

## Understanding Lean Six Sigma as a Waste Square

Article (Published Version)

Gillespie of Blackhall, Robert (2022) Understanding Lean Six Sigma as a Waste Square. Academia Letters.

This version is available from Sussex Research Online: <http://sro.sussex.ac.uk/id/eprint/109497/>

This document is made available in accordance with publisher policies and may differ from the published version or from the version of record. If you wish to cite this item you are advised to consult the publisher's version. Please see the URL above for details on accessing the published version.

### **Copyright and reuse:**

Sussex Research Online is a digital repository of the research output of the University.

Copyright and all moral rights to the version of the paper presented here belong to the individual author(s) and/or other copyright owners. To the extent reasonable and practicable, the material made available in SRO has been checked for eligibility before being made available.

Copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational, or not-for-profit purposes without prior permission or charge, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way.

## *Understanding Lean Six Sigma as a ‘Waste Square’*

Dr. Robert Gillespie of Blackhall OBE PhD

---

### **Abstract**

For decades, manufacturing has successfully applied Lean and Six Sigma methodologies to resolve process problems.

Lean (Manufacturing) in the west derives from the Japanese Toyota Production System (TPS) (J. K. Liker, 2004; Womack & Jones, 2003) influenced post-war by W.E. Deming and developed during the 1950s; and Six Sigma (Breyfogle, 2003) was introduced during the 1980s by Motorola in the USA. These techniques are perfectly tested, function well to improve process efficiency and effectiveness, and fill a crucial role among current process-improvement methodologies. Lean and Six Sigma are thus widely applied, from industry to services, from healthcare to banking; however, those who have not learned and practised the approach sometimes struggle to find an ‘umbrella’ concept to properly understand what they are.

This short paper attempts to provide such an explanation by proposing Lean Six Sigma as a complementary efficiency and effectiveness waste model (George, 2002).

### **What do Lean and Six Sigma really do?**

Lean and Six Sigma are used to improve processes.

But first, what are *processes*?

Practitioners understand processes as work using resources (people, materials, equipment) to produce intended outputs: this definition assumes that processes generally

function to produce desirable outputs, whether assembling cars, banking or performing brain surgery. However, processes do not always function acceptably.

If there is a tried and tested method of running a process, this way is recorded, often in writing, under TPS as a ‘Standard Operating Procedure (SOP)’. Updated SOPs inform and instruct operators on the best currently accepted way to run the process. Such attention to operator skills and to process learning bring TPS to be described as a sophisticated *socio-technical system* (J. Liker & Meier, 2007) formalised by SOPs across the operator/equipment interface.

Processes can be quick, thus employing time (and resources) *efficiently*; and processes can be precise, so producing without error, that is *effectively* (George, 2002). To achieve such efficiency and effectiveness, Lean and Six Sigma methodologies provide tools to make processes faster (more efficient) on the one hand, and to produce more on target (to be more effective) on the other (Wheeler, 2000).

The section below outlines these tools.

## Lean tools

What the west calls Lean tools were developed by Toyota initially to reduce working capital in their manufacturing. Aiming at one-piece flow and only line-side inventory (Ohno & Bodek, 1988) Toyota is largely able to successively assemble hundreds of versions of a car (colour, options, trim, motor, etc.) along a single production line in the sequence in which they are ordered.

Essentially, Lean removes ‘Non-Value Added’ process time (and space) by applying methodologies which ultimately result in smooth low-stress work. The techniques and jargon of Lean attack process lead time and foster flow in one way or another (Womack & Jones, 2003), and include: -

- *Automated machine stopping* in case of error, attracting immediate correction by the operator (*jidoka*) and audio-visual signals of production line stoppage (*andon*).
- *Cellular* manufacturing to make flow visible.
- *Identification* and elimination of *Non-value added time* using *VSM*, which is *Current- and Future-State Value-Stream Mapping*, using time-data enriched process maps.

- *Kaizen*: focussed PDCA<sup>1</sup> process-problem solving to attain continuous improvement.
- *Kanban*: small *lot-size* production using *Pull* where one-piece flow is not usable.
- *Pull*: *Components* consumed in a downstream process supplied by the upstream *process* only as and when ‘*called*’ by the downstream; the upstream *stops producing* when downstream demand is met.
- *Poka-yoke*: error prevention which improves capability by making *process* mistakes impossible to commit, or at least immediately obvious.
- *SMED*: machine set-up time reduction to tend towards one-piece flow.
- *Takt time*: the time to produce a single piece at an average demand level.
- Theory of Constraints controlling bottlenecks (Goldratt, 2004) using *Takt-time* analysis and production levelling (*heijunka*).
- 5S: Process ‘housekeeping’ providing uncluttered, logical, visual control of process flow.

## Six Sigma tools

The Lean end-to-end, process-long view represented in the Lean Value-Stream Map is totally different from the vertically focussed analysis used in Six Sigma of variation within *individual* process steps. In ensuring process-output precision and accuracy, Six Sigma tools improve (Wheeler, 2000): -

- Process *Capability*, which is the aptitude of each process step to precisely meet its output specifications, and;
- Process *Stability*, which is the aptitude of the process not to vary (or shift or drift) over the longer term from its calibrated settings.

---

<sup>1</sup>Deming Wheel problem solving - Plan Do Check Act

Six Sigma is thus a methodology to attain process *effectiveness*, that is, to produce by better *meeting specifications* and by better controlling process variation. Six Sigma meets quality, rather than process lead time objectives; it is about doing things well, rather than doing them quickly, which is the primary goal of Lean. To achieve this, Six Sigma adopts different tools (Breyfogle, 2003) using another jargon, including: -

- A team-based, process-problem solving approach using DMAIC<sup>2</sup> to focus on individual process steps, suppliers, customers, inputs, outputs and process parameters.
- Cybernetic negative-feedback models to control process capability and stability, so better respecting customer specifications.
- FMEA<sup>3</sup> to reduce process risk.
- Statistical methods to measure and to analyse process capability and stability using parametric and non-parametric statistical analyses.
- The Experimental Method<sup>4</sup> to build process-regression models to optimise performance parameters and robustness.

## Lean Six Sigma together

Michael George (2002), promotes the joint practice of Lean and Six Sigma in, *Lean Six Sigma: Combining Six Sigma Quality with Lean Production Speed*. In statements which illustrate the efficiency role of Lean and the effectiveness role of Six Sigma, this author writes:

In the case of Lean, the key metric (*used to measure and to improve process lead time*) is Process Cycle *Efficiency* (PCE), which is the ratio of Value-Added time to total Process Lead Time (PLT). (George, 2002)

Thus, **Lean** addresses process lead time to make processes **efficient**, however:

Most of the methods and instruments associated with Six Sigma *do not focus on time*; they are concerned with identifying and eliminating defects. (George, 2002)

---

<sup>2</sup> Define, Measure, Analyse, Improve, Control: process-problem solving method

<sup>3</sup> Failure-Mode Effects Analysis

<sup>4</sup> Design of Experiments (DOE), or Experimental Method

Thus, **Six Sigma** addresses quality to make processes **effective**.

In this way, a combined Lean Six Sigma model can be seen to bring together:

1. A Lean *efficiency* vector through *lead-time reduction* supporting working capital reduction.
2. A Six Sigma *effectiveness* vector through *quality impact*, supporting direct cost reduction.

This is illustrated by a Process-Waste Square below (Fig. 1), which models the joint mechanism of Lean Six Sigma.

## The Process-Waste square

To sum up, Lean tools *generally* attack wasted time and working capital, as a methodology of *efficient* process; and Six Sigma, *generally* attacks quality related direct cost as a methodology of *effective* process. In this model then (Fig. 1),

Lean efficiency is about working quickly;

Six Sigma effectiveness is about working well,

where most work processes engage both speed and quality.

The function of Lean to eliminate wasted process lead time and of Six Sigma to eliminate process nonconformity are *plausibly* orthogonal and synergic to process performance, and the *Process Waste Square* (Fig.1) represents how Lean and Six Sigma appear to impact performance by working together across approximately orthogonal axes of waste. Thus, Lean and Six Sigma methodologies act independently but can be seen to act jointly on process waste: Six Sigma by reducing waste resulting from process variation and output non-conformities; and Lean by reducing wasted process time.

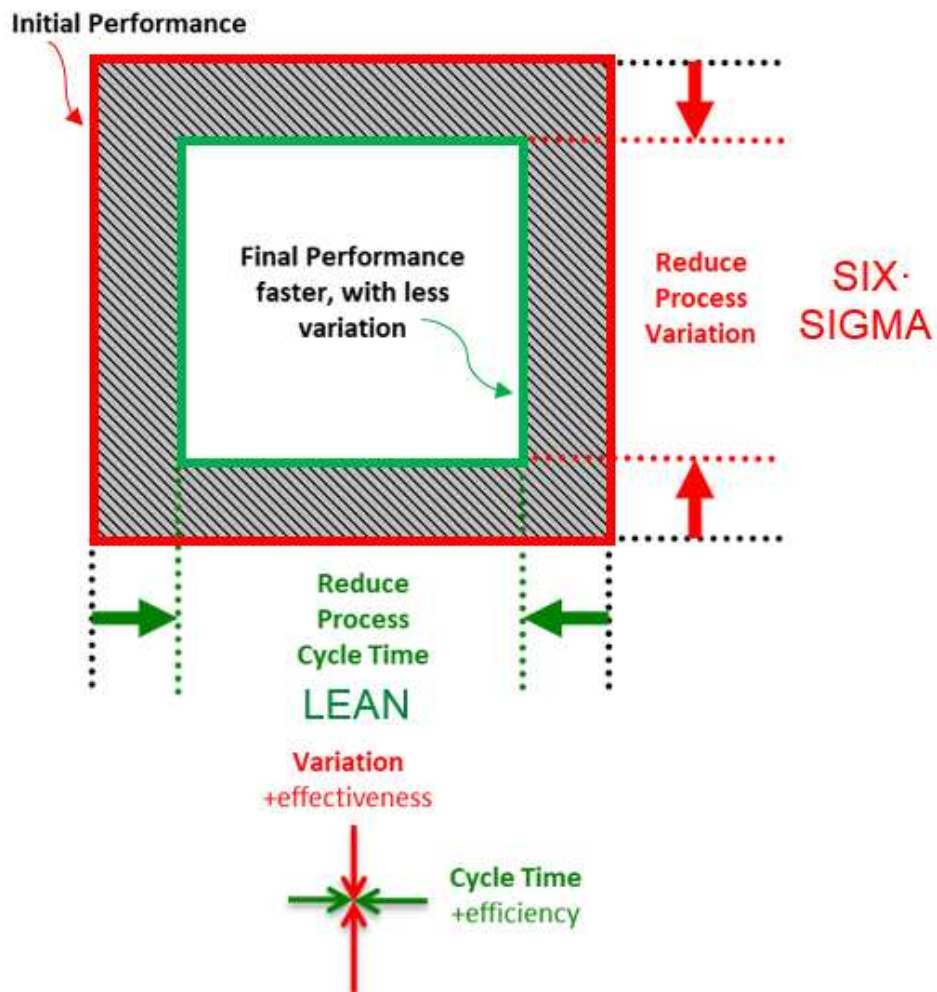


Fig 1. The Process-Waste Square

Ultimately, the Waste Square *intuitively* structures understanding of how these two methodologies interact.

## The Waste Square – a caveat

TPS possesses a capability (effectiveness) tool, *poka yoke* (Shingo, 1986), designed ex-ante to avoid error occurring in the first place, which thus impacts the vertical, process-variation axis of the Waste Square (Fig. 1). Indeed, successful error avoidance implies *infinite* capability, so *poka yoke* is a powerful effectiveness tool, but where *poka yoke* is difficult to apply ex-ante, for example to measurement of continuous data, Six Sigma statistical techniques are usually the analytical ex-post alternative.

Similarly, in discussing Six Sigma, George (2002) recognises poor quality as wasted time, he thus identifies an efficiency interaction on the horizontal axis of the model,

## Bibliography

- Breyfogle. (2003). *Implementing Six Sigma, Second Edition: Smarter Solutions Using Statistical Methods* (2 edition). Productivity Press.
- George. (2002). *Lean Six Sigma: Combining Six Sigma Quality with Lean Production Speed* (1 edition). McGraw-Hill Education.
- Goldratt, E. M. (2004). *The Goal* (3e édition). Routledge.
- Liker, J. K. (2004). *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer* (1 edition). McGraw-Hill Education.
- Liker, J., & Meier, D. (2007). *Toyota Talent: Developing Your People the Toyota Way* (1st edition). McGraw Hill.
- Ohno, T., & Bodek, N. (1988). *Toyota Production System: Beyond Large-Scale Production* (1st edition). Productivity Press.
- Shingo, S. (1986). *Zero Quality Control: Source Inspection and the Poka-Yoke System by Shigeo Shingo* (1 edition). Productivity Press.
- Wheeler, D. J. (2000). *Understanding Variation: The Key to Managing Chaos* (Revised edition). Spc Pr.
- Womack & Jones. (2003). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. Simon & Schuster.