# Requirements and Needs – A foundation for reducing maintenance-related waste

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**Abstract** The objective of this paper is to discuss and elaborate on requirements of maintenance and the resulting maintenance needs in order to maintain said requirements without introducing waste while doing so, taking into account both external and internal wastes. The paper will present, and elaborate on, conceptual models that can be utilized in maintenance operations in order to increase awareness of the importance of well-founded customer/stakeholder requirements in order to articulate appropriate maintenance needs in order to balance effectiveness and efficiency as well as to reduce or eliminate maintenance-related waste.

## 1 Introduction

In automotive manufacturing industry there is a large focus on waste elimination within production systems, especially through efforts to implement Toyota-inspired lean production systems. However, these efforts tend to focus on the more obvious waste that directly influences the actual production. This often leads to maintenance performance goals striving toward maximization of equipment availability without consideration to maintenance cost or the associated waste it can create.

Industrial maintenance is a substantial financial post that cannot be neglected. The total value of maintenance budgets in Europe has been estimated to be about 1,500 billion € per year (Altmannshoffer[3], 2006 in Parida, 2006). The total cost for maintenance in Swedish industry, including direct and indirect cost of maintenance as well as non-realized revenue due to poor availability, was, in 2002, estimated to 6.2% of the industry's turnover; in effect, close to 20 billion € per year (Ahlmann, 2002). Though, as early as in the 1990´s it was estimated that one-third

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of the maintenance cost was unnecessary (Wireman, 1990). The unnecessary cost was made up by: bad planning, overtime costs, poor usage of work order system, and limited or misuse of preventive maintenance (Wireman, 1990). Additional unnecessary cost may be found in: excessive/unscheduled maintenance, unplanned or unscheduled work, excessive and/or unnecessary activities, poor spare parts management, obsolete technology, poor quality work, poor quality spare parts, and equipment unavailability (Mohanty and Deshmukh, 1999). These factors are just some of the waste that constitutes maintenance-related waste. There are others. A study by Kinnander and Almström in 2008 highlights that within Swedish automotive industries, only 39% of the companies measured and documented causes of downtime, only 14% of the companies followed-up and took actions on short stops, and 14% of the companies did not perform any preventive maintenance. The above indicates that there exists an untapped potential for automotive manufacturing companies in starting to work systematically in reducing maintenance-related waste. Also, as previous research shows, if strategically managed; the maintenance of manufacturing equipment can contribute to the competitiveness of a company (Salonen, 2008).

Maintenance-related waste stems both externally and internally from a maintenance organization. Externally, maintenance-related waste can be found in, for example, insufficient/inappropriate, or even a total lack of, goal setting. For instance, a common requirement that customers/stakeholders demand is to maximize equipment availability without reflecting what availability levels is good enough. Setting a goal too high can render waste since more resources than are needed most likely will be used in order to realize the goal. Internally, maintenance-related waste can be found in, for example, excessive or poorly executed maintenance activities. For instance, in a lean production context it is common for a maintenance organization to implement preventive maintenance, autonomous maintenance, and condition based maintenance. If alignment of the various activities is not performed, companies can end up with different actors performing the same maintenance activities in excessively tight intervals without coordination with over-maintaining as a result. That is, tying-up possible value-adding hours in machine objects for unnecessary maintenance activities, i.e., both external and internal waste has been created, see Figure 1.

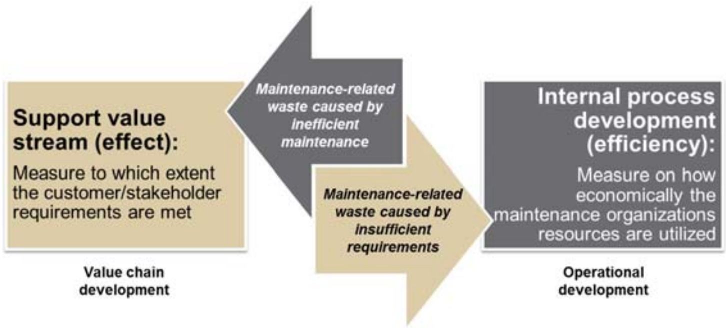


*Figure 1 Conceptual model of maintenance effectiveness (effect) and efficiency and how maintenance-related waste is created.*

# 2 Problem Background

Truly good maintenance cannot be achieved until both effectiveness and efficiency is taken into consideration. Neely et al. (1995) state that: "Effectiveness refers to the extent to which customer requirements are met, while efficiency is a measure of how economically the firm's resources are utilized when providing a given level of customer satisfaction" (p.80). As so, maintenance effectiveness can be explained as how well a maintenance organization meet its goals or needs, while maintenance efficiency can be explained as acting or producing with a minimum of waste, expense, or unnecessary effort. Effectiveness is related to indirect maintenance cost while efficiency is related to direct maintenance cost (Márquez et al, 2009). Previous research (Salonen & Bengtsson, 2011) indicates that companies struggle in analyzing the indirect maintenance costs and therefore focuses on the direct maintenance costs. Therefore, it is common that maintenance organizations are assessed on their effectiveness, for instance equipment availability, while only taking into consideration the direct maintenance cost, apples and oranges are thus being compared. What should be assessed is instead maintenance effectiveness in consideration to indirect maintenance cost, and maintenance efficiency in consideration to direct maintenance cost. This confusion has in many cases led to cost cutting in maintenance organizations with intent to reduce internal waste but instead, in the long run, end-ups in strongly affecting external waste with increased indirect maintenance costs as a result.

Effective maintenance is thus about delivering the objective of maintenance, often derived as to ensure system function of the production system and to provide the parameters of cost, reliability, maintainability, and productivity (Simeu-Abazi and Sassine, 2001). Coetzee (2004) shares this view on the maintenance objective, stating that: "It is the task of the maintenance function to support the production process with adequate levels of availability, reliability and operability at an acceptable cost" (p.24). The word *"adequate"* is of great importance in the quote since it indirectly specifies that support of the production process being either too high or too low is wasteful.

Surprisingly, efficiency is stressed as not being as important as effectiveness, as in Márquez et al. (2009) stating: "In this part of the process [strategy implementation], we deal with the efficiency of our management, which should be less important [than effectiveness]." (p.168), or do not stress the importance of efficiency at all, as in Pun et al. (2002) stating: "Effectiveness-centred maintenance (ECM) stresses "doing the right things" instead of "doing the things right" (p.346). However, total effective maintenance cannot be achieved before both perspectives, effectiveness and efficiency, are taken into consideration, see Figure 2.

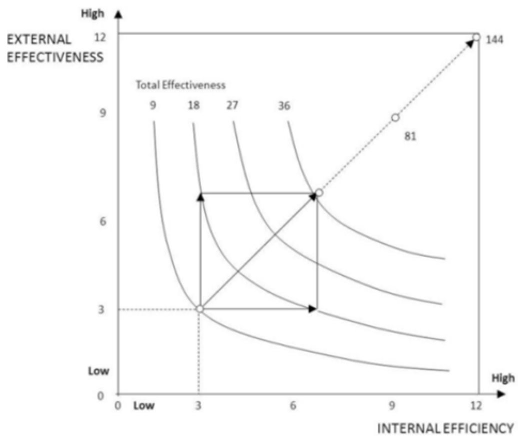


*Figure 2 As a first step, an organization can double total effectiveness by either by increasing effectiveness or efficiency. However, when working to increase total effectiveness from there, working with both effectiveness and efficiency is required (Ahlmann, 2002).*

# 3 Conceptual Model

In order to work towards total effectiveness in a maintenance process it is thus important to balance effectiveness (effect) with efficiency. The starting point of this task, or the foundation if you will, is to investigate the true requirements of the value stream (customer/stakeholder) and from there develop the true maintenance needs. If one does not start from the true requirements of the value stream, or work with this issue haphazardly, there is a risk in that the customer/stakeholder focuses their requirements on the wrong foundation, resulting in *"nice to have"* instead of *"need to have"* requirements or as Coetzee (2004) states *"adequate levels"*. That is to say, if not being perceptive and realistic, the customer/stakeholder sometimes focuses on what is nice to have without taking into account cost, direct and indirect maintenance cost included. It is nice to have, for example: 100% machine availability, zero breakdowns, 85% OEE, etc. – *"therefore it is wished for"*.

Similarly it is necessary for a maintenance process to truly focus the maintenance need and resources to the "need to have" requirements in order not to focus on maintenance possibilities. That is to say that maintenance, being problem solvers by nature as well as having a fondness to technology and technological possibilities, sometimes focuses on what is possible to do without reflection on what is needed to do and without taking into account cost, direct and indirect maintenance cost included. We can, for example: use vibration monitoring on all rotating parts, perform predetermined maintenance six times per year, purchase additional spare parts, etc. – *"therefore we do it"*.

Thus, what is needed is hard work to find and articulate true requirements on maintenance from a value stream perspective. These, most certainly, need to be differentiated and dynamic within an industrial site and over time. One flat rate requirement for a complete industrial site will not suffice. Or as, for instance, Levery (1998) states: "Why is it that organisations over-simplify maintenance requirements to fit in with organisational goals rather than base it on the *needs* of the assets?" (p.35). Further, Levery (1998) means that requirements continuously change due to wear and tear and various changes in technology developments, product quality, and other related topics. From these, the true requirements of the value stream, maintenance can design a maintenance process with "need to do"-activities and from there build an organization and specify the true need of resources in order to be cost-effective, see Figure 3.

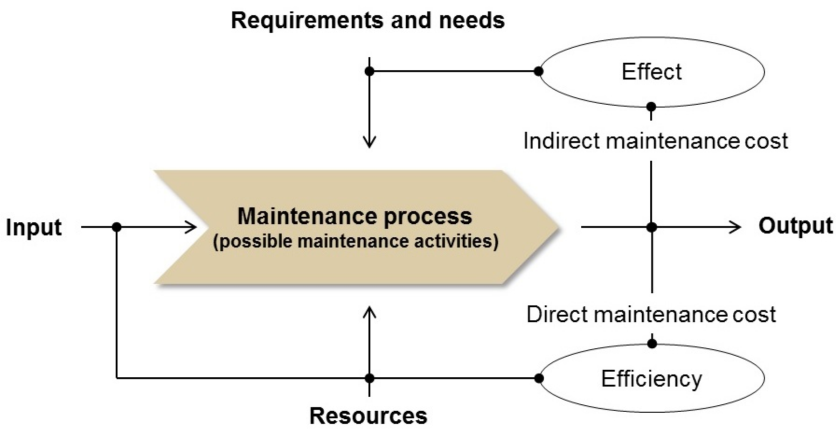


*Figure 3 Conceptual model of a maintenance process. Input may vary from industry to industry but could be made up of, e.g., production volumes, quality levels, etc. The requirements need to be based on the input in order to be on a "need to have"-level. The maintenance process and which activities to fill the process with should be based on the requirements and maintenance needs and the resources should be based on the "need to do"-activities. The economical measure of resource efficiency is connected to direct maintenance cost and the economical measure of effectiveness (effect) is connected to indirect maintenance cost. The model is adapted from O´Donnell and Duffy, (2002).*

## 3.1 Trade-offs in maintenance

One aspect of efficiency and in having a cost-effective organization is to be aware of various trade-offs that exist in maintenance activities. For instance, *good maintenance* has been defined as when:”...seeing very few corrective maintenance events; while performing as little preventive maintenance as possible.” (Cooke & Paulsen, 1997, p.136). With this view one can clearly see that there exist trade-offs in maintenance operations. There is always an optimum level to strive for. As in the example quote above, too much preventive maintenance would possibly imply too high direct maintenance cost as well as losses in machines due to too much planned maintenance. Too much corrective maintenance on the other hand would possibly imply too high indirect maintenance cost as unplanned maintenance increases production losses (not even mentioning safety and environmental losses). There is though, clearly, large variations from industrial context to context regarding this view on corrective and preventive maintenance, particularly concerning safety and environment. There is, of course, a big difference in comparing, e.g., the aerospace or nuclear industry with automotive manufacturing industry. And this is the gist of it, requirements and trade-offs need to be industrial contextualized as well as differentiated and dynamic within that specific context. General statements such as 80/20% preventive maintenance/corrective maintenance can be totally misleading in both examples above. In a nuclear industry, context 20% corrective maintenance can be detrimental to humans and environment while 80% preventive maintenance, in some automotive manufacturing contexts, can be totally out of proportion and cost (direct maintenance cost, efficiency) much more than it generates (indirect maintenance cost, effect).

See further, below, some examples of other trade-offs in maintenance that need to be taken into considerations with the perspective of effect and efficiency:

- predetermined maintenance vs condition based maintenance,
- operations based preventive maintenance vs calendar based (scheduled) preventive maintenance,
- spare part storage cost vs cost of waiting time for shipping of spare parts vs cost for increased buffer sizes vs cost of redundancy of machines
- focus on decreasing repair time (quick fixes of breakdowns) vs focus on root-cause analysis (could imply increasing repair times while increasing time between failure),
- autonomous maintenance vs professional maintenance,
- internal competence vs purchasing external service specialists,
- internal training and competence development vs external training and competence development, etc.

This list is by all means neither final nor written in stone and some bullets might not even be in question in some industrial contexts. However, it can serve as examples of various trade-offs that need to be taken into consideration in order to find the most beneficial solutions and activities in an organization without unnecessarily doubling up on efforts.

## 4 Discussion

In recent years, reliability and maintenance have been recognized as being of critical importance to the success and long-term future of an organization (Fraser et al. 2015). However, maintenance, in most industries, is highly costly. Certainly, much of the cost is spent to achieve competitive production; however, still, much of the maintenance activities and its related cost are pure waste. One viewpoint that can be used in working to reduce or eliminate maintenance-related waste consists of viewing maintenance with the perspectives of effectiveness and efficiency. This paper advocates the necessity to work with both perspectives in order to realize total effectiveness in maintenance and that the start of such work is in setting up well-founded customer/stakeholder requirements that are dynamic and based on the true need of the assets, in both a short- and long-term perspective, and from there work on realizing these as resource-efficient as possible.

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