Strategic maintenance management: Formulating maintenance strategy

Ali Rastegari¹, ², Antti Salonen²

¹Volvo GTO, Sweden, ali.rastegari@volvo.com
²Mälardalen University, Sweden, antti.salonen@mdh.se

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Abstract

In recent decades, by introducing lean manufacturing the vulnerability to system disturbances has increased and so, the demand for dependable production equipment. The need for having high production equipment availability causes companies to need a more effective and efficient maintenance strategy in order to stay competitive. Despite the increasing demand on reliable production equipment, few manufacturing companies work with strategic maintenance development and a large part of the manufacturing industry lack clear maintenance strategies. It is therefore difficult to develop the maintenance work in accordance with the strategic goals of the manufacturing companies.

The main objective of this paper is to define a process for formulating maintenance strategy in order to facilitate further development in a strategic way. The problem has been studied by literature review and through case study at one major manufacturing site in Sweden to investigate the company’s view on strategic maintenance development. Hence, a formulated maintenance strategy has been provided and presented. The company’s overall goals considered and translated to the strategic objective of maintenance. Moreover, balanced score card is used as a tool to make a framework of the maintenance strategy. As a result of this study, the company could easily formulate a maintenance strategy by using a simple process based on the tools that they have already used. In addition to this, the result indicated how maintenance strategy can contribute to the company’s business goals.

1. Introduction

In recent decades, production maintenance has evolved to be one of the most important areas in the business environment. The growth of global competition caused remarkable changes in the way manufacturing companies operate. These changes have affected maintenance and made its role even more crucial in business success. Implementing lean concept is one of the significant changes in manufacturing companies. By introducing Lean concept within manufacturing industry, many companies started to apply lean tools such as Just-In-Time production and Demand-Flow-Technology, in order to be successful in this competitive market. Consequently, the demand for dependable production equipment increases. The need for having high production equipment availability causes companies to need a more effective and efficient maintenance strategy in order to reach a competitive production system. In consequence, optimizing the maintenance of production equipment can act as one key aspect of continuous improvements of the company. In order to achieve world-class performance, Swanson (2001) states that more and more companies are replacing their reactive, firefighting strategies for maintenance with proactive strategies like preventive and predictive maintenance and aggressive strategies like total productive maintenance (TPM).

Many authors have pointed out that maintenance is a major contributor to the performance and profitability of manufacturing systems. With asset availability and reliability becoming critical issues in capital-intensive operations, the strategic importance of maintenance in such business should be recognized, (Tsang, 2002). Although, production maintenance as all production support functions is considered to be a cost center, by identifying the proper strategic goals of maintenance and implementing a well-formulated strategy, industrial companies can enhance the return on investment of their maintenance expenses. Salonen (2011) expresses industrial maintenance is a substantial financial post. But, if strategically managed, the maintenance of manufacturing equipment contributes to the competitiveness of a company. Wireman (1990) argues that as much as one third of the maintenance cost is unnecessarily spent due to bad planning, overtime costs, bad use of...
preventive maintenance, etc. Tsang (1998) states that considering maintenance a purely tactical matter is myopic. It also has a strategic dimension covering issues such as design of facilities and their maintenance programs, upgrading the knowledge and skills of the workforce, and deployment of tools and manpower to perform maintenance work. These decisions have lasting effects on the future operation and maintenance of physical assets. However, a large part of the manufacturing industry lacks clear maintenance strategy today. Previous research has shown that less than half of industry uses formulated maintenance strategy. It is therefore difficult to develop the maintenance work in accordance with the strategic goals of the manufacturing companies. The maintenance manager must develop a valid maintenance strategy. But, in many cases the maintenance managers lack the necessary tools to formulate a feasible maintenance strategy. Perhaps, some of existed proposals for formulating maintenance strategy are resource demanding and companies lack competence to use them. Also, in some cases the management lack insight in the financial impact of good maintenance strategy.

2. Production maintenance

Although, the word maintenance is well defined in literature, there are different ways of definition for other maintenance related terms such as maintenance types, maintenance concepts and maintenance strategy. Moreover, it often makes it difficult to understand which one is the term that author refers to. In consequence, definitions for the terms used in this paper are needed.

2.1 Maintenance definition

The term maintenance is defined in Swedish standard SS-EN 13306 (2001, p.7) as “the combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function (function or a combination of functions of an item which are considered necessary to provide a given service).”

Khairy (2008, p.22), describes the key objective of maintenance as “total asset life cycle optimization which means maximizing the availability and reliability of the assets and equipment to produce the desired quantity of products, with the required quality specifications, in a timely manner. Obviously, this objective must be attained in a cost-effective way and in accordance with environmental and safety regulation.”

2.2 Maintenance types

Maintenance may be performed according to various actions. One classification of maintenance types and their relationship is indicated in the standard SS-EN 13306, as shown in Figure 1.

![Figure 1 - Overview of different maintenance types (SS-EN 13306, 2001, p.23).]

Maintenance is divided in two main actions, preventive and corrective.
- Corrective maintenance or break down maintenance (BM).
- Preventive maintenance (PM): Preventive maintenance can be predetermined (Periodic) maintenance or Condition based maintenance.

2.3 Maintenance concepts

Various concepts have been developed to increase the effectiveness of maintenance and focus on the maintenance activities. The two more common concepts are Reliability Centered Maintenance (RCM), and Total Productive Maintenance (TPM).
- RCM: Moubray (1997, p.7) defines RCM as “...a process used to determine what must be done to ensure that any physical asset continues to do what its user wants it to do in its present operating context.”
- TPM: a Japanese concept for maintenance. According to Nakajima (1998, p.10), who introduced the concept, TPM may be defined as “Productive maintenance involving total participation”. Several explanations of the definition may be found in literature.

More recently, various attempts have been made to introduce a Lean Maintenance concept, but this is still not unanimously defined.

2.4 Maintenance management

Kelly (2006, p.26) gives the following generic expression for the maintenance objective: “...to achieve the agreed plant operating pattern, availability and product quality within the accepted plant condition (for longevity) and safety standards, and at minimum resource cost.” As
illustrated in Figure 2, Crespo Marquez and Gupta (2006) expresses that maintenance management must align with business activities at strategic, tactical, and operational levels.

According to Labib (2004), Computerized Maintenance Management Systems (CMMS) can provide these items: support condition based monitoring, track the movement of spare parts, allow operators to report faults faster, improve the communication between operations and maintenance personnel, historical information necessary for developing PM schedules, provide maintenance managers with information to have better control on their departments, Offer accountants information on machines to enable capital expenditure decisions to be taken, etc.

2.5 Maintenance performance measurement
According to Tsang et al. (1999), since maintenance spending constitutes a large part of the operating budget in organizations with heavy investments in machinery and equipment, tracking the performance of maintenance operations in such organizations should be a key management issue. Another reason for linking the measurements to the organization’s strategy, according to Tsang, is the influence of the used performance measurements on employee behaviors (Tsang, 1998).

Salonen and Bengtsson (2007) argue that dependability is being used to manage maintenance actions execution. Dependability is collective term used to describe the availability. Its influencing factors are; reliability, maintainability and maintenance supportability which are being measured by Mean Time between Failure (MTBF), Mean Time to Repair (MTTR) and Mean Waiting times (MWT).

3. Maintenance strategy

3.1 Maintenance strategy definition
Maintenance strategy is not univocally defined in literature. Some authors (e.g. Zaim, et.al, 2012) define it as the choice between corrective, preventive and condition based maintenance. Other authors mentioned it is combination of reactive maintenance, regularly scheduled preventive maintenance, inspection, back up equipment and equipment upgrades. The mix of these elements is specific for each facility and depends on the goals of the maintenance, the nature of the facility or equipment to be maintained, and the work environment.

Tsang (1998) means that the strategy reflects the organization’s conception of its intended long-term goal and the approach to achieving it. As it is often formulated at senior management level, the espoused strategy is usually too abstract to line management personnel. As such, it becomes difficult to relate departmental and individual activities to the attainment of the strategic goal.

Crespo Marquez & Gupta (2006) state that maintenance strategies are a means of transforming business priorities into maintenance priorities. By addressing current or potential gaps in maintenance performance, a generic maintenance plan will be developed.

Pinjala, et al (2006) discuss the relationship between business and maintenance strategies. They define maintenance strategy as a “…coherent, unifying and integrative pattern of decisions in different maintenance strategy elements in congruence with manufacturing, corporate and business level strategies; determines and reveals the organizational purpose; defines the nature of economic and non-economic contributions it intends to make to the organization as a whole.” (Pinjala, et al 2006, p. 216).

3.2 Formulation of maintenance strategy
There are few models for formulating maintenance strategy and some of proposed models are quite resource demanding. The
existing models are rather similar in their key elements. Authors like Tsang (1998), Wilson (1999), Kelly (2006), Crespo Marquez (2007), and Salonen (2012) all emphasize the following steps in their models:

- Identify the strategic goals of all stakeholders.
- Identify the strategic goals for the maintenance department.
- Identify relevant KPIs.
- Assess the current state of maintenance.
- Set the goals for each KPI.
- Make an action plan.

Even though these models share the presented steps, they have somewhat different approaches to fulfill the steps. Figure 3 shows an illustration of Salonen’s model for formulation of maintenance strategies (Salonen, 2012).

As shown in Figure 3, Salonen’s model includes all steps previously mentioned. Salonen & Bengtsson proposes stakeholder involvement for the identification of relevant KPIs for the maintenance department (Salonen & Bengtsson, 2008). For transformation of the identified gaps between current and wanted states, Salonen (2012) proposes the use of SWOT analysis. Further Salonen emphasize the importance of documentation of the strategy and that the company management approve the strategy to make it a steering document (Salonen, 2012).

4. Case study

The empirical base for the study is a case based study of one major manufacturing site in Sweden. The data is collected by interviews and document analysis of "Volvo GTO Powertrain Production". The company is the Volvo Group Strategic Center for powertrain components. It has approximately 1200 employees with total area of 93000 m² and production area of 75000 m². The company is adapted with lean production and Volvo’s own production system (VPS). Volvo Production System supports continuous progress in further enhancing the quality and efficiency of production process. World Class Manufacturing (WCM) method is the Volvo GTO’s way to implement Volvo Production System.

Two main factors at the company have been in consideration for this study; performance indicators and maintenance action plans. A number of KPIs are used in the company’s business strategy. Some of them that are used in formulation of maintenance strategy are presented and defined as follows:

- Personal Business Plan (PBP): the basic framework for good people management in Volvo Group, in line with the basic Volvo way values.
- Individual Contribution Plan (ICP): a concrete result of staff appraisal for employees. The aim is to clarify the planning for the employee, and to get a good monitoring tool for the development and goals.
- Volvo Group Attitude Survey (VGAS): a method for following up the implementation of the Volvo way – the global guide for Volvo behavior as individuals, team members and leaders within the Volvo Group.
- Standard Operating Procedure (SOP): a written document or instruction detailing all relevant steps and activities of a process or procedure. An SOP provides employees with a reference to common business practices, activities, or tasks.

In addition to the performance indicators, a number of maintenance activities aligned with lean concept set in maintenance management at the company. Figure 4 shows the alignment between PM works and Lean philosophies at the company.

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other pillars in WCM, PM has seven steps which aim to go from reactive maintenance to proactive maintenance.

- **Maintenance Pulse**: one way for maintenance and its purpose is to visualize status of machines and the planning of activities on short and long term. The maintenance pulse consists of two parts, follow up and planning.

- **Technical Andon process**: a signaling system that uses either text on a display, sound, light or flags to indicate the current status of a machine or machine group. Andon is also a mean that operators can use to get attention when a problem has occurred.

- **Quality-assured Emergency Work Order (EWO) process**: a new way of working for managing the process in order to increase quality of the EWOs.

- **Kaizen corner**: established with main purpose of gathering all information in one place; visualize it and follow up on activities.

- **Management by objectives**: based on model called Result Oriented Management (ROM) that focuses on activities to add value. Maintenance targets are set for next three years and followed up quarterly by relevant KPIs.

- **Spare parts project (WRaP)**: To further support the maintenance activities in becoming more efficient focusing on value adding, a review of spare parts management is launched. Losses linked to spare parts management are categorized in: missing parts, waiting, wrong use of resources and transports.

- **OEE Process**: To increase the integration between production and maintenance a new process has been implemented where the technical availability is a construct of an OEE target. Production decides on OEE level and the Maintenance organization calculates what level of technical availability is required and the cost of reaching/maintaining this. This is later agreed upon between the production and maintenance organization.

- **Ett KLIV (One step)**: a system for people development (PD) within the maintenance organization. The competences are categorizing by numbers in this system.

- **Audit Layer**: a system of regular inspections to further keep focus on the requests and monitor how the organization works.

### 5. Results and analysis

In this section, the result from case study is discussed in order to investigate the company’s view on strategic maintenance development. Further, a work-process for formulating the maintenance strategy is proposed. Finally, formulated maintenance strategy at the case company is presented which indicates the factors that must be included in the maintenance strategy.

#### 5.1 The company’s view on strategic maintenance development

The case study was performed in order to assess the views toward maintenance strategy in the case company. This study conducted mainly in interviews with the maintenance managers at the company. Here is the summary of the results. Maintenance managers at the company had different views toward maintenance strategy. For instance, the professional maintenance within WCM method has been considered as a maintenance strategy in one view. Figure 5, indicates one perspective of maintenance strategy at the company.

![Figure 5 - Maintenance strategy perspective](image-url)

However, the maintenance strategy defined in this paper was not clearly written and was not well-aligned with the company’s business strategy. In other words, there was not a clear plan for maintenance as a strategy to show the direction to fulfill overall organization’s objectives. The company used performance indicators for control on strategic as well as tactical and operational levels. Also, relevant performance indicators were defined for controlling internal efficiency of maintenance. Nevertheless, performance indicators were not well-identified in the maintenance strategy according to the company’s overall goals. The company worked with continuous improvements of their maintenance activities and they were more or less satisfied with the outcome of their maintenance activities so far. In addition to this, the new management of maintenance department has started to bring lean concept within maintenance by adding some activities such as Kaizen corner. The company used
CMMS, for their maintenance activities but the full functionality of the system was not utilized and they made efforts to compensate the lacks in the new CMMS for the company. However, the maintenance department was aware of the remaining improvement potential and they attempt to compensate deficiencies in the new organization of maintenance. The maintenance manager at the company had a clear view of the strategic importance of maintenance. Moreover, the top-level management and the maintenance manager shared the view of maintenance as a strategically important function.

5.2 The proposed work-process of maintenance strategy formulation

One positive point in formulating maintenance strategy in such a case company is that the business strategy has been formulated and existed and also both the company and its maintenance had clear vision and mission. Moreover, although there was not a clear maintenance strategy, some maintenance goals and activities have been identified in different framework of management like management by objectives. These positive facts at the case company helped the process of formulation to be even one step further than some other proposed process in literature. Figure 6 shows different phases of formulating the maintenance strategy and also factors that should be included in the maintenance strategy.

As Figure 6 illustrates, the work-process starts with collecting data from the company including different perspectives of maintenance strategy that explained in previous section, vision and mission of the company and maintenance as well as maintenance activities enclosing management by objectives, professional maintenance within WCM method and etc. Based on the information gathered strategic objectives of maintenance and their relevant KPIs can be identified. In this step, balanced scorecard is proposed to structure maintenance strategy in a proper way. Depending on the company’s objectives, targets for next three years must be decided. Action plans to reach these targets and objectives must be established. Then relevant measures indicating status of the action plans must be classified. Next phase is to classify the maintenance strategy in three levels of strategic, tactical and organizational. By having different levels of action plans, factors like responsibility and time would be more recognizable. In addition to this, the maintenance manager and other personnel can have more appropriate overview of maintenance activities and the way to manage them.

The last phase is to make a clear link between maintenance strategy and the company’s business strategy. In this step, maintenance strategy must be classified in the same areas as business strategy. In some cases, maintenance strategy has more areas than business strategy. However, the important aspect here is to make the relation between factors included and objectives and action plans. According to definition of strategy, the main purpose of maintenance strategy must show the clear direction between activities and their result to achieve company’s strategically goals.
5.3 Formulated maintenance strategy

The formulated maintenance strategy is divided to the two parts of strategic objectives and action plans. The description regarding these parts is presented in this section.

5.3.1 Strategic objectives

The strategic objectives of maintenance is formulated and presented in the form that Figure 7 illustrates.

<table>
<thead>
<tr>
<th>Strategic Objectives</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety/Quality/Environment</td>
<td></td>
</tr>
<tr>
<td>Improve safety culture</td>
<td>Days without accident</td>
</tr>
<tr>
<td>Reduce Energy consumption</td>
<td>Energy saving in 2008</td>
</tr>
<tr>
<td>Leadership</td>
<td></td>
</tr>
<tr>
<td>Reaching step 5 for all machines within Professional/Maintenance criteria of World Class Manufacturing</td>
<td>Number of Break downs for AA machines which are in step 5</td>
</tr>
<tr>
<td></td>
<td>Cost reduction (PM related)</td>
</tr>
<tr>
<td></td>
<td>Coverage on A components in VMMS (%)</td>
</tr>
<tr>
<td>Employship</td>
<td></td>
</tr>
<tr>
<td>VGAS</td>
<td>EEI (Employee Engagement Indicator) (%)</td>
</tr>
<tr>
<td>Improve SS</td>
<td>Audit measurement (%)</td>
</tr>
<tr>
<td>Organization and Way of Working</td>
<td></td>
</tr>
<tr>
<td>Right First Time EWOD</td>
<td>Decidable EWO/Total number (%)</td>
</tr>
<tr>
<td>Improve Andon process</td>
<td>MWT (Machining)</td>
</tr>
<tr>
<td></td>
<td>MWT (Assembly)</td>
</tr>
<tr>
<td>Competence</td>
<td></td>
</tr>
<tr>
<td>Decrease MTTR</td>
<td>MTRT (Machining)</td>
</tr>
<tr>
<td></td>
<td>MTRT (Assembly)</td>
</tr>
<tr>
<td>Development of team competence</td>
<td>Development of team competence</td>
</tr>
<tr>
<td>PBP/ICP</td>
<td>Completed activities (%)</td>
</tr>
<tr>
<td>Delivery</td>
<td></td>
</tr>
<tr>
<td>Improve technical availability</td>
<td>OEA</td>
</tr>
<tr>
<td>Productivity</td>
<td></td>
</tr>
<tr>
<td>Increase MTBF</td>
<td>MTBF (Machining)</td>
</tr>
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<td></td>
<td>MTBF (Assembly)</td>
</tr>
<tr>
<td>Decrease MWTSP</td>
<td>MWTSP (Machining)</td>
</tr>
<tr>
<td></td>
<td>MWTSP (Assembly)</td>
</tr>
<tr>
<td>Increase Planned Maintenance Capability</td>
<td>Time for all activities / Total available time</td>
</tr>
<tr>
<td></td>
<td>Using Preventive Maintenance compared with Corrective Maintenance (%)</td>
</tr>
<tr>
<td>Economy</td>
<td></td>
</tr>
<tr>
<td>Maintenance cost reduction per produced unit</td>
<td>Maintenance cost / Gearbox compared with baseline 2008</td>
</tr>
</tbody>
</table>

Figure 7 - Strategic objectives

As described, balanced score card is one appropriate way for formulating the strategy which has been applied as a solution in this paper. According to the company’s business strategy the strategic objectives of maintenance are classified in different areas including: safety/quality/environment, leadership, employee ship, organization and way of working, competence, delivery, productivity as well as economy. Within these areas, the relevant KPIs and their measures are set and the targets for the current year and next three years.

In safety/quality/environment area Improve safety culture and reducing energy consumption are strategic objectives for maintenance department. Reaching the highest steps of professional maintenance within WCM method is the strategic objective for maintenance in leadership area. Therefore, the maintenance manager can have supervision properly by measuring the defined KPIs for each step such as number of breakdowns for classified machines; reduced PM related cost as well as coverage of the components in CMMS.

In employee ship area, there is a significant measurement for the manager which is VGAS. The purpose of VGAS is to continuously improve the working climate. Thus, the engagement of employees in this survey is significantly important for the managers. Results can be calculated include the Employee Engagement Index (EEI). Improving 5S in working climate is also part of the strategic objective of maintenance within Employee ship that can be measured by its audit measurement.

EWO acts as a key role in way of working with maintenance and “right first time EWO” is a process implemented by maintenance department in order to increase the efficiency of work orders. It can be measured by decidable EWOs per their total number. A dependability measurement indicating maintenance supportability of the organization is MWT which can include mean waiting time for spare part (MWTSP) and etc. MWT can be improved by well implementing Andon and its improvement is one important strategic objective for maintenance.

MTTR is a dependability measurement indicating maintainability. It illustrates the competence of maintenance personnel in doing maintenance works. And decrease in MTTR is one important strategic objective for maintenance. PBP and ICP are two other competence indicators in this area and percentage of their completed activities is as strategic objective for maintenance.

In delivery area, increase technical availability is the strategic objective that can be measured by Overall Equipment Availability (OEA). This objective is absolutely one of the most important objectives that indicate how much maintenance department delivers services to the production as its customer.

MTBF is a dependability measurement indicating equipment reliability. MTBF, MWTSP and capability of planned maintenance can illustrate productivity of maintenance. Therefore, these objectives are formulated in productivity area.

One important aspect of maintenance, which is often missing in formulating maintenance strategy, is the financial aspect of maintenance. Having a financial factor within maintenance strategy can
show how much cost-effective have been maintenance works. In that way, maintenance manager has a better view on how to manage cost in order to have both effective and efficient maintenance. Maintenance cost reduction per produced unit has been considered as a strategic objective here.

5.3.2 Action plans
In the formulated maintenance strategy, maintenance actions are classified in relevant areas linked to business strategy and by this way the maintenance manager can have an obvious view on which action plan is taking place in which area and see the result directly in defined KPIs. Figure 8 illustrates formulated maintenance action plans in different areas.

<table>
<thead>
<tr>
<th>Action Plans</th>
<th>Strategic Measure</th>
<th>Tactical Measure</th>
<th>Operational Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety/Quality/Environment</td>
<td>Safety</td>
<td></td>
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<td></td>
<td>Energy</td>
<td></td>
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<td></td>
<td>SOP</td>
<td></td>
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<tr>
<td>Leadership</td>
<td>Professional Maintenance within WCM</td>
<td></td>
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<tr>
<td></td>
<td>Management by objective</td>
<td></td>
<td></td>
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<tr>
<td>Employment</td>
<td>Reorganization in place</td>
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<td></td>
<td>ETT Klv</td>
<td>Audit Layer</td>
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<td></td>
<td>5S</td>
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<tr>
<td>Organization and Way of Working</td>
<td>VMMS</td>
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<td></td>
<td>Cross functionality</td>
<td></td>
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<tr>
<td></td>
<td>Andon</td>
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<tr>
<td>Competence</td>
<td>Competence</td>
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<tr>
<td></td>
<td>ICP/PBP</td>
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<tr>
<td>Productivity</td>
<td>Time Efficiency</td>
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<td></td>
<td>Wrap</td>
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<tr>
<td></td>
<td>Maintenance Pulse</td>
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<td></td>
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<tr>
<td>Economy</td>
<td>Cost Control</td>
<td></td>
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<tr>
<td></td>
<td>OEE process</td>
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</tbody>
</table>

Figure 8 - Action plans
The maintenance strategy’s action plans must be structured in three levels of strategic, tactical and operational. One significant aspect is to define responsibilities for each level and also measures to follow up maintenance actions. Moreover, the maintenance manager can also define time or deadline for action plans.

In this paper maintenance action plans are classified in the same areas as maintenance strategic objectives related to business strategy’s action plans. Action plans are structured in levels according to organizational layers.

6. Conclusions
In order to describe the research findings in a structured way, research questions are reviewed followed by a brief description of how they are answered within the conducted research.

How to formulate maintenance strategy that supports company’s business strategy?
A literature review and case study performed to answer this research question and relevant evidence collected to describe the current situation of the studied phenomenon. In this study, a work-process for formulating maintenance strategy was suggested to the case company and feasibility of this process tested by cooperation with the maintenance managers. For instance, the company’s overall goals considered and translated to the strategic objective of maintenance. Moreover, balanced score card used as a tool to make a framework of the maintenance strategy. As a result of this study, the company could easily formulate a maintenance strategy by using a simple process based on the tools that they have already used such as management by objectives and the company’s business strategy. In addition to this, the result indicated how maintenance strategy can contribute to the company’s business goals.

What aspects or components must be included in the maintenance strategy?
Based on the concepts reviewed in the literature in order to answer this question, there is no unanimous view in academia that shows which aspects must be included in the maintenance strategy. Therefore, different companies may have different factors to consider while formulating maintenance strategy depending on the company’s size, product type, competitive environment, and the company’s business strategy. From case study, factors considered in the same areas of the company’s business strategy related to both efficiency and effectiveness of the maintenance. Since there is no standard to set these aspects or components in the maintenance strategy, the factors identified in the performed research can be as a basic version of setting aspects in the maintenance strategy for the case company. The presented list perhaps is not to be viewed as complete, but rather as a sample of key factors.
6.1 Discussion
In order to fulfill the purpose of this research to formulate a maintenance strategy at the company a simple process has been presented, tested and verified by the case study. The performed study has indicated how a relatively simple and non-resource demanding process may be used to formulate maintenance strategy that aligns with the company’s overall strategic goals. The formulated strategy is based on a set of aspects that the company concerns strategically important for their maintenance development. The company has found the presented process logical and easy to comprehend. Moreover, some participants at the company have remarked that the formulated strategy not only can illustrate what factors to improve, but also can be viewed as a map to see all maintenance related activities and their influencing factors.

By setting a well-formulated strategy for the maintenance management, the company has the required necessities to achieve the strategic goals. One special benefit to gain from the strategy formulation is the agreement between the company and its maintenance provider on which the strategic goals of maintenance should be. A formulated strategy helps the company to have a clear picture of what deliveries they need to achieve their strategic goals. Moreover, it can help the company in identifying which relevant performance measures to use for their maintenance activities. For instance, using financial KPIs for strategic maintenance goals makes it obvious to see the clear influence of strategic maintenance development on finances and difference in cost between a planned and unplanned stop. Finally, since the strategy is signed and approved on board level, it acts as a management document.

For the case company that implements lean production principles in their manufacturing, predictable production capabilities are crucial. Therefore, applying professional maintenance and autonomous maintenance as well as working on root-cause failure elimination can increase production stability. The case study conducted in this research has shown that the company has a large improvement potential within their maintenance and it has just started to re-organize the maintenance department by increasing attention to proactive tools and methods such as Condition Based Maintenance, Root Cause Analysis, and Continuous Improvements. The maintenance manager is very experienced in operative maintenance management. He has already worked with strategies and had previous knowledge of the used tools in formulating strategy. He has found the proposed formulated strategy easy to understand and beneficial to use.

A well formulated maintenance strategy which is clearly linked to the company’s overall-goals can motivate why they should perform preventive maintenance planning in the production schedule as well as increase the awareness of the benefits to operators and production managers. One important aspect is that the company identifies the proper goals of their maintenance and which factors to develop in order to facilitate a strategic contribution of their maintenance programs.

Although, maintenance is a cost center as all production support functions, by identifying the proper strategic goals of maintenance and implementing a well formulated strategy, the company can enhance the return on investment of their maintenance expenses. The conducted research in this paper can provide guidance to such efforts to make the maintenance department seen as a potential contributor to the overall company goals.

6.2 Further works
This paper has mainly focused on maintenance strategy formulation. A prospective continuation of the research could be to follow and investigate the implementation. A number of forces and obstacles that influence maintenance must be defined while implementing as a guideline. The result from an implementation investigation may show the importance of a well-formulated maintenance strategy and it can motivate the management team to have further development in maintenance. Introducing lean concept within manufacturing companies causes the companies to be more concerned about equipment capability and as a result demand for effective maintenance is significantly increased. However, the companies may forget to develop maintenance when implementing lean production. One interesting area to continue this research is to develop maintenance strategy in lean environment. For instance, TPM concept is developed in lean environment as autonomous maintenance. But, the question is how well the company can implement such concept that can be linked to their maintenance strategy and how to follow up way of working to be successful.

Moreover, the company showed a large potential within maintenance department by increasing interest in proactive tools and methods such as Condition Based Maintenance in order to have world class maintenance management that can fulfill the company’s overall-goals in a lean environment. A research area can be to design and develop a strategic Condition Based Maintenance System (CBMS) for the manufacturing company to reach the highest possible in proactive maintenance.
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8. References