



Cyber Physical System based Proactive Collaborative Maintenance

D1.2 Consolidated State-of-the-Art of Sensor-based Proactive Maintenance Appendix 20: Economic evaluation of the current business models of each value chain

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Abstract

This report describes the existing business models between different value chains involved in maintenance process and assess the economic impact of these different models. Equipment manufacturers have increased their maintenance services for companies in recent years. They are now not only manufacturing and selling machines, but also offering long-term maintenance contracts, which are signed at the same time when machines are sold. In some cases, equipment manufacturers are not selling machines, but for example produced tons. Equipment life-cycle management has gained more and more attention in recent years. Manufacturing companies have outsourced their maintenance activities and focused in their core business and at the same time equipment manufacturers have increased their after-sales and maintenance services. In many equipment manufacturing companies the overall revenue consists of 60% of manufacturing and 40% of selling life-cycle services.

Development of maintenance business models have happened from internal maintenance towards outsources maintenance. In addition internal maintenance are moving from centralized model towards decentralized model. However, both of these changes are happening at the same time. Companies are outsourcing their internal maintenance activities and also moving remaining internal activities from centralized model to decentralized. Usually this means, that production companies are outsourcing equipment level maintenance activities to equipment manufacturers, low level maintenance tasks e.g. during the production shutdown to maintenance subcontractors and special maintenance activities to service providers like condition monitoring requiring special skills and equipment. In addition, some of the remaining internal activities are moved from centralized maintenance organization under the production organisations e.g. low level maintenance and condition monitoring. Still, not all activities are outsources and moved from centralized maintenance organisations to operators. Some of the activities are seen beneficial to keep in own internal maintenance organisation. Even if the whole internal maintenance actions are outsources, some of the maintenance activities are kept under the production organisation.

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1 Introduction

Maintenance as a service business

Equipment manufacturers have increased their maintenance services for e.g. mining companies in recent years. They are now not only manufacturing and selling machines, but also offering long-term maintenance contracts, which are signed at the same time when machines are sold. In some cases, equipment manufacturers are not selling machines, but for example produced tons. New business models increase equipment manufacturers' responsibility (and risk) for maintenance activities. [1]

Equipment life-cycle management has gained more and more attention in recent years. Manufacturing companies have outsourced their maintenance activities and focused in their core business and at the same time equipment manufacturers have increased their after-sales and maintenance services. This kind of change in business models results longer life-cycles e.g. for mining equipment and this progress needs to be supported. Maintenance contracts, after-sales and life-time care services are growing business for many companies producing machines for the mining industry. If maintenance operations are outsourced, mining company can focus on its main business and win-win situations can be found. [1]

Integration of condition monitoring and process operation brings additional challenges, but also new possibilities for maintenance services. [1] Maintenance development is shown in figure 1.

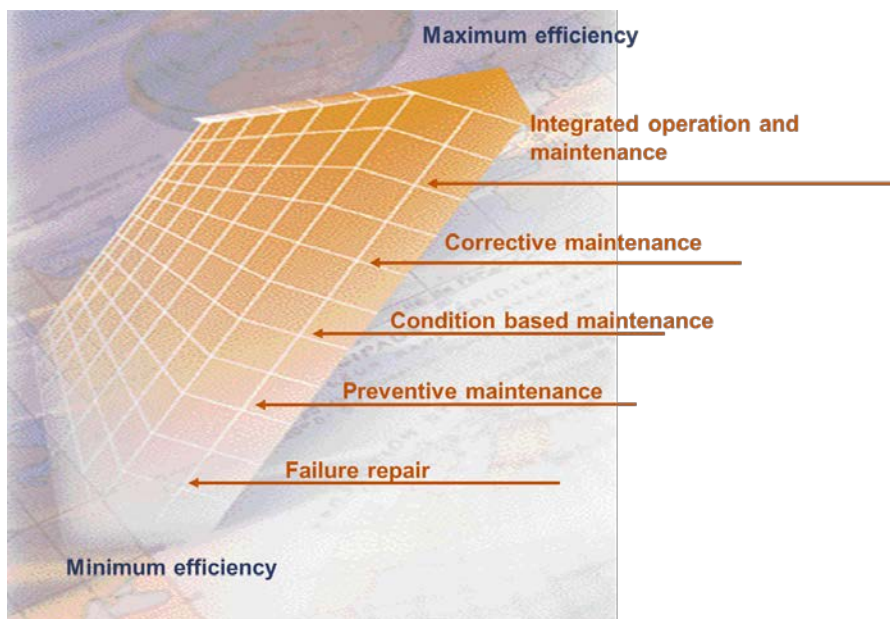


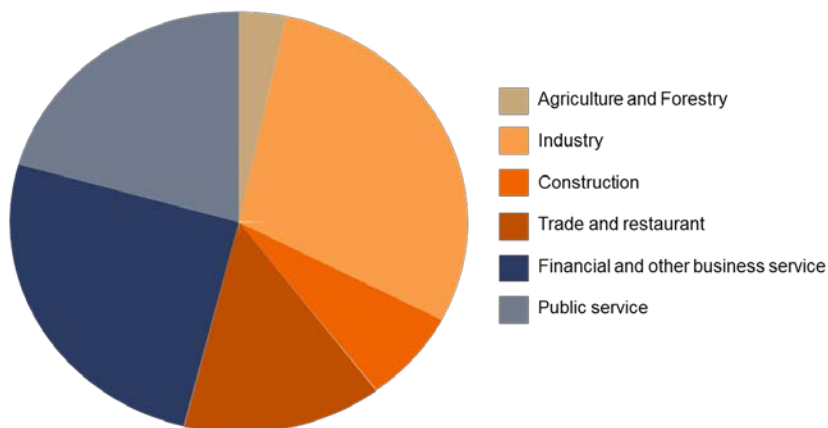
Figure 1 Maintenance development [2]

2 Maintenance statistic numbers

These section figures have been extracted from the Finnish Maintenance Society Promaint's proposal (2007) [2] and the book "Maintenance - management of production assets. Available figures are a little bit out of date. However, experts believe that the figures are relatively representative, because there have been no significant changes in the industry. [3] Even though these figures are from Finland, it is believed that this kind of figures are found also from other countries.

Maintenance share of the national economy

In year 2005 Finland's GDP 157,4 mrd. €



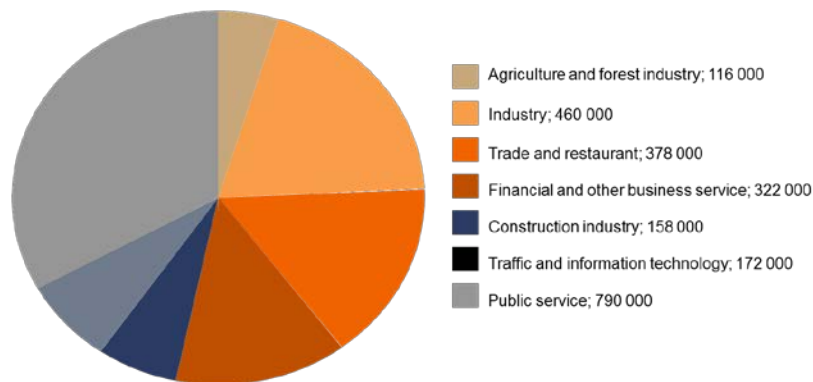
Source: Statistics Finland, Confederation of Finnish Industries (EK), VTT, Repair-, Maintenance and Improvement work in Finland 2000 – 2010

Figure 2 Maintenance share of the Finnish national economy in year 2005 [2]

The maintenance percentage of the replacement value of the industry is more than 3%, i.e. approximately 3.5 billion euros per year. On same grounds mentioned above, the proportion of total capital stock is approximately 15 billion euros. The share of Grand Domestic Product (GDP) labor measured is approximately 20 billion euros (figure 2). [2]

Labor and maintenance

Employed in Finland 2005 altogether 2,4 million people.



Source: Statistics Finland, Maintenance association Promaint

Figure 3 Employed in Finland 2005 altogether 2,4 million people. [2]

Labor and maintenance (figure 3), Employed in Finland 2005 altogether 2.4 million people. The role of work force in maintenance is (mentioned in table 1) 200 000 people i.e. over 8% of the employed. Maintenance is needed in all areas of the society. [2]

Maintenance is a very significant business and employer. Annually around 24 billion euros are invested in maintenance in the Finnish national economy [2]. In the public sector the investment is approximately 14 billion euros. The corresponding figure in the private sector is approximately 10 billion euros, of which the industrial part is about 3.5 billion euros. [3]

The total amount of the maintenance-related employment is estimated to be over 200 000 [2], [3], of which industry employs around a quarter (25%), i.e. 50 000 people. Of these, about 15 000 people work for the service provider, that means that about 35 000 people make their company own workload in maintenance. Other maintenance duties employ around 150 000 people. These other functions include road and rail networks, shipping routes, communications and electricity networks and ports etc. The total of industry employee maintainers accounts for about 11%. If the maintenance would be considered as a separate line of business, it would be the third-largest industry in Finland. [3]

Maintenance statistic numbers in Finland are shown in table 1. The statistic main source is collected from Confederation of Finnish Industries (EK), Statistics Finland, State budgets and Finnish Maintenance Society Promaint. [2]

Table 1 Maintenance statistic numbers in Finland [2]

Description	Figures
Maintenance in industry	ca. 3.5 billion €/a
Maintenance in national economy	ca. 24 billion €/a
Maintenance in public sector	ca. 14 billion €/a

Maintenance in private sector	ca. 10 billion €/a
All personnel working in maintenance, of which	200 000 employees
Working for maintenance service	15 000
Working for industrial service	35 000
Working for infrastructure	150 000

In table 2 are key figures from Finland's maintenance industry. The figures are based on VTT (Technical Research Centre of Finland) research, during 2003-2005.

Table 2 Key figures in maintenance industry during years 2003-2005 [2]

Description	Figures
Turnover of the production units average	167,5 M€
The purchase value of the unit average	297,9 M€
The average age of the machines	17,1 year
Operating rate	70,4 %
The lost production in the turnover because of maintenance	2,8 %
Maintenance costs of the replacement value	3,2 %
The percentage of maintenance subcontracts in all maintenance costs	39,5 %
Maintenance staff	19,8 %
Mean time to restoration	4 h
Overall Equipment Effectiveness, OEE	74,1 %
Availability	88,3 %
Planned maintenance	65,2 %

Figure 4 shows that the industrial maintenance costs are spread fairly equally into three sub region. The recent trend has been that the workload of the company has decreased and the share of services has increased. This trend is likely to continue partly due to the baby boomer generation leaving the labor market and companies are as a rule not replacing own workforce, but are buying manpower from outside. [3]

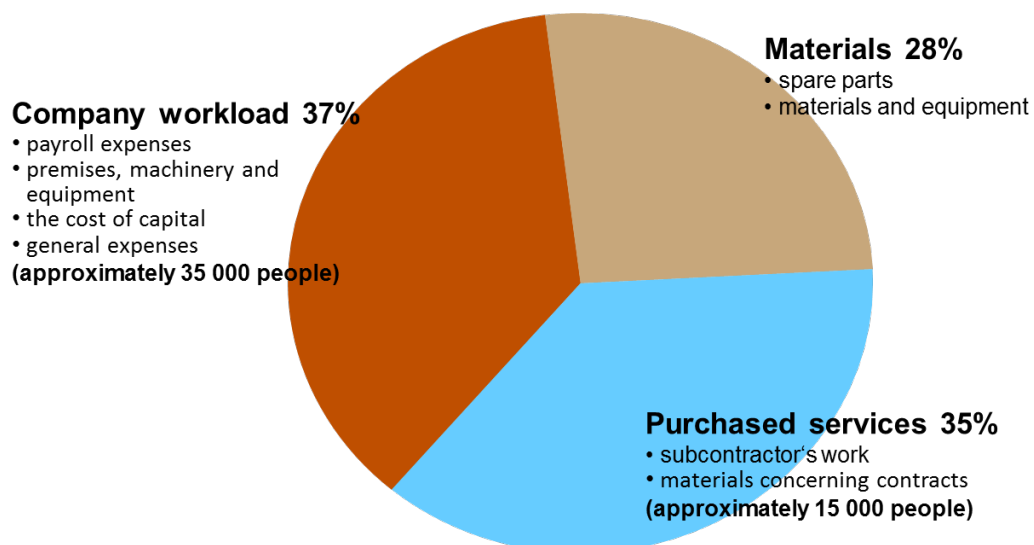


Figure 4 Distributed maintenance costs in Finnish industry. [2]

Figure 4 also shows the distribution of maintenance costs in industry. Investment in machinery maintenance is 3.5 billion euros per year. Materials, which consist of spare parts and materials and equipment, those percentage is 28 % of maintenance costs. Purchased services are 35 %, which consist of subcontractor's work and materials concerning contracts, employing approximately 15 000 people. In Finland in 2007 there was approximately 3 000 maintenance (sector) company. The part of company workload in maintenance is 37%, consisting payroll expenses, premises, machinery and equipment, the cost of capital and general expenses. [2]

Maintenance is a combination of all the technical and administrative actions, including supervisory actions and managerial actions during the life cycle of an item intended to keep it in, or restore it to a state in which it can perform the required function. [4], [5] Industrial maintenance is mainly concerned with production equipment. In Finland, maintenance costs are on average about 5.5% of company turnover. However, the ratio may vary from 0.5% to as much as 25% [6].

Industrial maintenance has two essential objectives; a high availability of production equipment and low maintenance costs. Many writers and standards suggest several other classifications what maintenance types are [6]. According to PSK Standardization in Finland, maintenance operations are divided into four main groups; preventive maintenance (condition monitoring, condition based actions, scheduled maintenance), failure repair, corrective maintenance, and other planned maintenance [5]. In figure 5 is showed role of different maintenance type Finnish industry [2]

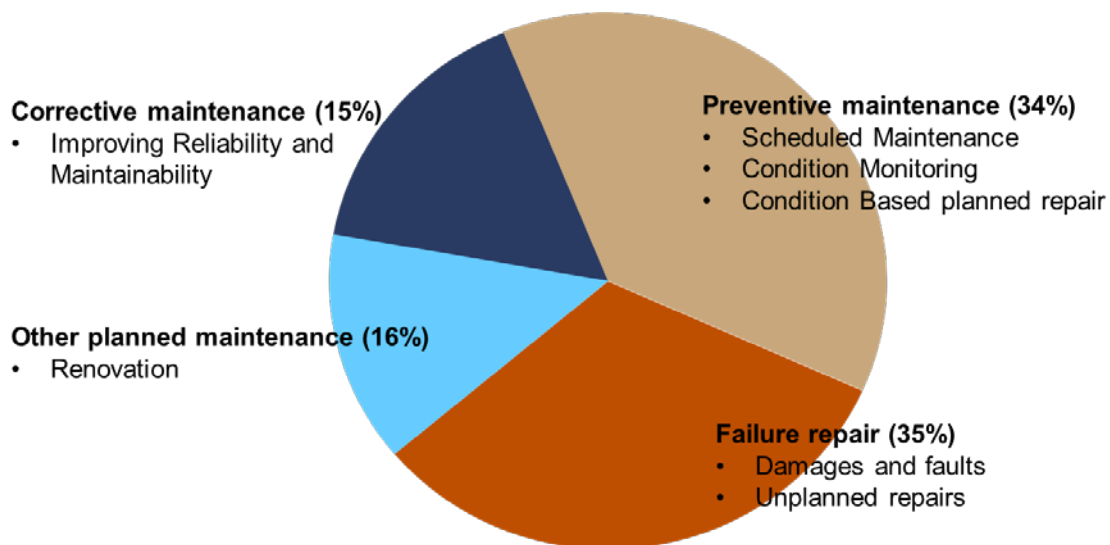


Figure 5 The role of maintenance in different areas of Finnish industry.

Quantitative Indicators of the Business Environment □ There is not a unique or precise source and there are not reliable statistics to estimate the real current value of the maintenance in the European market. The maintenance costs and related administrative and technological expenditures could be estimated in the range of few percentages of the internal gross production of European Countries. In any case it is important to consider maintenance as an investment rather than a cost. The role of a specific use of the standards can help to control the benefit of the costs. The individual use of the standards can enable to measure and evaluate the costs and the operational benefits. □ [7]

According to Imad Alsyof, maintenance is not a cost centre, but a profit generating function. Based on the case study made during 1997-2000 concerning a case study performed at a Swedish paper-mill. It showed that a paper-mill machine could generate extra profit of at least 7.8 million Swedish kronor (SEK) (approximately US\$ 0.975 million) per year if all unplanned stoppages and bad quality production are avoided due to maintenance-related causes i.e. 12.5% of its yearly maintenance budget. [8]

Because of globalisation (crossing boundaries) nowadays more efforts have been done to create internal and external partnership between maintenance and other elements in the supply chain. For example:

- helping in improving the production process
- helping the purchasing department in selecting the original equipment manufacturer (OEM)
- helping designing the production process
- using company wide information systems
- monitoring the deviations in both the machine condition and product quality [8].

Properly utilizing the maintenance function a company can potentially increase its production and revenue through higher levels of availability. This is important for those companies that are capacity constrained. Alternatively, by adopting a maintenance policy appropriate to its equipment, a company can reduce maintenance costs and production costs by reducing disruptions to the production process. Regardless of which financial ratios a company uses, the bottom line is an improvement in profitability. [9]

Imad Alsyof in paper "The role of maintenance in improving companies' productivity and profitability", illustrates how an effective maintenance policy could influence the productivity and profitability of a manufacturing process. Profitability is the result of interaction of controllable and uncontrollable factors. Among the uncontrollable factors are the economic and political environment, market growth or decline, inflation, etc. These uncontrollable factors could impose significant positive or negative impact on profitability. [8]

The strategy research has emphasized resources internal to the firm as the principal driver of firm profitability and strategic advantages. According to Alsyof, several studies showed that resources are specifically said to confer competitive advantages to the extent that the resources must be difficult to create, buy, substitute, or imitate. [8] For example in Finland, if 3,5 billion euros are used annually for maintenance its profit and additional value is estimated to be approximately 20 billion euros. [2]

"Proper maintenance of plant equipment can significantly reduce the overall operating cost, while boosting the productivity of the plant. Although many management personnel often view plant maintenance as an expense, a more positive approach in looking at it is to view maintenance works as a profit centre. The key to this approach lies in a new perspective of proactive maintenance approach. The definition of maintenance often stated maintenance as an activity carried out for any equipment to ensure its reliability to perform its functions. Maintenance to most people is any activity carried out on an asset in order to ensure that the asset continues to perform its intended functions, or to repair any equipment that has failed, or to keep the equipment running, or to restore to its favourable operating condition. Over the years, many new strategies has been implemented as a maintenance strategies which is intended to overcome the problems which is related to equipment breakdown." [10]

3 The current business models in maintenance

□ Maintenance services can be classified in several ways depending on the various aspects of the concept. For example, we can make a distinction between preventive maintenance (on condition or predetermined) and corrective maintenance (immediate or deferred). A useful way of classifying maintenance services in the context of service design is to consider different customer segments or the various options available to a company requiring maintenance (table 3). □ [11]

□ In addition to the option of having an in-house maintenance department, there are alternatives related to obtaining support from equipment manufacturers, outsourcing maintenance to one or more service providers, outsourcing maintenance to equipment manufacturers or outsourcing maintenance to equipment manufacturers and local service providers. Although equipment manufacturers prefer direct outsourcing to themselves or a dependent service provider, customers often benefit from using a local provider familiar with both the equipment and the local culture. Using independent service providers instead may cause problems in relation to product data management if the equipment manufacturer is unaware of the changes that have been made, which in turn may cause problems with spare parts, warranties or equipment modernization. □ [11]

Table 3 Types of maintenance service offerings by customer segments [11]

Type of maintenance service offering	Characteristics and elements
Basic	Price-focused No long-term contracts Spare parts and maintenance
Extended basic	Long-term service contract or an own maintenance department supported by the equipment manufacturer Technical support
Availability (full service)	RCM (reliability centered maintenance) Service contract Spare parts, maintenance, training, inspections
Performance partnering	OEE (overall equipment efficiency) □ focus Service contract Same as availability plus consulting
Value partnering	Focuses on customer □s business process instead of maintenance Service contract, long-term close relationship Adds business consulting to performance partnering

Below (figure 6) is a one example how the increase of operating rate will effect in the revenue of the company.

- Revenue is 145 M□/a and the operating rate is 70%
- Increase of operating rate up to 75% will increase the revenue 7,3 M□
- Increase of operating rate up to 90% will increase the revenue 29,2 M□

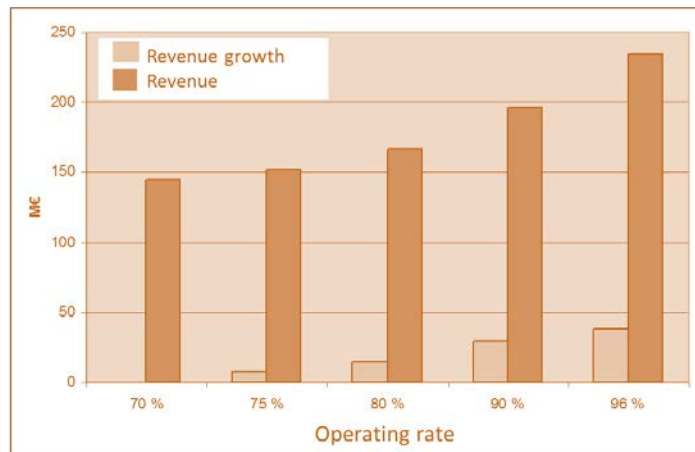


Figure 6 Importance of operating rate

Companies must be aware that in the maintenance network, customer, maintenance company and the equipment supplier experienced values consist of the value of various combinations of elements. Identification of each network partner's value of elements is important in order to make a mutually satisfactory solutions, for example maintenance contracts. To preserve the competitiveness of the network, it is also important that the value of the network can be shared between the parties fairly. [12] This model is win-win-win situation and the results are not seen immediately, but gradually.

In maintenance strategic decision-making, lifecycle computing is an important tool. Strategic changes, for example, focus on preventive maintenance, often require many years of monitoring before the results start to show. For this reason, in decision-making it is recommended to use the information throughout the life cycle of the device. [12]

3.1 Internal maintenance model

The main principle of internal maintenance is to organize company's maintenance of their own with internal stakeholders. Previously the use of outside labor wasn't appreciated the use of outside labor, it was a matter of honor to do the work on their own and keep the machines running and equipment in condition using their own resources. In modern times, manufacturing equipment and machines have become more complicated and their repair requires specialized knowledge and skills. This leads to a situation where it's not viable to rely on the internal maintenance but it is necessary in use external maintenance services. [13]

The Internal maintenance model in figure Figure 4 shows the percentage of company maintenance workload to be 37% and external maintenance to be 35%, so the ratio is assumed to be 50/50 from total maintenance workload.

Centralized maintenance model

Process and manufacturing companies traditionally use centralized maintenance model. In centralized maintenance model maintenance acts as its own separate centralized organization. These organizations are traditionally called manufacturing plant/factory service, maintenance unit, service unit, service

department etc. In centralized model organization has its own centralized functions like machine- and electricity-automation workshops. [13]

Almost all of the internal maintenance was hundred percent centralized, i.e. the operating staff did not do hardly any maintenance work. When we assumed that the internal maintenance and outsourced maintenance relationship has been previously mentioned fifty / fifty, from that internal maintenance is distributed so that two-thirds is the centralized and one third is decentralized maintenance.

Decentralized maintenance model

In decentralized maintenance model maintenance works in the sub-units and under of the authority of the production and immediate vicinity of the production equipment. Maintenance personnel are organized in accordance with production, and the persons responsible for maintenance are at the same time process operators or with closely with process operators and work directly under production authority. [13]

For example, in one of the biggest production companies in Finland maintenance functions were reorganized into new in 2011. Previously the centralized maintenance department was divided into the production department specific maintenance and factory services for the whole plant. Ongoing maintenance was divided into organizations subject to regional production managers and section managers in production that also included parts of the maintenance personnel. Service functions supporting maintenance operations remained in centralized maintenance/factory service. In connection with this change the role of the operating personnel during maintenance work was solidified and they are part of maintenance resources for example during downtime. Following this change the operating personnel learn to better maintain their PCs and their equipment (ownership). The main objective of this change was to use company workload as efficiently and flexibly as possible. [14] The use of described integrated operation and maintenance model is a growing trend in the industry.

Using maintenance services has dramatically increased over the past 20 years. As maintenance tasks of machines and equipment has not increased in similar manner, one can assume that production facilities have decreased their internal maintenance and increased their maintenance related outsourcing. [15]

3.2 Partially outsourced maintenance model

Outsourcing maintenance to a third-party specialist can be a cost-effective way to realize higher overall equipment efficiency and better process control. With limited internal resources, it's tough to transform machine maintenance from reactionary to preventive maintenance, and ultimately to proactive maintenance, despite the obvious upsides in higher overall equipment efficiency, better process control and lower total cost. Outsourcing this requirement to a third-party specialist, however, is a cost-effective alternative. Usually the outsourcing agreements provides interactive diagnostic help, preventive maintenance, field service, training, replacement and spare parts, productivity improvements, machine rebuilding, and even machine and system relocation and set-up. [16]

Below table 4 is listed some risks, which have recognized in the maintenance service business. [17]

Table 4 Risks concerning the maintenance service business in studied companies [17]

Client organisation	Both client and service provider	Manufacturing company & maintenance service provider
Risks related to purchase/acquisitions/outsourcing of the services:	Risks related to cooperation:	Risks related to moving towards service business:
loss of know-how	variances in the expectations	inadequacy of skilled staff
difficulties in problem solving	poor task definitions	lack of information or incorrect

		information from the client → wrong decisions, poor service
quality deviations	contractual risks	not enough maintenance know-how
unexpected production breaks	vague border lines of responsibility	wrong timing (clients are not ready for services)
safety and security risks	lack of information and accounting methods	risks related to acquisitions
lack of integrated services	poor/not enough communication	risks related to organizational and cultural changes→poor service culture
vague pricing	misunderstandings	wrong pricing basis
not clear how to influence maintainability with service	cultural differences	losing clients trust →image risks
circumstances and processes are not understood by the service provider	difficulties in managing the subcontractor network	choosing the wrong technology and e-tools
using several subcontractors in service providing upraises the price (contribution margins are multiplied)	other risks related to new service development	risks related to networking

For many manufacturing industries who would like to save on labour costs without sacrificing the efficiency of work done, outsourcing has become a viable alternative for running certain aspects of their business. [18].

Outsourcing strategy has been credited with helping to cut cost, reduced capital expenditure, greater flexibility, access to talent and skills, access to the latest technology, improve capacity, improve quality, increase profitability and productivity, improve financial performance, lower innovation costs and risks, and improve organizational competitiveness. On the other hand there are problems generated from outsourcing such as loss of core knowledge, increased cost, low morale, risk of exposing confidential information and hidden cost. [19]

Reasons for outsourcing

- The organization is able to access to exceptional expertise from the external resources which are not available internally. Internal resources are freed for other purposes.
- Organizations improves the company focus. Some people in the organization do not concentrate on their area of expertise. Through outsourcing they will be able to handle exactly what they were hired to do.
- Through outsourcing, organization is able to concentrate on its core activities giving the other organization to concentrate on theirs. This can the organization to improve its productivity.
- There is reduction and control of operating cost. The organization is able to maximize its restructuring benefit.
- The main reason for outsourcing is reduction of cost. When a firm is restructuring it needs to improve costs, quality, service, or speed, and non-core business functions may get pushed aside.
- The firm is able to reduce cost of staffing, training, health insurance, employment taxes and retirement plans. [19]

Outsourcing Low Level Maintenance

□ *Outsourcing low level maintenance describes the task of maintenance during e.g. a scheduled downtime. Factory workers perform their shift and focus on their tasks. When the shift ends a contractor can perform maintenance or improvements tasks. Outsourced services of maintenance are*

e.g.: installation service, design work, measurements, washes, conveyor services, dust removal, corrective maintenance, condition monitoring, preventive maintenance work, projects (construction), replacement of wear parts, pipe and tubing replacement work as well as special measurements. The advantages include, that the factory does not need to employ maintenance workers or their workers do not need to focus on maintenance. Furthermore a scheduled downtime can be used to perform maintenance, so that there is no loss of production time. A contractor who specializes in maintenance will be much more efficient and maintenance can be achieved at a lower cost. [13]

When we assumed that the outsourced maintenance relationship has been previously mentioned fifty, because for example about 650 maintenance partners working in scheduled downtime.

Outsourcing Equipment or System Maintenance

Outsourcing equipment or system maintenance is a logical step derived from the customer-supplier model. An equipment manufacturer sells machinery to a customer, usually including aftersales services. Those services may include installation and training. Additionally maintenance service may be offered, in form of e.g. remote monitoring services. [13]

Business model of the equipment manufacturer point of view could be such that revenue comes from e.g. 60 % equipment delivery and 40 % service delivery to the customers. E.g. life cycle services maximizes the value of the equipment and its maintenance investments. By service manufacturer often ensure spare parts and competence availability throughout the equipment lifetime. Life cycle service typically enable efficient product support and maintenance for improved reliability. It also add functionality to the initial product by upgrading or retrofitting and providing a smooth transition to new technology at the end of the product lifetime.

In life cycle services, manufacturer sell product or equipment first (it happens once) and offers services like equipment maintenance and condition monitoring. Services brings a stable income to equipment manufacturing company.

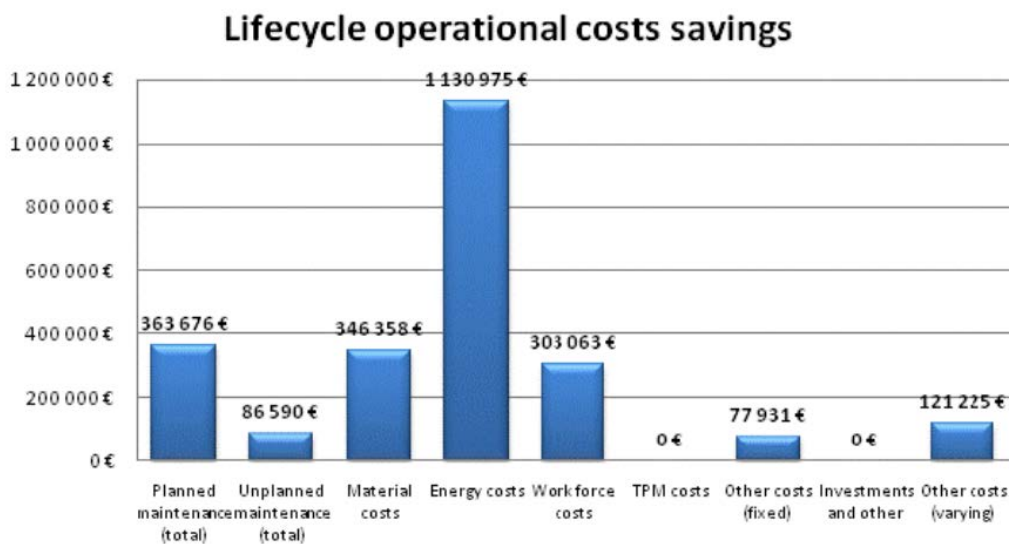


Figure 7 Example of the effects of a combination of services on the operating costs

The figure 8 addresses the effects of a combination of services on the operating costs. The life cycle failure costs can be addressed likewise. From the perspective of provider customer collaboration, the key issue is that considering these results together, customers and service providers are able to achieve a

common understanding of the need for various services and also identify the subjects which need to be further addressed, for instance by developing additional services. [11]

Outsourcing Special Maintenance

□The next step in outsourcing is to widen it to tasks which need special knowledge and skills. A maintenance expert is hired to do special measurements, e.g. vibration measurements, rod mill worn parts measurements, data-analysis, wear parts checking etc. This can be done on a regular basis or the expert offers single visits.

Gaining expert knowledge which is needed for some tasks is cost and time intensive. An expert at this topic can offer his services at lower costs and to many clients. A customer might train his employees to become experts, but special tasks are often only required in a few cases. This means, that a lot of manpower is wasted. □ [13]

3.3 Totally outsourced maintenance model

□Totally outsourced maintenance means that the company of the production process has outsourced the whole of their maintenance department to another company. This outsourced company provides reliability and/or services to the manufacturing organization. The company has only operators who take care of the production process. That's why it's often called operation and maintenance. They usually do corrective maintenance and increasingly operators do condition monitoring rounds and preventive maintenance work.

The Business logic in this model is that the maintenance company's outcome measure is linked to customer's production processes annual availability rate. The lower the downtime for the better is a bonus that the maintenance company earns. This is very common in the pulp and paper industry.

Although maintenance actions have been outsourced to another company, there are usually the same maintenance persons who know the manufacturing process, equipment and people. If it is compared between outsourced maintenance and low level maintenance, they didn't necessarily know the manufacturing process, equipment and people so well. That's why the knowledge transfer between outsourced maintenance service provider (supplier) and manufacturing company (customer) is better. □ [13]

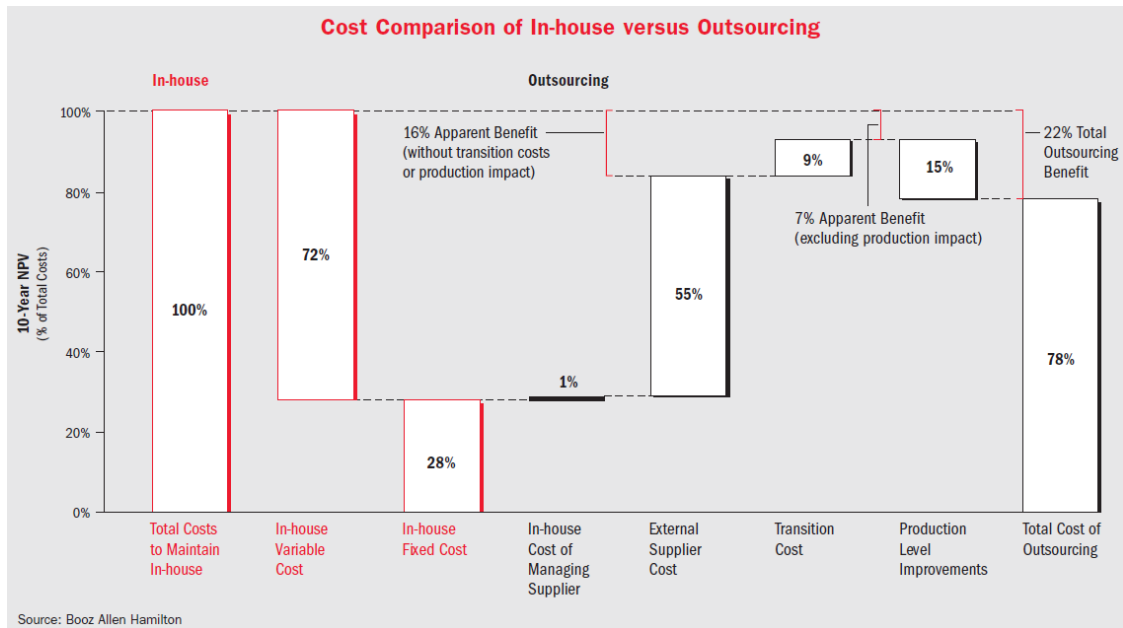


Figure 8 In the figure above are analysed the decision to outsource maintenance activities. [20]

□ Booz Allen recently analysed the decision to outsource maintenance activities for a global industrial company; the findings are featured in the chart above. Upon initial review, it seemed as though the external supplier being considered enjoyed a 45 percent cost advantage, primarily due to higher employee productivity and lower labour costs. However, closer examination revealed that 28 percent of these costs associated with maintenance e.g. supervision, occupational health and safety and site services were essentially fixed and could not be outsourced away. In addition, significant transition costs needed to be taken into account, primarily related to severance payments and new supplier management costs. [20]

When these fixed and transition costs were included, the outsourcing proposition became decidedly less attractive; the anticipated costs savings declined to approximately 7%. Given the risks involved in transitioning to an outside supplier and the likelihood that some of the savings would get lost in the implementation process, there was some debate about whether to proceed. However, there was still one factor in outsourcing's favour. The higher perceived motivation and productivity of the new service provider, combined with improved planning processes, led company executives to conclude that maintenance-related downtimes would be sharply reduced if they went ahead and outsourced. On an NPV basis, outsourcing was estimated to deliver a 22% improvement to the bottom line. [20]

An alarmingly long list of tech-related manufactures have experienced reversals of fortune in the past year owing, at least in part, to execution problems in their outsourcing relationships. Whereas original equipment manufacturers (OEM) had difficulty forecasting product demand, the contract equipment manufacturers (CEM) to which they had outsourced their manufacturing were experiencing their own set of problems. Shortages forced CEMs to miss deliveries; systems implementations took longer than expected; and other problems kept the supply chains from scaling up as fast as promised. [20]

When infrastructure development slowed and markets failed to materialize, OEMs cut forecasts. Dramatic revenue shortfalls were compounded by the OEMs' inability to step back from their commitments to inventory and capacity. As a result, balance sheets became bloated. Profitability

forecasts at the unit level took a direct hit, and customers complained as the OEM marketing machines continued to help create unfulfilled demand. The overall message was clear: the OEM/CEM model didn't scale the way everyone had expected. [20]

4 Conclusions

This report describes the existing business models between different value chains involved in maintenance process and assess the economic impact of these different models. As earlier in this report is mentioned, maintenance labour input is already about 200 000 person-years and the annual investment in maintenance is approx. 24 billion €. So maintenance is a major player.

In order to succeed better and to increase their activities in the traditional manufacturing company will expand and develop its activities and operate on the market as smoothly as possible. The operation of a natural extension of the direction of the traditional manufacturing company is to offer customers only the component / product rather than a broader combined service and component supply, as well as any necessary maintenance and design services. Product and service entity client gets more benefit from the combined company, and operate more efficiently be able to recover the inside of the company's product and maintenance expertise.

Modular maintenance and logistics processes, architectures allow for the modelled service parts re-ordering and customization to customer needs. Thus, the modelling work does not always have to start from scratch to support the new decision-making support and upon processing operations or services.

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List of annexes

- Annex A1. The relevant standards for Appendix 20; Economic evaluation of the current business models of each value chain
- Concerning WP6; Business impact and models
- Task 6.3 - New Industrial Business Models economic evaluation

Annex A1.

Standard Organization	Number	Title	Publishing Year
BSI	55002	Asset management - Management systems. Guidelines for the application of ISO 55001	2014
BSI	55001	Asset management - Management systems. Requirements	2014
BSI	13306	Maintenance terminology	2001
BSI	13460	Maintenance. Documentation for maintenance	2009
BSI	13269	Maintenance. Guideline on preparation of maintenance contracts	2006
BSI	15341	Maintenance. Maintenance key performance indicators	2007
BSI	1325	Value Management. Vocabulary. Terms and definitions	2014
CEN	16646	Maintenance - Maintenance within physical asset management	2014
CEN	15628	Maintenance - Qualification of Maintenance personnel	2007
DIN	31051	Fundamentals of maintenance. (Grundlagen der Instandhaltung)	2012
IEC	60300-3-3	Dependability management - Application guide - Life cycle costing	2004
IEC	60300-3-14	Dependability management - Part 3-14: Application guide - Maintenance and maintenance support	2004
IEC	60300-3-16	Dependability management - Part 3-16: Application guide - Guidelines for specification of maintenance support services	2008
IEC	60300-3-12	Dependability management -Part 3-12: Application guide - Integrated logistic support	2004
IEC	62550	Spare parts provisioning	2015
ISO	18480-2	Facilities Management - Part 2: Guidance on strategic sourcing and the development of agreements	2015
ISO	18480-1	Facility management - Part 1: Terms and definitions	2015
NF	X60-008	Industrial maintenance - Maintenance outsourcing draft guide - Pre-contractual approach	2013
NF	X60-100	Maintenance – Preconditions to the maintenance contracts – Inventories and evaluation for the states of items	2007
NF	X60-000	Maintenance function	2002
PAS	55-1	Asset Management Part 1: Specification for the optimized management of physical assets	2008
PAS	55-2	Asset Management Part 2: Guidelines for the application of PASS 55-1	2008
PSK	7502	Key performance indicators of logistics. Material function	2002
PSK	7501	Key performance indicators of maintenance for use in process industry	2010

PSK	6201	Maintenance. Terms and definitions	2011
PSK	7901	Teollisuuden kunnossapito. Palvelusopimus. Maintenance in Industry. Service Agreement. 1 s.	2001
SFS	ISO 55002	Asset management - Management systems -- Guidelines for the application of ISO 55001	2014
SFS	ISO 55001	Asset management - Management systems -- Requirements	2014
SFS	ISO 55000	Asset management - Overview, principles and terminology	2014
SFS	EN 60300-3-1	Dependability management - Part 3-1: Application guide - Analysis techniques for dependability - Guide on methodology	2005
SFS	EN 60300-3-11	Dependability management - Part 3-11: Application guide - Reliability centred maintenance	2015
SFS	EN 60300-3-12	Dependability management - Part 3-12: Application guide - Integrated logistic support	2012
SFS	EN 60300-3-14	Dependability management - Part 3-14: Application guide - Maintenance and maintenance support	2004
SFS	EN 60300-3-16	Dependability management - Part 3-16: Application guide - Guidelines for specification of maintenance support services	2009
SFS	EN 60300-3-2	Dependability management - Part 3-2: Application guide - Collection of dependability data from the field	2005
SFS	EN 60300-3-3	Dependability management - Part 3-3: Application guide - Life cycle costing	2005
SFS	ISO 37500	Guidance on outsourcing	2014
SFS	IEC 60300-3-9	Luotettavuusjohtaminen. Osa 3: Kytöopas. Luku 9: Teknisten järjestelmien riskianalyysi	2000
SFS	EN 13269	Maintenance. Guideline on preparation of maintenance contracts	2006
SFS	EN 15341	Maintenance. Maintenance Key Performance Indicators	2007
SFS	EN 13306	Maintenance. Maintenance terminology	2010
SFS	EN 16646	Maintenance. Maintenance within physical asset management	2015
SFS	EN 15628	Maintenance. Qualification of maintenance personnel	2014
SFS	EN ISO 9000	Quality management systems. Fundamentals and vocabulary (ISO 9000:2015)	2015
UNI	10685	Maintenance - Criteria to prepare a maintenance global service	2007
UNI	10144	Classification of maintenance services	2006
UNI	10146	Criteria to prepare a contract for supplying maintenance finalized services	2007
UNI	10145	Definition of evaluation factors of services maintenance firms	2007
UNI	10147	Maintenance - Additional terms and definitions to EN 13306	2003
UNI	10652	Maintenance - Appraisal and evaluation of the goods condition	2009

UNI	10449	Maintenance - Criteria to prepare and to manage the permit to work	2008
UNI	11063	Maintenance - Definitions of ordinary and extraordinary maintenance	2003
UNI	10366	Maintenance - Design criteria of maintenance	2007
UNI	10749-1	Maintenance - Guidelines for management of maintenance materials - General aspects and organizational problems	2003
UNI	10749-2	Maintenance - Guidelines for management of maintenance materials - Criteria for classification, codification, standardization and support	2003
UNI	10749-4	Maintenance - Guidelines for management of maintenance materials - Criteria for operational management	2003
UNI	10749-5	Maintenance - Guidelines for management of maintenance materials - Criteria for purchasing, tests and final check	2003
UNI	10749-6	Maintenance - Guidelines for management of maintenance materials - Administration criteria	2003
UNI	10749-3	Maintenance – Guide-lines for management of maintenance materials - Criteria for the choice of materials to be managed	2003
UNI	10148	Maintenance - Management of a maintenance contract	2007
UNI	10224	Maintenance - Process, sub-processes and main activities - Fundamental principles	2007
UNI	10992	Maintenance budget for manufacturers and suppliers of products and services - Guidelines for the definition, approval, management and check	2002
UNI	10584	Maintenance. Systems of information of maintenance	1997