The Impact of Business Improvement approach Lean Six Sigma on the EnvironmentIntroduction

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The purpose of this paper is to describe how an established business improvement approach, such as Lean Six Sigma, can have both a positive and negative impact on the environment. Further, that by understanding this impact such an approach can be used to better effect by organisations from any business sector. As, many thousands of companies globally already use Lean Six Sigma as part of their business strategy; it is therefore considered of value to raise awareness of these benefits and disadvantages to the environment. A final aim is to clarify why that for Lean Six Sigma to be sustainable in the long term, it is prudent for organisations to use a combined approach with environmental practices to maximise overall benefits.

What is Lean Six Sigma?

Lean Six Sigma (1) is a business improvement methodology widely used in industry (2) to reduce the amount of Non Value Added (3) waste to increase efficiency, quality and reduce costs. These wastes defined by Shingo (4) include excess inventory, transportation, defects, over production, waiting time, processing times, and motion of employees.

Lean Six Sigma has evolved over the last century and the journey has included Taylorism (5), the principles of mass production, statistical process control (SPC), and the Toyota production system (TPS). This has led ultimately to the combination of the key tools from Lean Manufacturing and Six Sigma. These two different approaches were initially conducted separately but it has been demonstrated that when used they are used in parallel it is possible to increase the overall benefits of improvement projects within organisations. This journey is demonstrated in figure 1.

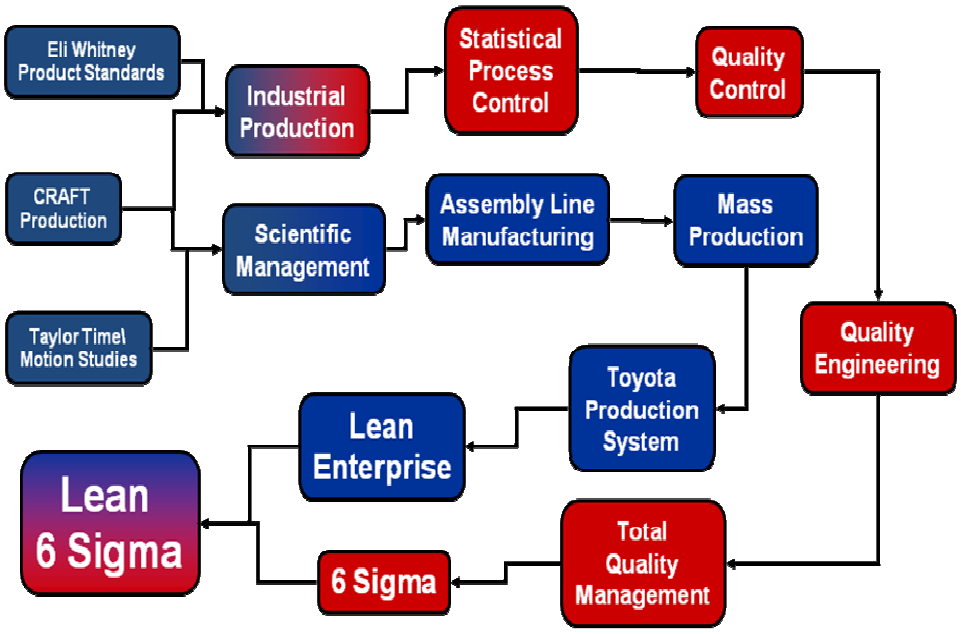

Figure 1 – Evolution of Lean Six Sigma

Lean

The term "Lean" is derived from Lean Manufacturing or Lean Production and it became highly popular in the 1990's and remains so till this date. However due to its growing use in other sectors and organisational functions, now tends to be known simply as "Lean"

Lean is defined as the reduction of waste within a process or system using a systematic and continuous approach. The resulting benefits include reduction in lead-time to get a product or service to the customer and significantly reduced costs. Many refer to the 5 Lean principles (6) which is a 5 step process developed to take an organisation towards a lean culture. Within each of the lean principles various tools and techniques are utilised to reduce wastes.

The philosophy and roots of Lean can be traced back to Toyota production system (TPS) from the 1960's. Lean takes many of the TPS principles and enhances them with additional methods and uses a more structured approach. However, the ethos of changing the culture at all organizational levels and empowerment remains.

Six Sigma

Six Sigma was originally developed by Motorola the mid 1980's and is popular in virtually all industry sectors. It is a focused improvement approach aimed at all levels of an organisation with the fundamental aim to identify and significantly reduce the number of defects, initially within manufacturing but subsequently broadened to business processes including finance and customer service.

Six Sigma as an approach focuses on reducing the level of variation within processes and the term "six sigma" originates from the principles of process capability. It is deemed that for a process to exhibit six sigma quality it must operate with defect levels which are less than 3.4 defects per million opportunities (DPMO). This is seen as the desired standard for world class companies to aspire to and meet. Six Sigma also incorporates

the philosophy of data driven decision-making, which is incorporated to avoid assumptions and guesswork wherever possible.

Motorola's success with Six Sigma (savings in excess of $17 Billion over the last 20 years) has influenced many thousands of other organisations to embrace the principle of the six sigma approach most notably General Electric (GE) and Honeywell.

The main reasons for this success are that Six Sigma follows a structured approach, which has a clear customer focus on achieving measurable financial returns for a defined project. It combines this with an ethos of strong management commitment, training and support. Each project has a defined team which contains champions (usually influential company members), black belts (project trainers and leaders) and Green Belt (project implementers).

Existing Research on Lean Six Sigma and the Environment

A literature review to find existing research and work has been conducted in the area of Lean Six Sigma and its environmental impact has yielded some interesting results. One key conclusion, is that although there is widespread information about Lean, Six Sigma, Lean Six Sigma and its benefits including waste reduction (7) , these are not widely viewed in Environmental terms but are seen as more akin to the working environment (8).

Of the publications found that are relevant to environmental impact, these are predominantly associated with Lean, not Lean Six Sigma. As a combined approach LSS is a much more powerful as a technique and is now superseding Lean and Six Sigma as individual approaches, as demonstrated by the likes of companies such as Lockheed Martin, Caterpillar, Textron, Honeywell and General Electric (9).

With reference to Lean, the ideas of Sawhney (10) are a case in point. Within the metal cutting supply chain he discusses "however less obvious is the impact of lean on the environmental performance of the manufacturer". He proposes a methodology to examine the relationship between Lean principles and their overall environmental impacts.

Further evidence of Lean and its associated benefits to the environment are highlighted by Folke (11) who examined how to use Lean and Green production techniques to improve industrial compliance with the effluent regulations at a Romanian tissue paper mill. This resulted in an 87% reduction in wastewater discharge.

Regarding Six Sigma there is again little in the way of recognition of the combined benefits with the environment. However Nukala (12) recognises that rapid technological developments and the growing desire of customers to acquire the latest technology have led to a new environmental problem "waste". He proposes that "as a result, both consumer and government concerns for the environment are driving many original equipment manufacturers (OEM) to engage in additional series of activities stemming from the reverse supply chain" Using the Six Sigma method devised by Motorola, Nukala explores how to improve the synchronisation of the closed loop supply chain.

There is limited evidence that Lean and Environmental consultancy have been combined into a working framework. Ball (13) discusses the applicability of lean management principles to improve business operations in an environmental consulting company. He presents the principles "in a manner that environmental managers may use as a model to achieve specific operational goals". Examples illustrate how lean concepts were applied at two environmental consulting firms. This however has not resulted in full adoption of the process the reasons for which need to be clarified.

There is recent recognition by Venkat (14) regarding the potentially negative side of Lean, but this does not expand to Lean Six Sigma. This argument is backed up by Womack (15) who questions moving operations to the East when this can be environmentally damaging due to the increase transportation.

Of the research conducted so far in the area of Lean and the Environment the most detailed work undertaken would appear to be that of the Environmental Protection Agency (EPA) in the USA. The EPA has developed a Lean and Environment toolkit (16). This toolkit in conjunction with business partners has been developed by combining Lean tools and techniques with principles of environmental management. Its purpose is to enable Lean practitioners to improve both the business and environmental performance of an organization. It has a structured approach using some of the key Lean tools but these have been further tailored in environmental terms. The toolkit itself is very logical and easy to understand and implement within just about any business. The EPA has a range of business cases to back up the argument (some examples are discussed below in benefits of Environmental Lean Six Sigma (ELSS). However, the work conducted by the EPA is mainly focused on Lean and the Environment and not ELSS.

IBM has also developed an approach called Green Sigma (17). This methodology is part of a series on carbon management and it identifies the increasing on pressures of increasing legislation on organisations and rising energy costs effecting businesses. It utilises a number of Key Performance Indicators (KPI's) such as logistics, carbon footprinting and energy usage. They have adapted certain lean tools such value stream mapping into carbon value stream mapping and the voice of the customer into the voice of the environment.

Overall positive effects of Lean Six Sigma has been identified in a limited number of fields, however there appears to be very little research on its negative impact on the environment and, more importantly, how this could be overcome.

Environmental Benefits of Lean Six Sigma

Lean Six Sigma (LSS) has not been developed to benefit the environment however from personal experience of implementing these types of projects it seems that in many cases it could be environmentally friendly. By reducing lead times, defects and costs of products or services, there are concomitant and significant environmental gains. This is not to claim that implementing Lean Six Sigma always results in environmental benefits and further research should be undertaken to understand more about this.

Below are a few simple examples of how LSS can benefit the environment for a manufacturing company based on real life experiences, using the Lean tool 7 wastes (4 wastes identified as examples): -

Transportation

Reducing the physical distances between processes on the factory floor which require mechanized trucks or handling systems would inherently reduce energy consumption and any emissions from these transport systems. It would also provide the business benefit of reducing the time to produce the product and costs.

Waiting times

LSS uses line balancing techniques (18) between manufacturing processes. Conducting this process will improve the flow of the products and significantly reduce the waiting times between processes. Any waiting time is seen as a waste as machines and heating and lighting are still operable. Therefore by reducing the waiting times, a significant positive impact of organizations yearly emissions will result.

Defects

LSS tools such as Statistical Process control (SPC) are used to reduce unwanted variation of products. This variation could be in terms of dimensional accuracy in relation to a customer specification. Reducing the variation and the number of defects outside the defined specification will result in less scrap or rework. This would therefore save time, costs and would overall lower an organizations CO2 and energy usage. There would also be the environmental benefit of less disposal costs of any scrap or defective products.

Over production

In situations where products have a shelf life, such as in the food sector, producing what the customer wants when they want it will have significant positive effects on the environment. This is a fundamental part of Lean principles where a customer "pull" is utilized rather than a manufacturer "push" into the marketplace. Any waste food from over production will invariably end up in landfill sites. Producing food when the customer wants in the right quantities will also help the food manufacturer save costs on fuels and materials as well as a reduced CO2 footprint.

A good case study of where combining the benefits of Lean and the environment can be seen from EPA's work with Aerospace organisation Lockheed Martin. The Manassas's plant in the USA used lean thinking on its chemical and waste management processes which identified that large amounts of chemicals were being sent to the hazardous waste stream without being used. Just in time principles (JIT) were therefore implemented for their chemical management system. This comprised of delivering the chemicals in the right quantities based on real time demand. These chemicals were delivered at an appropriate frequency, which helped reduce inventories and reduced storage costs and eliminated chemicals going beyond their shelf life. This, however, is a Lean and environment case study and dedicated Lean Six Sigma and the environment case studies are much harder to find.

Environmental Disadvantages of Lean Six Sigma

As mentioned earlier in the paper Lean Six Sigma was not developed with environmental impact in mind and, although some organisations are researching how Lean and/or Six Sigma can be combined with environmental management processes, very little has been done to investigate the negative impact of Lean Six Sigma.

One exception is that of Venkat (14) who discussed the negative impact of Lean and as LSS is a combined approach his findings would still apply. His research demonstrated that by following lean principles for a supply chain (transport and storage) of ready meals for a food manufacturer the overall emissions in certain circumstances were higher than for a more traditional supply chain. Reducing inventories of cold stored products saved costs but meant that more frequent deliveries were required of the product, which in turn increased transport emissions. The study did recognise however that its focus was on carbon dioxide emissions and did not cover other environmental wastes. As a result, its findings are not conclusive and further research is required.

Another negative of Lean Six Sigma comes from personal experience of the approach. A key tool used in the approach is design of experiments (DOE). This particular tool is used to optimise processes by changing the inputs to a process to influence the output. To understand this in simplified terms, in the case where the desired output is miles per gallon (MPG) for a car, the inputs that could be changed to influence the MPG include the tyre pressure, the number of passengers (additional weight), or the driver of the car. Changing the combination of these inputs by conducting a number of experiments means it is possible to determine the optimal settings of each input to achieve the best output.

The DOE tool is used by numerous industry sectors to optimise products and processes but isn't always environmentally friendly. One popular area of application is the chemical sector where it is used to optimise the raw materials required. By changing the inputs it is possible to achieve a better product, but in order to do so the ingredient that is increased in weight or volume could be one which is bad for the environment. This is a key area where Lean Six Sigma and more specifically some of the tools and techniques used do not consider the environmental consequences

Market need for Environmental Lean Six Sigma Assessment (ELSSA)

So far it has been argued that LSS is currently widely implemented without considering the environment and the positive or negative impact it can have. Yet, with arguments about climate change becoming ever more frequent (19) with CO2 levels at their highest for 650,000 years, and businesses and the general public face increasing taxes and legislation in this area (20-22) such ignorance seems overdue for remedy. These issues could provide the catalyst for implementing an approach to LSS which fundamentally concerns the environment. However, no structured approach on "how to do this" appears to exist or if so is seen as common practice within the widespread LSS community.

An integrated approach to reducing business waste and "saving the planet" could be very desirable in many industry sectors. This approach could be applied to Small to Medium sized Enterprises (SME's) to large Global organisations and within many functions (finance, production, quality, planning, marketing, R&D, Service etc) of an organisation. Therefore it is proposed that the development of an ELSSA approach would have a significant market need within just about any industry sector.

Conclusions and Recommendations

The research undertaken so far has identified that LSS can have both positive and negative environmental impact. It is argued that which will depend largely on whether the environment is considered during the different phases of the LSS approach. There is evidence that LSS tools and techniques are beginning to be adapted to areas such as energy usage, water usage/pollution and air emissions; however the deployment of this into industry is still very much in its infancy. Furthermore, knowledge of this work within the LSS community is still limited and is not currently recognised as of high importance by practioners even though environmental issues are one of the most talked about topics in the media. The recognition of LSS and the environment thus far appears to have more positive attention from the environmental community.

Many companies using LSS recognise the benefits of the approach and also recognise environmental management practices but don't see the connection between the two. The recognition that developing a specially tailored approach using the core principles of LLS but keeping the environment in mind would help companies achieve their business goals whilst meeting the latest environmental legislations.

The next steps of this research are to develop a generic questionnaire to be issued to various industry sectors that will determine in more detail the benefits of LSS to the environment. By examining different sectors, it is hoped to determine both similarities and distinct unique differences where environmental benefits can be obtained. The questionnaire will also aim to determine any negative impacts caused by the implementation of LSS. By understanding the negative effects it will be possible to investigate how they can be ameliorated so that a compromise between environmental and business performance can be made. From this analysis, it is hoped to understand the percentage distribution between positive and negative environmental effects of LSS - something which does not currently appear to be well understood.

The long term aim of the research is to develop the Environmental Lean Six Sigma Assessment process (ELSSA process), which is depicted in concept form below in Figure 2.

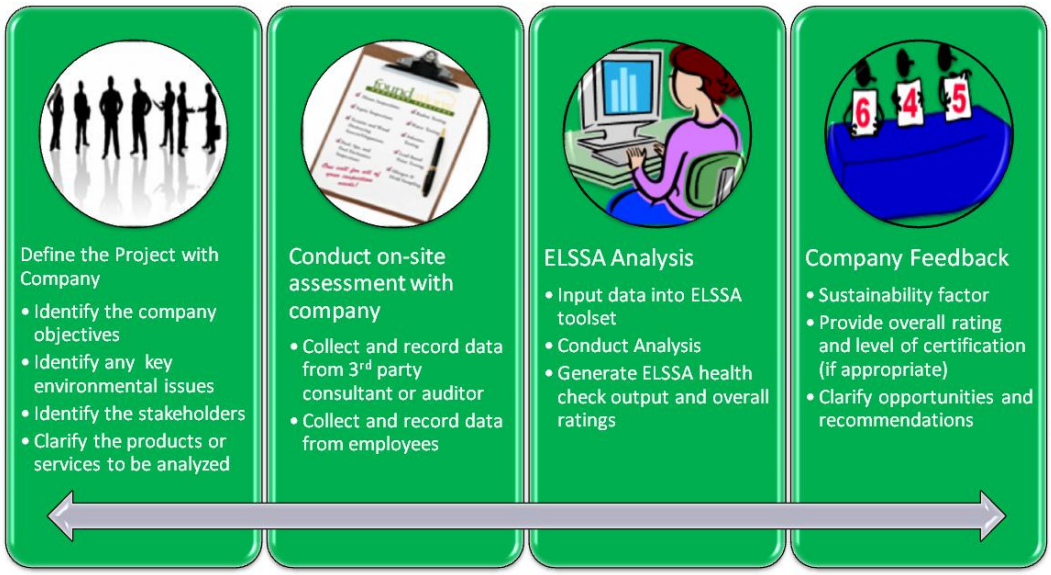

Fig 2 Proposed Environmental Lean Six Sigma Assessment (ELSSA) Process

The concept assessment process is currently in its infancy in development terms but it is designed as a structured approach that can be used by companies and consultants to provide clarification of the environmental condition of the organization with a measured rating or value. The framework consists of four main phases each with a control gate to the next phase. The assessment process would identify where the strengths and weaknesses lie in relation to Lean Six Sigma and the environment as well as where the opportunities for improvement lie within the company.

The ELSSA process could be conducted by consultants or internal trainers and will examine the sustainability of the environmental Lean Six Sigma approach across all levels of the organization. It will also examine how well each of the environmental lean six sigma tools are being used and give an overall rating or score. The ELSSA approach could be useful for identifying training requirements for individuals or teams at any level from senior management to operational roles. It could be used to re-align a company's strategy and key objectives. Further work on this concept will be detailed in future papers.

Finally for LSS to be sustainable in the long term, it needs to evolve to take into consideration environmental legislation. Otherwise, the benefits of the LSS approach could, in the circumstances highlighted in this paper, be reduced or eliminated by fines imposed by the growing number of environmental laws being passed globally. This is especially true in the United Kingdom where the newly passed (House of Commons 8th July 2008) Climate Control Bill with its ever increasing environmental targets for organisations to meet, has at this point no strategy or framework to help these companies meet these targets.

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