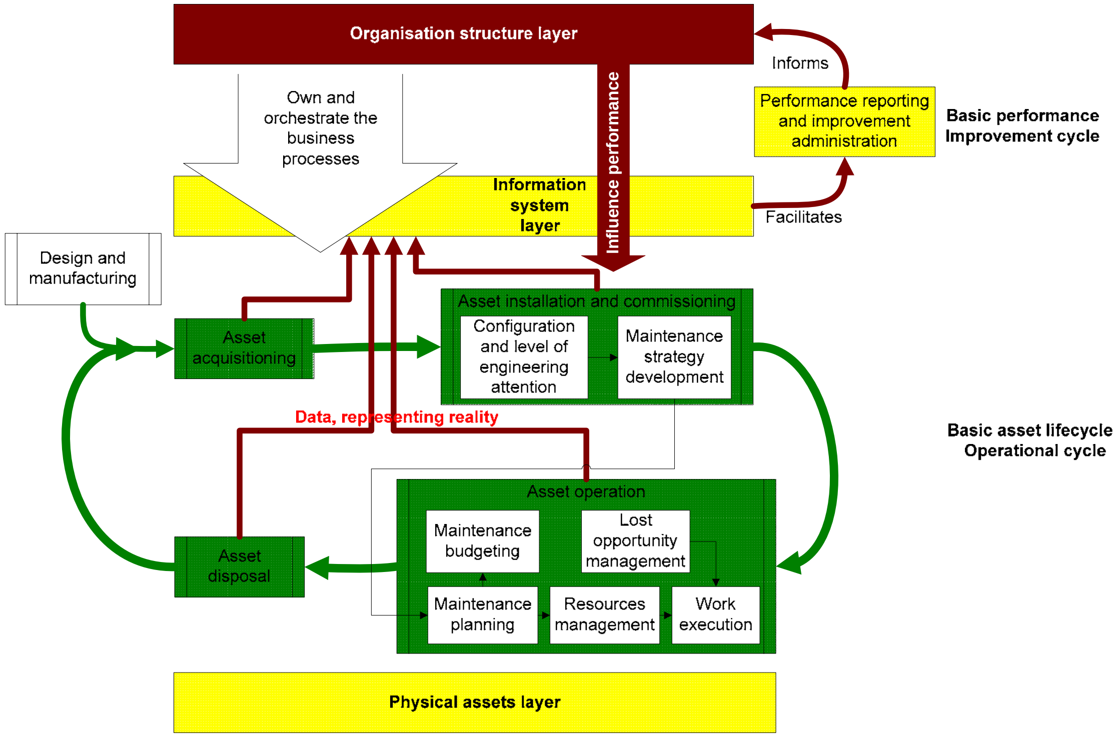

Diagram 2: Physical Asset Lifecycle Overview

4. SOME ELEMENTS OF A FUNCTION-CENTRIC STRATIFIED MODEL

If the previous paragraphs are considered with attention, it should be clear that the single overwhelming concept is that Physical Asset Management must be understood from the broader business perspective, and must at the same time be understood as discipline in its own right in order to manage it properly.

The model called "Intelligent Physical Asset Management" or i-PAM is used as superior reference. The scope of the course does not allow for a detailed discussion, so only a few selected areas will be reviewed.

1) Develop Physical Asset Breakdown Structure

The business of Physical Asset numbering is not quite as simple as it appears on the surface. In the light of the concepts of Reliability Centered Maintenance (RCM), the overwhelming idea is to have a very clear and specific understanding of the primary function, together with performance standards, which the Physical Asset is intended to perform. All such functions "roll up" to the level of a functional, profitable business. At the same time, such functions can be cascaded down to individual primary or support functions like "Supply dry air at a pressure of x KPa, without interruption, and with maximum pressure fluctuation of ±2%".

The key point is that we can only formulate and apply the most appropriate maintenance strategy, focused on the correct level in some kind of functional breakdown / hardware breakdown structure, if we have an exact understanding of the function that needs to be preserved.

This also means that we will not only attach a number to the locomotive – if an air compressor requires focused maintenance work, that compressor must be identifiable in some sort of way.

2) Manage documentation and configuration

The ever-increasing technical sophistication was mentioned earlier. This means that technical knowledge needs to be ordered, and organized such that it can be offered readily and in suitable format to artisans, engineers and reliability personnel. This function is therefore closely related to the previous function of structuring and numbering.

The must fundamental requirement is that what we have, is exactly what we ordered, and is exactly what our documentation says. The detrimental effect of technical knowledge which is not managed with absolute punctuality, and is freely available to maintenance staff, cannot be over-stressed.

3) Develop maintenance strategy

Once a suitable level of maintenance focus has been determined, the specific object installed to perform the intended function is investigated. The technique of RCM is often blamed as being labour-intensive, but the counter-argument is simply that a proper investigation of this nature, done in a disciplined and structured manner, is a good investment. Compare the alternative, where the knowledge accumulated during the RCM study is only gained over time, upon failure, with the additional loss of production or service delivery time. Another interesting figure which is often quoted, but possibly needs verification in the South African situation, is that the total cost of corrective (firefighting) maintenance is around four times the total cost of applying a sound, appropriate maintenance strategy.

Maintenance strategy development is in short the structured assembly of experience and knowledge, and involves the following steps:

- Identify the primary and secondary functions, together with performance standards. Consider the loss of these functions from a production / service, people safety and environmental damage perspective.

- Prioritise the functions.

- For each function, identify the possible failure modes (mechanisms of failure). Consider the failure modes from a visibility / detectability perspective.

- Rank the failure modes by decreasing probability.

- For each failure mode, identify the possible root causes.

- Rank the root causes by decreasing probability.

- For each root cause, identify appropriate preventive actions. If such actions will not eliminate the root cause altogether, also identify the appropriate corrective actions.

- The result of the exercise is a mixture of preventive, detective, corrective and adaptive tasks, which are now optimized according to frequency and content.

4) Plan maintenance work

   For purposes of maintenance management, planning is taking place at three levels.

   - Task planning: The output of the strategy development process is packaged as “standard tasks”, optimized in terms of contents and resource requirements.

   - Medium- to long-term planning: The maintenance tasks are projected into the future, at the hand of the allocated frequencies or expected rates of occurrence. Because the tasks are individually planned, and the resource requirements are known, an accurate forecast of labour, material, tools, workshop facilities, outwork etc can be made.

   - Workshop planning: The compelling need to cut cost means that no skill hours are redundant – on the contrary, we mostly have more work in hand than can be done by the available staff. It is therefore critical from a production / service delivery perspective to allocate work to staff and machining workstations in a sequence that will maximize equipment availability. The well-known and often misused technique of work prioritization plays a major role here.

5. MAKING IT WORK

The pre-requisites for successful locomotive maintenance are the following:

a) A sound technical understanding. Refer the section on breakdown structure development.

b) Identification of all the maintenance-significant items.

c) The existence of a solid, documented maintenance strategy.

d) Well-structured maintenance tasks, resulting demonstrably from the maintenance strategy

e) A comprehensive model of the business, presented as a model consisting of the elemental system components. A logic diagram works best, with all the element inter-dependencies shown.

f) Allocation of responsibility and accountability to each and every system element.

g) Cross-referencing of each system element to the relevant software system screen or transaction.

h) Each cross-referenced screen or transaction to be fully described at data level, for example what and how goes into every field.

i) The above to be well-organised, friendly in appearance, and in the language of the train driver and artisans.

j) Training, re-training, and then some more training in the above. Curricula to be assembled by role.

6. REFERENCES

1. None.