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OPTIMUM MAINTENANCE USING KNOWLEDGE FROM A COMPLETE PRODUCT POPULATION

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ABSTRACT

Company's today aim towards increased performance and effectiveness in order to stay competitive. Being a part of such development programs, the maintenance function tries to be more precise in their doings and more cost-efficient in order to increase their value contribution. However, as a company only is one of many customers to the various suppliers of systems, machines and equipment being used, the maintenance function will remain a sub optimized small part of the various product populations. The lack of information and knowledge from the complete product populations hampers development and makes all efforts to optimize maintenance in individual company organizations more or less meaningless. The key to improvement is the ongoing experience and the knowledge developed from use of a whole product population.

This paper describes how maintenance functions must develop using the knowledge acquired from an as complete product population as possible. The development achievable is described and exemplified and key actors are defined together with estimates of the economic potential that could be realized.

KEYWORDS: Maintenance principles, maintenance prerequisites, maintenance optimization, maintenance development, supplier-user development, government steering, maintenance requirements.

1 INTRODUCTION

Maintenance is a targeted activity area in industry today. As a profession, maintenance secure that infrastructures, plants, systems, and components, can be used for their purpose during the course of their life-length by upholding asset properties such as functions and performance. As such, maintenance is an important contributor to sustainability and business economy.

Modern equipment with better quality tend to decrease the number of faults and errors and times between failures increases. The knowledge acquired around a previous failure fade away. Hence, the relatively small amount of events that occur inside company walls hampers productivity development and the in-house resources can never compete with external specialists. Modern equipment requires deep knowledge difficult to obtain and retain over time.

It is clear that the major component affecting what activities needed to uphold functions and performance is knowledge. The knowledge chain is driven by a flow of information from product manufacturers and suppliers to end users but also from end users to product manufacturers or suppliers interested in life experience of their products.

Actors in this chain are the suppliers delivering their solutions to the end users and their ambitions - through requirements and specifications - to get what they need in their facilities. Hence several delivery-use chains could be involved in establishing and end user facility. The fundamental connection between supplier and user lie in the establishment phase in each connection of a delivery-use chain. Here, the supplier could not only deliver a valuable product with high reliability, long life, with correct functions and performance – but also connect to end users and the products life phase. There, valuable information could be obtained in order to improve existing or next generation products /1/.

From an end user perspective, the establishment phase define what product to buy – the physical one only or a product where a part of or a complete service package is included. Here, end users could get suppliers taking care of spare parts, maintenance and even be responsible for up time!

When a product is shipped to the end user, it should fully meet design requirements, be manufactured according to specifications, and be capable of satisfying customer needs throughout the service life of the product. The products ability to perform its intended functions - can be defined as quality over time or maintaining continuous customer satisfaction. Including necessary maintenance prerequisites is natural for a supplier caring about the market and customers there.

The importance of product quality and product reliability when customers start using a product has been known for a long time /2/. Ahmed distinguishes between on and off line methods. Off line means during product design and manufacturing and on line for measuring, monitoring and assessing product reliability that design engineers can act upon. He point out that the techniques available could be used to continuously monitor reliability performance of a total population of products in field use for product uplifts and engineering changes.

Closed loop approaches from supplier to user and then back to the supplier are today common practice in the semiconductor and telecommunication industry in order to monitor the product from the first second in use in order to increase field system MTBF. The approach has given companies lower warranty costs and early warning signals to take necessary corrective and preventive action to ensure product safety and effectiveness /3/. It is evident that the entire process of controlling and increasing reliability must be based upon knowledge about the end use of a product.

In the aviation industry, product manufacturers such as Rolls Royce (RR) have developed Total Care program where RR gets paid per flying hour (performance contracting). RR (the Original Equipment Manufacturer) assumes the cost of maintenance and support services and has to consider operating performance and any disruptive events which take the engine out of operation. This will cause the engine to cease generating income for the OEM. In the concept, the performance of the product and its functions are monitored in order to feedback deviations for corrective actions, but also to prevent such deviations to occur in other products in the product population.

However, outside these application areas – Telecom and Aviation - closed loop approaches are rare. It is, by intuition, and shown in Section 2, that the knowledge base around a specifice item – a system, machine, component etc – must be arranged so that it is as big as possible. This could be arranged bottom up in a company, through functional areas, through product grouping and finally in contact with the suppliers of a specific product or type of product:

- suppliers really caring about their products and their customers must interest themselves for what happen with their products when they are used
- suppliers must – as a minimum - use such information for their own product improvement
- suppliers must realize the information potential in their product populations
- suppliers offering maintenance services must – if they should be thrustworthy – arrange their knowledge development through feedback from all servcie contracts and use that as a point of departure for service improvements

The scheme should be established at least in purchasing situations, but could also be established as industry and government standards or requirements in tendering and purchasing situations.

This paper will show, by using examples from several application areas, the effects of using knowledge from as large product populations as possible for optimization and improvement of maintenance. The proposed approach will lead to savings and benefits both at company level, in the particular industry and in society. First, the principles for maintenance based on large product populations will be given.

2 PRINCIPLES FOR OPTIMUM MAINTENANCE BASED ON COMPLETE PRODUCT POPULATIONS

Let us assume that we have a company with n_i products of a certain type J thus creating a subset with information content I_k where k=1-m and m=total no of subsets.

$$I_k\ [J^{ni}]$$

Let us assume that there are totally N products of the type J constituting the total product population:

$$\sum_{i=1}^{m} ni = N$$

Let us assume that there exists several subsets in one or different companies of that particular product J. Then the knowledge and information from 2 or more subsets is greater than for a single subset:

$$I_k + I_{k+1} > I_k$$

The information content could be, e.g., incidents, events, and faults with data describing these. The benefits gained are obvious. They could be used to:

- increase precision of preventive measures
- lower resources needed
- by preventive measures hinder faults and disturbances
- obtain more data for quantitative analysis
- improve risk analysis
- lower expenditures and higher asset utilization and performance

3 APPLICATION AREAS

3.1 Asset management in company structures

Today, maintenance functions often are divided into an asset manager and one or several service provider(s). The asset manager function may also be found in government bodies responsible for, e.g., infrastructures. For the asset manager it is important to obtain maximum asset performance at the lowest possible expenditure level given that requirements and company goals are fulfilled.

In order to implement maintenance based on a maximum product population, people should work with the entire product population base in the company. Doing that, they will develop maximum possible experience and knowledge about the particular subject area.

Not using the internal knowledge base obtainable will lead to difficulties in recruiting and keeping competent enough resources since the internal development possible is not being allowed for.

An arrangement should cover the asset manager side since they have the power to rearrange the whole maintenance function in a company. For the service provider, resources tend to be local, but through modern cooperation techniques knowledge sharing is simple and easy.

3.2 Suppliers of systems, machines and components

Not all vendors/suppliers deliver services along with their products. Today, they must at least in tender and purchasing phases deliver initial requirements on service and preventive measures along with documentation about their product(s) and spare parts necessary. The company buying their product(s) needs to establish a maintenance regime throughout the intended usage period and life-time of the product(s).

Vendors not having any intention to deliver service or interest themselves for knowledge from use of their products will, as long as users do not require that feature, survive on the market. Hopefully, enlightened users could cooperate in order to obtain the same position in knowledge without “disturbing” the vendor. This could of course be arranged in a voluntary manner, be required by industry bodies representing a certain type of companies or be required by government bodies.

3.3 Suppliers offering maintenance services along with their products

Today, many companies do deliver services along with their product. In such cases they should be required to base their service proposal and their actual doings upon the knowledge from the whole product population – or at a minimum a larger population than the one at a specific customers site. By doing so, they could improve their own product development, but most important, deliver a service level that no single user of their product could obtain. On the market today there are many contracted services that do not possess this elementary feature. How and why these contracts exist could only be motivated by a non-existing own capability to raise such requirements or perform maintenance.

3.4 Maintenance service suppliers competing for contracts

Exactly the same principle applies for the service provider trying to compete for a service contract. Without the additional advantage obtained from ongoing contract work at other customers sites, where the resources develop competence around product populations of the same type, it should be impossible to arrange a better maintenance environment than what is already in place.

So, the main criteria in a tender process should be to evaluate how knowledge development is organized and taken care of. How it is fit to different product population volumes and what knowledge advantage could be offered?.

Of course, volumes already in the service providers care could fit more or less to those present in the specific company trying to implement a service agreement.

3.5 Maintenance of infrastructures

There are many systems that is used in order to serve society: electricity, telecommunication, railway, roads etc.

Government bodies have the ultimate responsibility to arrange the business environment in an optimal way and by law or by raising requirements, in contracts and with agreements, reach the best solution possible.

An example would be a split up of an infrastructure without requirements on maximum possible operational efficiency. Since customers could not change infrastructure, they use it, the business arrangements must comprise requirements on cooperation in order to gain maximum benefits for society. It must be considered a duty for society to have, e.g., as few disturbances in electricity supply as possible.

If government bodies do not require optimal prerequisites, as is the case with maintenance based on a maximum product population, they will diminish possibilities for that market to develop and include many actors. In the long run, small actors will die (or the will be acquired) and only large will remain.

<u>Electricity Networks</u>

The simplest and most obvious case is asset management of electricity networks. These networks are perhaps the most important infrastructure of modern society. The market is considered a monopoly and today regulators stipulate requirements on, and boundaries for, the companies’ active in that market, se Figure 1.

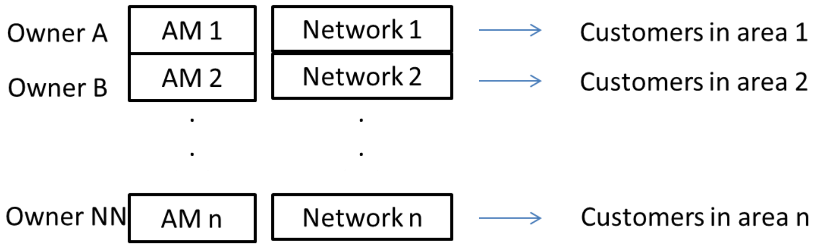

Figure 1 – The electricity network market (AM-Asset Manager)

It is self-evident from the picture, that each company could develop optimal arrangements in maintenance with respect of knowledge gained from their own product population numbers. As such, the large companies have a big advantage over the small ones. Hence, it is amazing why the smaller ones have not developed better prerequisites through cooperation, or, why the industrial body for electricity companies has not done the same.

Since market actors say that "they are in a competitive market" and obviously they are not, they obstruct development beneficiary not only for them but more important, for society. The market is "stiff" since customers could not switch to another distribution company unless they physically move from one place to another.

Official government bodies should at least, since many of them say they are doing everything to promote a well-developed market, require that all companies cooperate in order to utilize benefits from the maximal information content, i.e., deliver maximum operational efficiency in terms of minimum number of disturbances and length of disturbances. This is especially important for the small and medium sized companies.

In Sweden, the industrial body launched a database for disturbance reporting. However, not all companies contribute and many deliver incomplete data. Since the Swedish regulator body requires a performed risk analysis from each network company, there is a need for drastic improvements if the line of business should be trustworthy in the eyes of the society. That includes the regulator, which need to arrange the regulatory regime so that society can benefit from lowest tariffs possible but still allow for high enough profits.

Railway

Here, the railway network is the infrastructure that in many countries still is in the hand of a national government body. On that infrastructure, different commercial companies are allowed to run traffic. The quality and status of the railway infrastructure is directly dependent on how well these commercial companies perform their maintenance. Hence, it is clear that the government body responsible for the tendering process must require that winning companies have and do perform train and wagon maintenance. In order to benefit society optimally they also should require cooperation in between companies and from large actors already having traffic contracts in creating knowledge around different types of product populations. Not doing so, they will create an unbalance between different commercial actors. A small actor is by definition not capable of getting the same advantages as a larger actor, i.e., an actor having other commercial traffic contracts in one or several countries.

Electricity generation

Even in electricity generation, there are examples of counterproductive activities. On this market, the business actors say "that they cannot cooperate" mainly because they "will get attention from competition authorities". Here, society's interest should come first! Government authorities could, by law and through regulatory bodies, require a development that is sound and in a correct direction. This includes cooperation in order to get maximum possible product population knowledge in order to get safe dams and power station infrastructure/buildings, get safe electricity generation e.g. in NPPs, get risk analysis results based on best prerequisites possible and maximize availability and reliability in electricity supply.

4 IMPLEMENTATION ISSUES

A key element in developing better and more reliable products as well as the maintenance function itself is knowledge. The connection between end users striving against value for their investments and the supplier's ambition of developing products with high end user value could be used to gain momentum.

Based on the user perspective it is clear that real value does not appear until the user is able to use the product bought and enjoy the benefits from a (well enough) functioning product throughout its lifetime. By increasing suppliers value proposals, market analysts and market developers try to get companies interested to develop their activities from the traditional product design, manufacture, deliver scheme to activities closer to the end-user, so the push is really existing from the suppliers side /4,5,6,7/.

In order to be able to implement a closed loop product life cycle system, a key element is acquiring the information from the product in the field. Many product suppliers introduce such schemes today. In research, projects are on-going such as the IMS-project in USA and the Promise project in Europe /8,9/.

By using smart embedded systems a seamless e-transformation enable product lifecycle information to be transferred to knowledge. In the Promise project , application scenarios include products early, middle and end of life product lifecycles. By introducing such means, manufacturers and suppliers of those products could improve product and service quality, efficiency and sustainability.

5 CONCLUSIONS

Obtaining maximum possible benefits from the largest product population possible is sometimes only a decision. In other cases some work must be added. This paper has described the basic principles of optimum maintenance based on complete product populations. By using examples from several application areas, the effects of using knowledge from as large product populations as possible for optimization and improvement of maintenance have been demonstrated. The proposed approach will lead to savings and benefits both at company level, in the particular industry and in society. Without a larger knowledge base than the one that could be obtained in s single company, most maintenance functions will have severe difficulties to develop and reach good enough efficiency. In the same way, a large company must use the internal product population present to reach the same effects.

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