

# Measuring the effectiveness of lean thinking activities within maintenance

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## Abstract

Maintenance has become a management issue, with its function as a contributor towards profit. This indicates the need for the maintenance operation to align with the business objectives and increase value for the enterprise. As a contributor to current management techniques, lean thinking approaches are now more commonly used. Without strong evidence to support the presence of generic lean thinking strategies especially in maintenance, a lean practice template needs to be developed, representative of activities possible within a company and maintenance in particular.

The use of performance measurements and their strategic importance to organisations have been well documented. However, lack of research in their implementation and use, relation to the organisation, and satisfaction of the decision-maker's requirements needs further consideration.

Keywords: Lean thinking, Maintenance, Performance measurement, Lean maintenance

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## Introduction

This paper discusses the combined issues of lean thinking, maintenance, and measures of performance, in particular performance indicators to identify the impact of lean thinking within maintenance. Specific attention focuses on the contribution of lean thinking within an organisation, the need for maintenance to align itself with the business objectives of the organisation, and the need for performance measures to inform of improvement within the organisation, and maintenance in particular, through lean activity.

## The Lean thinking issue

The concept of lean thinking (Womack and Jones, 1996) originated from the Toyota production system (TPS) developed in 1950s Japan (Katayama and Bennett, 1996), through the lean principles described by Womack *et al.* (1990). The industries not influenced by the principles and demonstrated benefits of lean, along with its associated methodologies such as just-in-time (JIT), total quality management (TQM) and total productive maintenance (TPM), are becoming fewer (Katayama and Bennett, 1996). A brief summary of the central theme, principles and characteristics of lean thinking which among other features refer to the total enterprise (Womack *et al.*, 1990; Womack and Jones, 1996; Bicheno, 2000), is summarised by Bicheno (2000).

Comm *et al* (2000) state that "Industries strive for leanness, because being lean means being competitive by eliminating the non-value added practices", i.e., wastes. However, the

strategy for a generic lean practice implementation, and achieving leanness throughout, lacks strong evidence and is not clear to many (Comm *et al.*, 2000; Chang 2001).

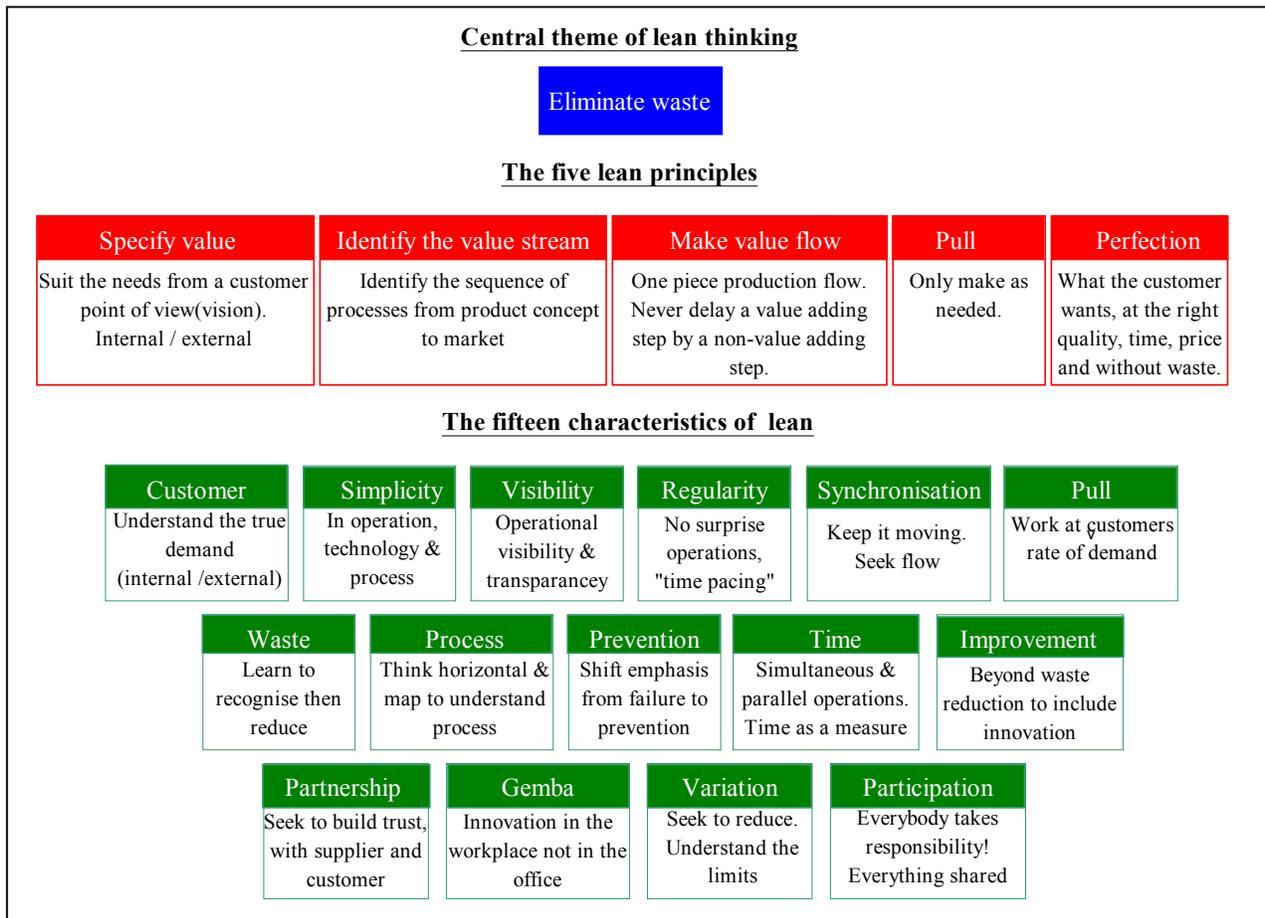


Figure 1. Theme, principles and characteristics of lean thinking

### The maintenance issue

Maintenance is the management, control, execution and quality of those activities which ensure optimum levels of availability and overall performance of plant are achieved to meet business objectives (DTI, 1997). Machines have also become more complex, making the effectiveness of the maintenance function a major management issue through increased demand on productivity, quality and availability (Labib, 1998; Tsang, 1998). This has led to the realisation that maintenance activities should not only be technologically improved but also blended with managerial concepts (Blanchard, 1997). Due to, the change of process technologies, customer expectations, supplier attitudes and increased competition; maintenance has been without proper integration of suitable techniques (Coetzee, 1999). It would appear that the aim of the maintenance function currently is to contribute towards an organisation's profit, clearly bringing the need for maintenance operations to be in harmony with business objectives (Kutucuoglu *et al.*, 2001).

## The maintenance issue and lean thinking

From a lean thinking perspective, improved efficiency and profitability can be sought by increasing value within an organisation through the elimination of waste (Womack and Jones, 1996; Womack *et al.*, 1990). Ohno (1985) identified seven initial wastes within manufacturing production to which Bicheno (2000) added a further seven. A characteristic of lean thinking associated with maintenance to improve efficiency and reduce waste is through the use of total productive maintenance (TPM). TPM is aimed at zero breakdowns and zero defects which deviate from the specialist maintenance function to improve global consideration, i.e., the operator, the process and environment (Nakajima, 1998). Analogous wastes within maintenance to those proposed in production (Bicheno, 2000; Ohno, (1985) are also shown in Figure 2.

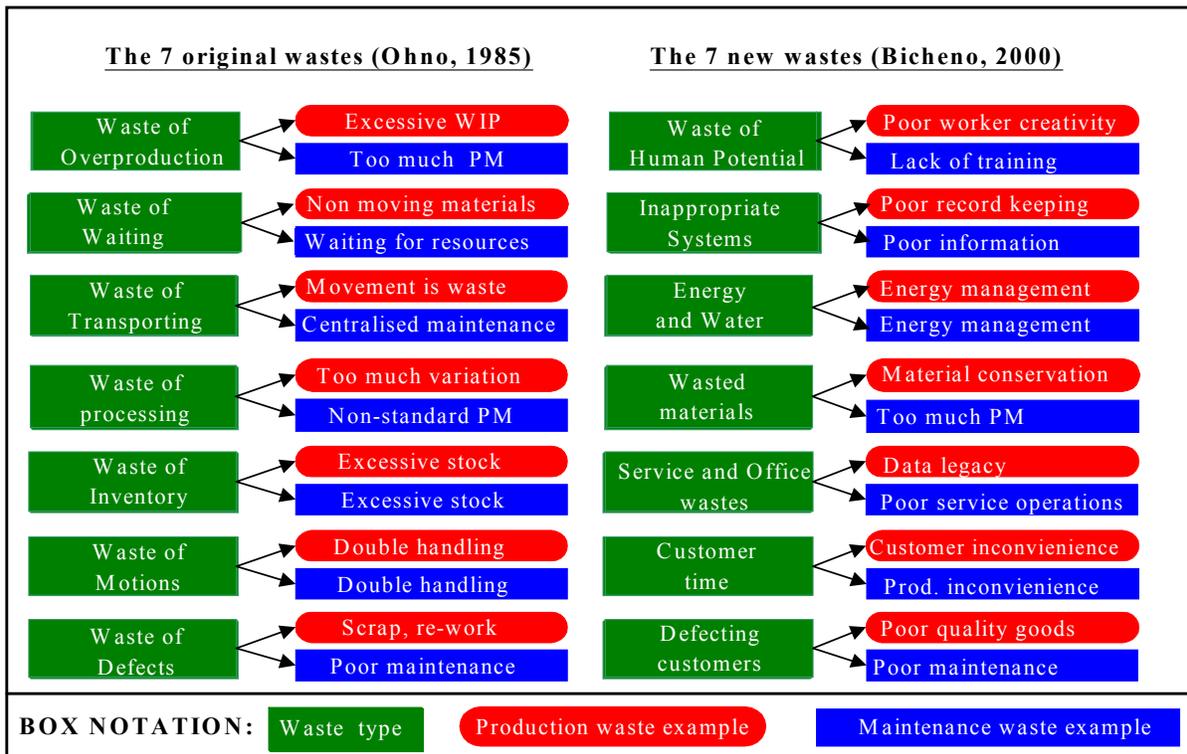


Figure 2, Lean production wastes and analogous wastes within maintenance

Research has shown that other lean thinking approaches and techniques, not just TPM, are used by maintenance to support their activities (Davies and Greenough, 2001). However, this research could not identify a strategy for generic lean practice implementation, or a comprehensive list of lean activities used by maintenance.

### Possible lean thinking activities within maintenance

Lacking strong evidence for a generic implementation order of lean practice, efforts have been made to formalise the introduction (Chang, 2001), however these focus more on production (Chang, 2001; Monden, 1994; Shingo, 1989), and purchasing issues (Womack and Jones, 1996; Womack *et al.*, 1990; Chang, 2001) than maintenance. As no clearly

defined lean practice framework can be referred to, especially concerning the maintenance function for further research, an alternative approach needs to be taken.

A lean practice template comprehensive enough to fairly represent lean activities possible within a company and in particular the maintenance function was developed. Table 1 summarises various lean activities known and used by maintenance (Davies and Greenough, 2001) and additional lean activities possible within a company as a framework. Table 1 selection groups similar components together where possible, and makes use of known lean practices (Chang, 2001; Davies and Greenough, 2001). See Table 1 for additional references.

Source (reference)	Lean activities (approaches / techniques)	Lean emphasis (see Figure 1)	Perceived benefit examples
Monden 1994	5S (CANDO)	Participation	Improved asset M'tance
Nakajima 1988	TPM	Prevention	Asset uptime
Nakajima 1988	OEE	Improvement	Asset availability
Bicheno 2000	Standards	Improvement	Standardised work
Hines et al 1997	Mapping	Process	Task improvement
Bicheno 2000	Inventory management	Waste	Improved turnover
Henderson <i>et al</i> 1999	Visual management	Task visibility	Workforce involvement
Bicheno 2000	Root cause problem solving	Improvement	Defect reduction
Bicheno 2000	Continuous improvement	Gemba	Improved efficiency
Imai 1986	Kaizen activities	Improvement	Waste reduction
Shingo 1989	Pokayoke	Prevention	Improved throughput
Bicheno 2000	Process activity mapping	Time	Improved utilisation
Bicheno 2000	Self audits	Visibility	Self-evaluation
Bicheno 2000	Story boarding	Visibility	Information access
Monden 1994	Kanban	Pull	Task control
Bicheno 2000	Scenarios	(Decision)Pull	Organisational learning
Henderson <i>et al</i> 1999	Takt time	Customer	Rate uniformity
Bicheno 2000	Lead time mapping	Time	Lead time breakdown
Bicheno 2000	Value focussed thinking	Variation	Aid decision making
Bicheno 2000	Supplier associations	Partnership	Cost reduction
Semler 1993	Open book management	Partnership	Ownership

Table 1 A lean reference framework

### **An overall measure of maintenance performance with indicators of lean activity**

Future research could lead to the development of a common generic lean strategy for the maintenance function. In the meantime, a framework of lean activities for reference has been developed that provides a summary of lean activities possible within a company and maintenance in particular. The next section discovers which lean activities presented in Table 1 are measurable in terms of maintenance performance.

- **Performance measurement**

Performance measurement is the process of quantifying action and can be defined as measuring the efficiency and effectiveness of action (Neely *et al.*, 1994; Neely *et al.*, 1995). Overall, the use of performance measurements and their strategic importance to organisations have been well-documented (Kaplan and Norton, 1992). On a more essential level, efficiency and effectiveness measurements focus on the central issues of the business which are usually cost, quality, delivery, people, suppliers, markets and new product introduction (Bicheno, 2000; Kaplan and Norton, 1992; 1996). However a lack of research in the practical implementation and use of performance measurement systems has been noted (Bourne *et al.*, 2000.).

- **Maintenance performance measurement**

To measure the efficiency and effectiveness of the maintenance function, performance measurements should reflect all relevant factors that affect performance (Niegel, 1994; Jardine, 1970). Stated simply, any choice of action concerning performance measurement generally and within maintenance should fulfil at least two fundamental criteria: all actions should be viewed in relation to the organisation, and should satisfy the requirements of the decision-maker. (Neely *et al.*, 1994; Neely *et al.*, 1995; Bourne *et al.*, 2000; Niegel, 1994; Jardine, 1970).

Various index and quality-based methods for measuring maintenance performance and for controlling maintenance effort have been developed ((Kutucuoglu, 2001; Jardine, 1970). Measures regarding various lean activities have also been developed (Kutucuoglu, 2001; Nakajima, 1988; Dal *et al.*, 2000). However, it has been suggested that these measures, although beneficial as monitors, are either not suitable as sole performance measures or require further research (Kutucuoglu, 2001; Dal *et al.*, 2000).

A set of measures of performance measurement needs to be developed that can relate to the organisation and satisfy the decision-maker's needs. For this research, the decision-maker requires descriptive performance information that may indicate change within maintenance through circumstance or improved activity, in particular those activities possibly related to lean thinking issues.

- **An overall measure of maintenance performance**

A number of desirable properties should be considered when developing a measure of maintenance performance (Jardine, 1970; Dal *et al.*, 2000). These relate to the ease of data retrieval, cost of retrieval, and ease of understanding (i.e. the results), through administration, effectiveness and overall costs. Two such methods of measurement when summarised comprehensively satisfy the change through action variables of the maintenance function (Priel, 1962), and fundamental criteria of maintenance performance measurement (Niegel, 1994). Figure 3 shows a representation of an overall maintenance performance measure developed from these summarised performance measures.

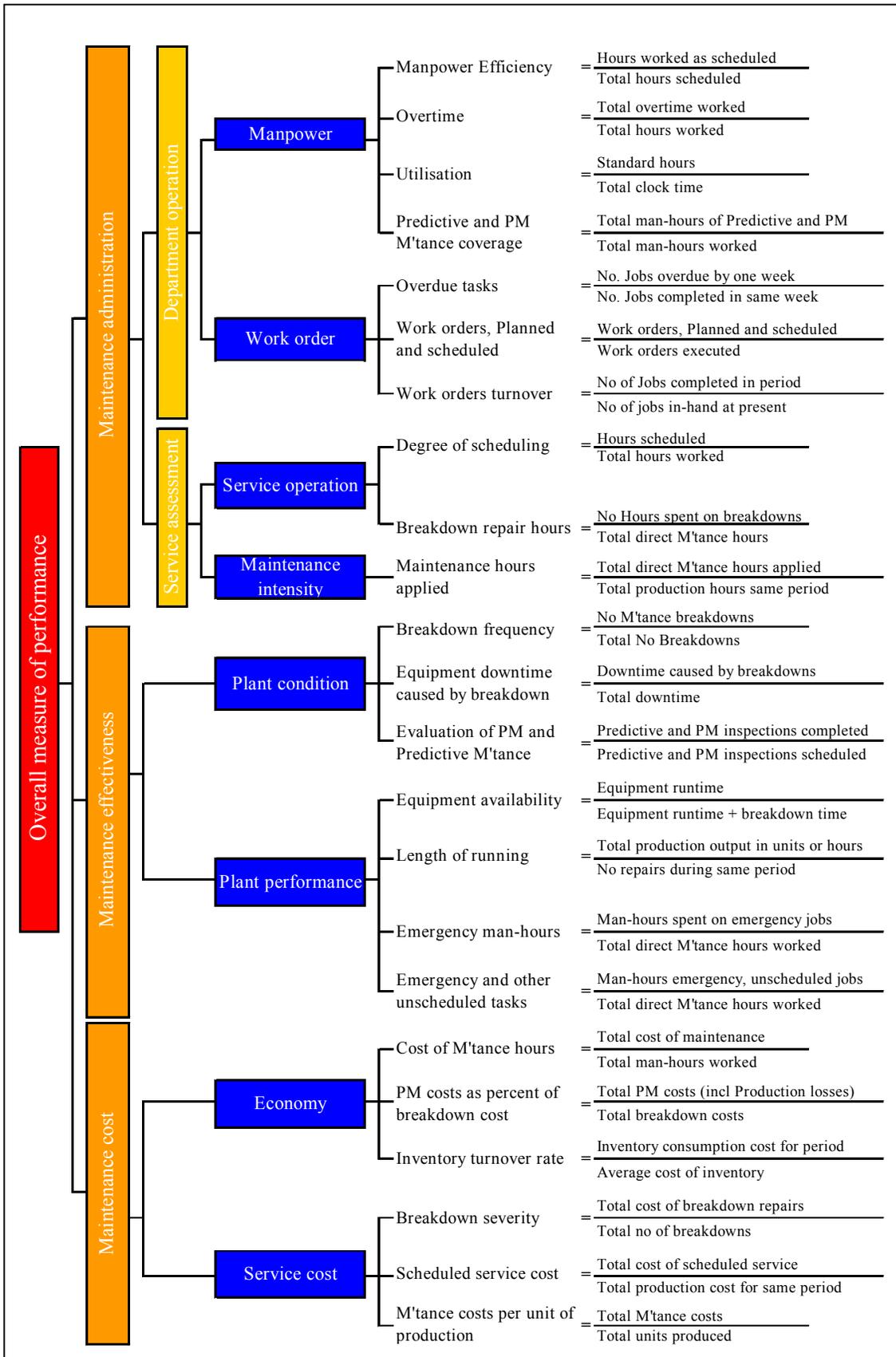


Figure 3 Overall measure of maintenance performance

## **Concluding summary**

The concept and use of lean thinking refers to the total enterprise and is aimed at adding value to an organisation through the elimination of waste. The maintenance function is expected to add value through its activities, requiring greater management integration within the enterprise. However, despite some methodologies associated with lean thinking being used by maintenance, evidence could not be found to support a generic structure for lean activities. Furthermore, there is no evidence that suggests a suitable methodology that can identify possible improvements for the maintenance function of lean thinking activities, other than direct operational measures.

It is evident from the literature, research, and management perspective that the maintenance function would benefit from a lean approach to align with business objectives. As a contributor towards an organisation's profit, there is a need for maintenance to improve efficiency. These elements are fundamental characteristics of lean thinking and are implemented using TPM and other approaches to support maintenance activities. The added need of management to measure improvement through use of these and other techniques calls for a strategy of generic lean practice implementation and performance measurement.

Research has also shown that there is little evidence of a defined order of lean practice, or a comprehensive list of lean activities used by maintenance. As no clearly defined lean practice framework can be referred to, a comprehensive template sufficient to represent lean activities possible within a company, and in particular the maintenance function, needs to be developed.

For this research, descriptive performance information that may indicate change within maintenance, through circumstance or improved activity (in particular those activities possibly related to lean thinking issues) is required. A framework for reference has been developed that provides a summary of lean activities possible within a company and maintenance in particular. Activities are identified as measurable in terms of maintenance performance, taking into account that activities may be used by maintenance.

## **Future work**

Future research will focus on further development of performance indicators for lean maintenance. It will also concentrate on the refinement of an overall measure of maintenance performance usable by organisations. The overall aim is to develop a standard methodology for comparing improvements within maintenance against the introduction and use of lean thinking practices. Additional research will also help define a standard performance framework for maintenance departments to benchmark their own improvements.

Case study research, within a number of different companies, has been undertaken to identify lean thinking within maintenance, and to investigate the value of such measures of performance. Initial results suggest a greater use of lean thinking by maintenance than otherwise suggested in the research, and that improvements have been noticeable both subjectively and quantitatively. As such, this research will continue to develop the themes discussed within this paper.

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