
# Lean production:

# Successful implementation of organisational change in operations

# instead of

# short term cost reduction efforts

by

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**Abstract**

**Lean production:**

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This lean survey investigates critical success factors for sustainable lean implementation.

Applying lean production tools of the Toyota Production System (TPS) has helped Porsche to increase their operational result from -122 million € in 1994 to 933 million € in 2004.

The goal was to

- Shed light on the concept of lean production
- Analyse tools and concepts that have to be applied in order to become a lean operating organisation and evaluate how and in which functions these tools can be used

and

- Investigate how important the lean philosophy and management behaviour are as well as related implementation issues.

This lean survey first describes the philosophy, the tools and the supporting management behaviour to successfully implement lean manufacturing and continuous improvement.

As shown, lean is not simply a set of tools and concepts, which can be implemented by command and control. Rather it is a fully integrated manage-

ment and manufacturing philosophy and approach in which the human dimension is the single most important element for success.

Primary data form a survey was gathered from a number of organisations that are applying lean principles in order to analyse the critical success factors for sustainable lean implementation.

Recommendations based on a variety of hypothesis tested were made to implement organisational change and the philosophy of the Toyota Production System (TPS).

It was concluded that cultural and leadership aspects seem to play a more important role than the TPS tools itself.

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| | |
|---|---|
| OEM | Original Equipment Manufacturer |
| EU | European Union |
| TPS | Toyota Production System |
| TQC | Total Quality Control |
| CEO | Chief Executive Officer |
| COO | Chief Operating Officer |
| VSM | Value Stream Mapping |
| ToC | Theory of Constraints |
| 5S | Sort, Simplify, Sweep, Standardise, Self discipline |
| WIP | Work in progress |
| SMED | Single minute exchange of die |
| OTP | On time delivery |
| TPM | Total Productive Maintenance |
| OEE | Overall Equipment Effectiveness |
| GM | General Motors |
| . $\chi^2$ Test | Statistical test (Chi-Square) which evaluates if methods or classifications are independent |
| $H_o$ | Null Hypothesis |
| $H_a$ | Alternative Hypothesis |
| t-test | Statistical test which compares the means of two distributions |
| p-value | Probability value |
| HR | Human Resources |
| R&D | Research & Development |

## 1. Introduction

### 1.1 Recent economic trends in German automobile branch

In order to underline the need for cost reduction through cultural change the actual situation in Germany's automobile branch has to be assessed.

General Motors has been reporting losses for the last 5 years is now going to lay off 9,500 jobs in their German plants in Bochum, Kaiserslautern and Rüsselsheim. The management wants to reduce the annual fixed costs by 500 million € until 2006, because Opel lost 397 million € in the first three quarters of 2004 in Europe. Major reasons for these losses were quality and engineering lead-time issues (Sass, 2004).

German OEMs (Original Equipment Manufacturers) are investing in countries like India or China. Volkswagen, one of the major car producers, has sold more cars in China than in Germany in 2003. However, also eastern European countries are becoming more and more important in this sector. Table 1 shows current production capacities and labour costs.

**Table 1: Capacity and labour costs: Germany versus Eastern Europe (Peters, 2004)**

| Country | Planned production capacity (automobiles / year) | Labour costs [€/h] |
|---|---|---|
| Poland | 550.000 | 5,40 |
| Slovakia | 850.000 | 3,30 |
| Czech Republic | 800.000 | 4,20 |
| Hungary | 200.000 | 4,70 |
| Slovenia | 200.000 | 7,30 |
| Germany | 5.430.000 | 28,50 |

During the last couple of years the share of foreign production by German OEMs has steadily increased to a current level of 45. Production sites in the 5 most important new EU member states (see table 1), are currently able to manufacture 1.4 million cars. This capacity is expected to double within the next 3 to 4 years. Low labour costs as well as competitive productivity and quality of the workforce lead to even more engagement of the manufactures. Overall it is estimated that roughly 500 out of 1,300 OEM suppliers have production facilities in Eastern Europe.

Since the above-mentioned countries are EU members, the investment risks are decreasing. Additionally these locations are even more attractive since tax rates are around 20%, which is roughly 16% less than in Germany.

The share of production-oriented labour (production, machine set–up, maintenance) in Germany is expected to decrease from 30.7% today to 24.0% by 2010 (Peters, 2004).

This brief overview about the actual situation and economic trends shows that there is a threat of losing even more competitiveness if car manufacturers and the industry keep relocating labour without having made all possible efforts to make both significant and sustainable cost reductions first.

Examples like Porsche in Stuttgart, Germany have recently shown that turnarounds are even possible in areas where labour costs are not competitive (Johnson, 1997). Applying lean production tools of the Toyota Production System (TPS) has helped Porsche to increase their operational result from -122 million € in 1994 to 933 million € in 2004.

Porsche basically applied concepts and tools that have made Japanese car manufactures successful.

Now companies like Opel are facing closedowns instead of really trying to implement lean change before making final decisions about relocations.

### 1.2 Aims and objectives

The questions to be answered are:

- How did Porsche make the difference in their business transformation process?
- How far have other companies gone on their journey to become a lean enterprise?
- Is lean production only seen as a cost reduction tool?
- Are companies applying lean manufacturing tools?

The answers seem obvious – companies are always trying to reduce waste in operations in order to become more profitable. However, there are success stories like Porsche and Toyota as well as failures.

This lean survey was derived from the correlation of these reflections, with the author's organizational, "on the job", experiences with helping clients to seek cost reduction opportunities linked with lean initiatives. As the process of becoming lean is tied together with organisational change it cannot be done in the short run. Experience shows, if lean implementation is not fully integrated in a company's management system, it is very often not successful. Moreover, improvement programs sometimes worsen business performance, triggering layoffs, low morale, and lead to the collapse of commitment to continuous improvement.

The aim of this lean survey therefore is to

- Shed light on the concept of lean production
- Analyse tools and concepts that have to be applied in order to become a lean operating organisation and evaluate how and in which functions these tools can be used

and

- Investigate how important the lean philosophy and management behaviour is, as well as related issues during implementation.

### 1.3 Lean survey structure

After introducing the topic in chapter 1, chapter 2.1 gives an overview of the background and evolution of operations management and the Toyota Production System and chapter 2.2 deals the implementation of the lean philosophy and the management of the lean transformation process with focus on critical success factors.

The findings of these chapters will then be verified with the help of the results gained from a survey (chapter 3) conducted among the author's employing organisation's customer base which mainly operates in the automotive (suppliers), industry in Western and Eastern Europe. Chapter 4 deals with recommendations resulting from the survey.

Thus, the lean survey will be based both on literature review and on data gained from field research.

This approach will allow for viable conclusions to be drawn, which might eventually help organisations on the road to lean.

## 2 Literature review

### 2.1 Historical development of production: from scientific management to the Toyota Production System

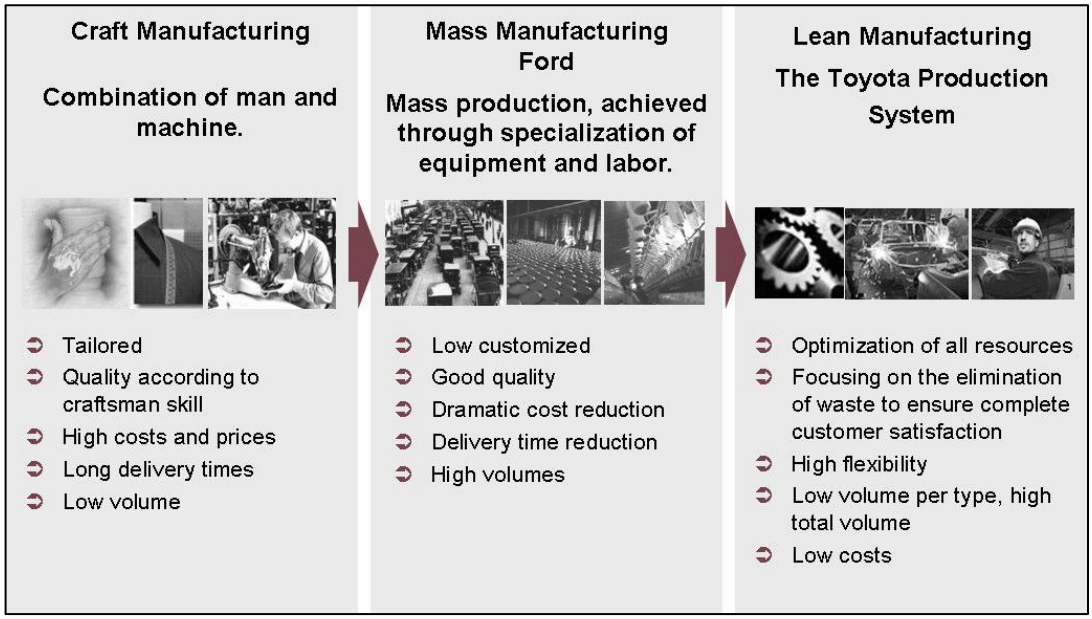
#### 2.1.1 The history of production

In the following section, the evolution of lean production and its evolution from

Taylor's work to its deployment at Toyota will be reviewed.

Lean production has its roots in Taylor's work (deployment of reproducible processes) and Henry Ford's invention of the conveyor belt. The latter was the basis for mass production, which dominated the last century (Voss, 1995).

**Figure 1: The history of production (based on Chase, Aquilano, Jakobs, 1998)**




Taylor's theory states, that production efficiency can be greatly enhanced by closely watching individual workers, in order to find and eliminate wasted time and motion in the operation. Management could identify the one best way to do a job, determine the correct productivity level, and set a pay rate based on that level.

Taylor encouraged workers to suggest improvements and made management responsible for careful analysis of these suggested methods. Whenever it was found to be superior to the old, he wanted it to be adopted as the standard for the whole establishment (Chase, Aquilano, Jakobs, 1998).

This shows clearly, that even Taylor recognized the importance of workers for effective changes.

The year 1913 saw the introduction of the moving assembly line for the production of Ford automobiles, which reduced the lead-time from 12.5 hours to 93 minutes. However, the assemblers in Ford's mass production line had only one task – to put two nuts on two bolts or perhaps to attach one wheel to each car. They kept their heads down and thought about other things.

The next major paradigm change in the manufacturing philosophy took place in Japan. At the end of 1949 a collapse in sales forced Toyota to terminate a large part of their workforce. The engineers at Toyota came to the conclusion that Taylor's mass production was not efficient (Ohno, 1988). From this tentative beginning was born what Toyota came to call Toyota Production System (TPS) and, ultimately, lean production.

Coupled with total quality control (TQC) the TPS aggressively seeks to eliminate waste and causes of production defects.

As a consequence, Manufactures around the world are trying to copy the methods and began implementing TPS tools on existing mass production systems.

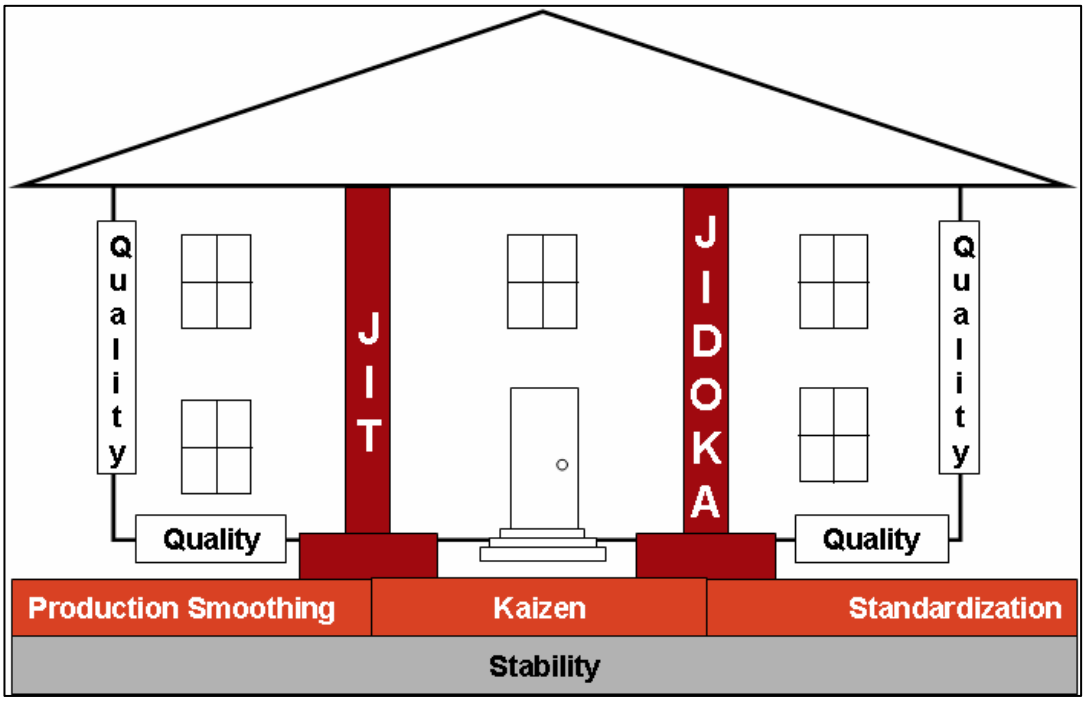
In the following paragraph the TPS basics will be analysed.

### 2.1.2 The evolution of the Toyota Production System (TPS)

After Japan had lost World War II Toyota's president wanted to catch up with America (productivity and quality) within three years.

The two pillars needed to support the TPS are just-in-time (JIT) and autonomation (Jidoka) or automation with a human touch (see figure 2).

**Figure 2: The Toyota Production System (based on Sears, Shook, 2004)**




The TPS assumes that all processes are stable (see figure 2) and therefore under control. It has to be said, that Ohno (1988) does not deliver a strategy to become lean, if a business still has unstable processes, i.e. in a production ramp up phase. Tempel and Holländer (2001) say that Ohno's TPS does not deal well with complex process control problems and does not give an answer to solve complicated problems across the whole value chain.

According to Ohno (1988) just-in-time means that, in a flow process, the right parts needed in assembly reach the assembly line at the time they are needed and only in the amount needed. The goal is an implementation of a flow production with zero work-in-progress (inventory). When trying to work just-in-time, people at Toyota experienced that conventional operations management methods did not work well: a problem early in the process always resulted in a defective product later in the process. Parts were produced without regard to the later process steps, which resulted in huge and wasteful inventories (Shingo, 1989).

The second pillar is called autonomation. This principle was invented when Toyoda Sakichi, the company founder, created an auto-activated weaving machine at the end of the 19th century, which stopped instantly if one of the warp or weft threads broke (Mildenburg, 2000). This human machine intelligence allowed Toyota to enforce three concepts (see table 2), which led to dramatic productivity improvements.

**Table 2: Jidoka**

| |
|---|
| 1) Whenever a defect product is produced the machine stops automatically, which prevented the operations from producing more than one defective. |
| 2) This fact allowed Toyota to reduce the workforce and implement multi-manning at their machines: one operator was able to run more than one machine. |
| 3) At Toyota's assembly lines trigger liens were introduced which allowed operators to stop the assembly line whenever a certain problem appeared which forced management awareness on everyone. |

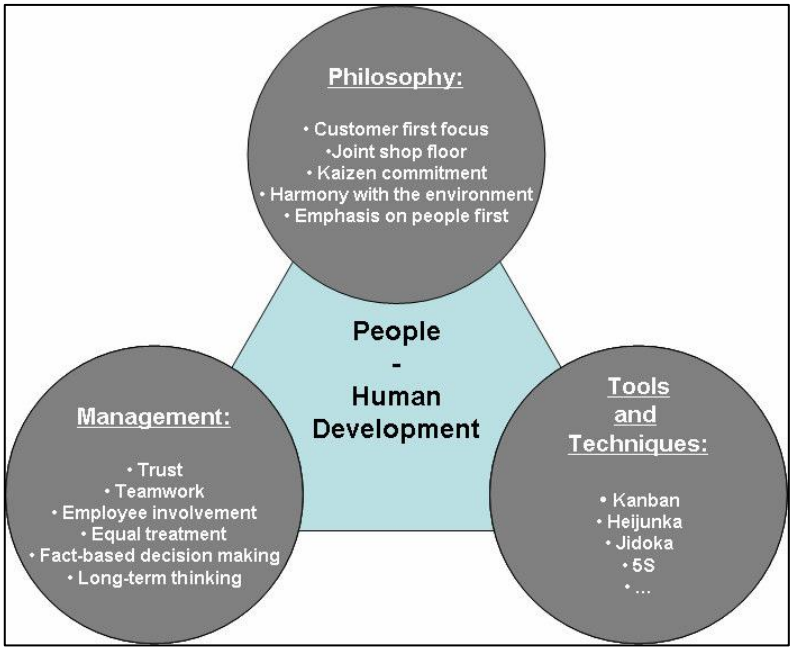
However, only few manufactures have managed to imitate Toyota successfully, even though the company has been extraordinarily open about its practices (Spear, Bowen 1999). Copying only the above mentioned principles seems not to be enough.

Gary Convis (Convis, 2001), an American Toyota Motor Manufacturing President calls the TPS an integrated and interdependent system involving many elements: the tools, the philosophy and management (see figure 3). He criticizes that Ohno's theories were misunderstood, because a lot of managers tried to implement the individual elements like JIT or Jidoka instead of the entire approach. It misguides engineers to think that if the tools are implemented they have captured the essence of TPS.

In his opinion, Ohno's theory lacks the direction that the key to successful TPS implementation is the total commitment of everyone in the organisation to make it work.

These findings guided him to his TPS triangle model. In the middle of this triangle human development is at the very core of the TPS (see figure 5). It is implemented through example, through coaching and through understanding and helping others to achieve their goals.

**Figure 3: The Toyota Production System (based on Convis, 2001)**




Comparing Convis' and Ohno's model shows clearly that TPS is not simply a set of tools and concepts, which can be implemented by command and control. Rather it is a fully integrated management and manufacturing philosophy and approach. Convis (2001) underlines, that the human dimension is the single most important element for success. However, the fact that neither Ohno (1988) in his TPS, nor Shingo (1989) in his following study of the TPS, are mentioning these aspects, but only concentrate on the techniques, may have led to the misunderstanding that the tools are the most important aspect and not the fundamental manufacturing philosophy. That perhaps made companies around the world only copying these tools and making experiences that the TPS does not work in their environments.

The TPS clearly reveals excess manpower but as human development stands in the centre it is strictly not a means of making workers redundant. Drickhamer (2004) points out, that lean still has the connotation that it is about getting rid of people although the idea is to empower shop floor personnel. This is very important to understand, as people today may associate lean with layoffs. Moreover, Ohno (1988) even suggests using freed-up resources for further improvements.

### 2.1.3 Lean Production

In 1990 Womack, Jones and Ross created the term lean production. Since then, it has become common to use the word lean as shorthand for lean production.

They define lean as a way to create new work rather than simply destroying jobs in the name of efficiency.

In their definition, lean is a thought process and a philosophy, not a tool, used to look at a business whether it is manufacturing, service or any other activity with a supplier and a customer relation with the goal of eliminating non-value added tasks (Womack, Jones, Ross 1990). The principles of lean production include teamwork, communication, efficient use of resources and continuous improvement (Kaizen, see figure 2). It can be said that they pioneered the idea of applying the concepts outside of manufacturing environments.

According to Marchwinski and Shook (2004) lean production is a system for organising and managing product development, operations, suppliers, and customer relations that requires less human effort, less space, less capital, less material and less time to make products with fewer defects to precise customer desires, compared with the previous system of mass production.

The concepts of both Ohno (1988) and Womack/Jones (2003) search for ways to reduce lead time by eliminating waste it can be said that the terms “Lean” and “Toyota Production System” are synonymous.

However they do not deliver detailed tools on waste reduction in indirect areas such as marketing, sales, research and development or others. It has to be said, that although Shingo (1989) points out that the TPS focuses on improvements in the factory and the office, the application of the lean tools on the rest of the value chain, i.e. in engineering is not clearly structured and explained in Ohno’s TPS (1988). This may be one reason why still the majority of continuous improvement activities in most companies focus on the shop floor.

Although the basic philosophies of Ohno (1988) and Womack/Jones (2003) apply to all work, the standard tools of lean manufacturing are much less effective when taken away from the shop floor and applied to office processes without any modification (Simon and Schuster, 1996). Drickhamer (2004) says that working under different circumstances presents different problems,

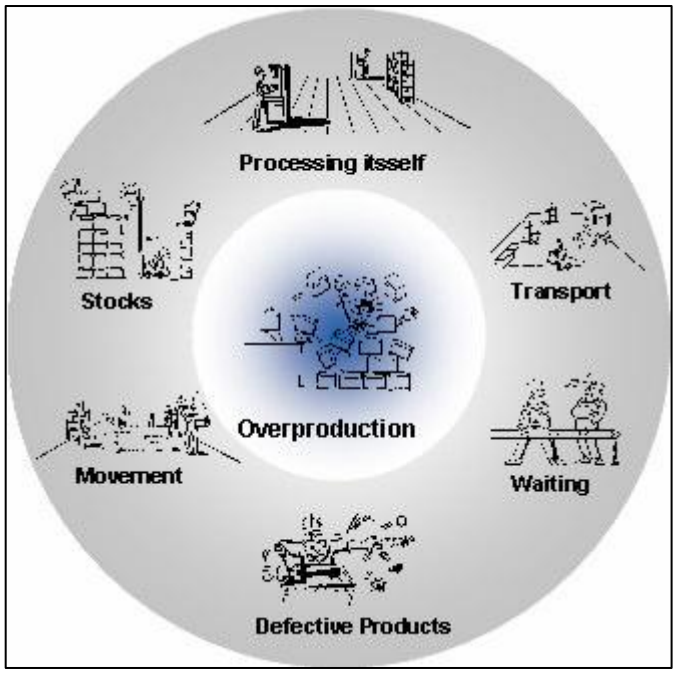
which requires different tools and different thinking. Benders and Morita (2004) add that the TPS is an abstraction and therefore a factory conforming for 100% of the model cannot be found.

Therefore the TPS must be seen as an ideal to which many organisations strive.

### 2.1.4 The seven wastes and lead time reduction

Then basic idea to reach that ideal is the principle of using Kaizen or continuous improvement to reduce waste. According to Shingo (1989) waste is any activity that does not contribute to operations and therewith does not add value, such as walking to get parts, unpacking supplied parts or waiting for lots to be finished. Value-adding activities transform materials, changing form or quality; they turn raw materials into parts or products (i.e. assembly, welding, stamping, heat-treating or painting). Figure 4 shows the seven wastes according to Ohno (1988).

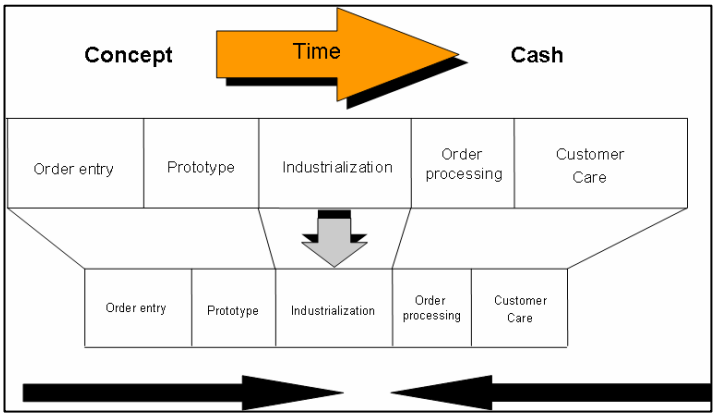
**Figure 4: The seven wastes (based on Ohno, 1988)**




Lareau (2003) additionally has identified four groups of office waste, such as people waste (i.e. lack of goal alignment, waiting and motion), process waste (i.e. control in the sense of only monitoring, variability, lack of standardization and errors), information waste (missing, irrelevant and inaccurate information) and asset waste (office inventory, buildings and offices that are not fully used and transport of information).

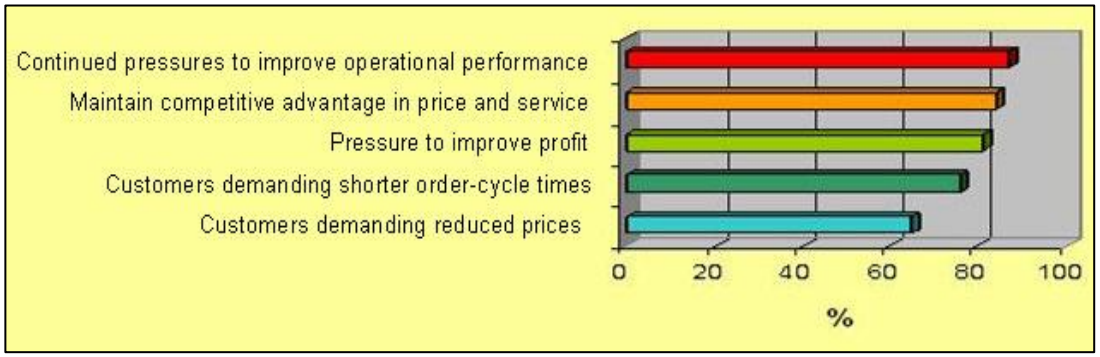
According to Womack and Jones (2003) the focus of continuous improvement lies on the time line from the point where the customer gives the company an order, to the moment at which the money is collected. The time line (see figure 5) is reduced by eliminating the non-value added waste.

**Figure 5: The timeline (based on Womack and Jones, 2003)**




Summarising, it would be interesting to find out why are organisations are trying to copy the TPS and applying lean thinking in their own environments. Wheatley (2005) has discussed these reasons (see figure 6).

**Figure 6: Top 5 business factors for lean adoption (Wheatley, 2005)**



The basic lean philosophy leads to the following critical factors (see table 3) that organisations have to understand in order to successfully implement TPS principles.

**Table 3: Critical success factors resulting from the TPS philosophy**

| | |
|---|---|
| **Basic TPS and lean ideas** | **Understanding the TPS focus**<br>- The TPS focus lies on improving quality and on-time delivery by lead-time reduction. Cost savings based on productivity improvement follow automatically. |
| | **Understanding the lean philosophy concerning productivity improvements**<br>- The idea is to identify excess manpower and use it effectively in the continuous improvement process. Therefore the lean philosophy has nothing to do with headcount reduction. |
| | **Understanding the need to eliminate waste**<br>- Waste has to be reduced in operations and offices. |
| | **Understanding the meaning of the basic TPS tools**<br>- The basic tools just-in-time and autonomation help to implement the lean thought process in operations but they seem to lack adaptability the rest of organisation, i.e. in marketing or finance. |
| | **Understanding that the TPS is a fundamental management philosophy and not a set of tools to improve production**<br>- The TPS is not a set of tools but a fundamental manufacturing and management philosophy, in which human development builds the central point. |
| | **Understanding the focus on people first**<br>- The key element in the development of lean production is the role of teams and the individual. |

In the following section of the lean survey the critical success factors for the lean transformation process will be analysed.

## 2.2 Implementation of the lean philosophy and the lean transformation process

Part 2.1 has shown that the techniques are important, but the basic tenet of TPS is that people are the most important asset and for that reason management must have a shop floor focus in order to identify non-value adding tasks.

As lean transformation is a profound change in business culture (Womack, Jones, Ross, 1990), implementation processes fail due to various reasons and it has to be said, that both Ohno (1988) and Shingo (1989) do rarely mention the change process itself.

In order to shed light on the additional critical success factors of successful TPS and lean implementation the Henley transformational framework was used to classify the relevant criteria mentioned by various authors. In the following part of the literature review this model was used as a frame of reference as the authors dealing with lean and TPS mainly only provide bullet points but no holistic approach or scheme. Table 4 gives an overview about the stages of a transformation process.

**Table 4: The Henley Transformational Framework (Herbolzheimer, 2003)**

| | |
|---|---|
| Mobilise for change | - Meet stakeholder expectations, reputation and sustainability<br>- Lead the change: communicate the vision, motivate, energise, overcome barriers to change and determine change agents<br>- What culture? |
| Translate strategy into objectives and initiatives | - Determine the nature and scale of change, critical gaps<br>- Define strategic goals, concrete objectives and initiatives<br>- Establish performance parameters |
| Design the change process | - Design choices and change architecture<br>- Set implementation agenda and milestones |
| Align the organisation | - Organisational structure<br>- Internal organisation (systems, policies and procedures; rewards and incentives)<br>- Skills, capabilities and resources (financial, people, infrastructure) |
| Organisational learning | - Build the learning organisation<br>- Manage innovation/knowledge and training |

In the following part of the lean survey these stages will be used a guidance to analyse the additional critical success factors for sustainable lean implementation.

### 2.2.1 Mobilise for lean change

- Stakeholder expectations

Successful lean implementation is approached from a strategic perspective and companies seek to reach certain goals with lean initiatives. As creating a lean workplace requires changing the corporate culture a robust change management strategy is needed (Parks, 2002). Such abrupt policy changes require a top-down approach to decision making (Kobayashi, 1995). Mader (2005) emphasizes the need for strong top management leadership in the implementation process. Carefully selected Kaizen events should support the organisation's strategy and vision.

Only seeing lean as a quick fix, may give some employees the impression that Lean might not work in certain environments, i.e. in low volume operations. Spear (2004) says that at Toyota managers act as enablers and in that sense coach co-workers in solving problems instead of just fixing them. Strong leadership is essential for the success of this initiative.

Together with the CEO or COO driving the lean changes, top-down operating through empowered teams is critical to success. This is done through continuous improvement. Benders and Morita (2004) call the continuous improvement system the backbone of TPS. The untapped knowledge of people on the shop floor is used for Kaizen (change for the better). Therefore, in the lean enterprise, the role of leaders and supervisors is to motivate, coach, train and facilitate the work of those adding value rather than to tell them what to do. People are kept enthused by continuously being allowed to change their processes in Kaizen events (Vasilash, 2000) and to personalise the changes where appropriative, for example by locating their equipment or positioning their machines on their own. In his opinion, employees should be free to allocate time to improvement.

The question however is how this can be linked to today's individual piecework pay schemes. Therefore internal pressure groups like i.e. workers' councils have to be integrated into the change process.

Especially in a crisis, where companies like Porsche had to lay off people, it is difficult to motivate people to improve productivity. Neither Ohno (1988) nor the other authors give satisfying answers how this should be done.

If an organisation reinvests in early improvement the positive feedback creates even bigger improvement. Carter (2004) suggests a no-layoff policy in

order to overcome operators' fears that productivity gains may cost them their jobs. However, short term cost pressure may not allow organisations to reinvest productivity savings that have been gained in the beginning and force managers to cut personnel costs. Management needs to address issues like that from the very beginning of the lean transformation.

Operating through empowered teams means that the lean organisation is less hierarchical than traditional businesses. It may be difficult to implement lean top down while at the same time empowering the workforce, which again shows that a clear implementation strategy is needed. One possibility would be that executives join Kaizen events on a regular basis.

- Lead the change

Convis (2001) says that in the TPS management has no other role than motivating and engaging large number of people to work together toward a common goal. Therefore the organisation should not be shaped through the power of will, but rather through example, through coaching, through helping others to achieve their goals.

Womack and Jones (2003) on the other hand, underline the need for strong will at the top management during the transformation process. Joe Day, US-based Freudenberg CEO, for example, spent 35% of his time during the first two years of their lean rollout (Vasilash, 1996).

Womack and Jones (2003) add that leaders should create a crisis in order to force the organisation to adopt lean thinking and that should be part of the strategy. It is interesting to see, that the other authors do not underline this point; however, the above mentioned Porsche and Toyota example clearly show that their success was based on a crises. Therefore lean thinking should first be applied in a troubled business unit or facility. This should be supported by the senior management demonstrating impatience during lean performance reports. The question arises, how companies can drive the lean transformation if there is no crises.

Whereas Womack and Jones (2003) additionally suggest removing managers who do not accept new ideas like lean, Henderson and Larco (2000) prefer confrontations and a few heart-to-heart talks to convince concrete heads among the management team. Paris (2000) on the other hand suggests ig-

noring those who chose to focus on their day-to-day assignments and not to punish them.

- Lean culture?

In the TPS philosophy the value of the produced goods from a customer's point of view is the starting point for improvements (Womack, Jones, 2003). They call this the first principle of lean. Therefore, the whole organisation has to concentrate on the place, where the value is created: the shop floor. This philosophy turns the lean enterprise upside down – departments and managers exist to support production, not the other way around (Henderson, Larco, 2000). Strong leadership is essential to communicate this idea. Convis (2001) adds that senior managers have to be willing to be involved in day-to-day improvements in operations. This needs the basic tenet that people in the TPS are the most important asset and not the TPS tools. Tempel and Holländer (2001) add that top management presence and availability on the shop floor is one of the most critical points during the lean rollout. Therefore a lean culture is characterised by emphasis on people first, trust, strong customer orientation and the joint shop floor.

### 2.2.2 Translate strategy into objectives and lean initiatives

- Determine the nature of change

Concerning the nature of change Keating (1999) et al. point out that successful improvement programs must grow organically. Generally they distinguish between two sources of commitment to improvement programs: managerial push and employee pull. Push ranges from mandatory participation in training and Kaizen events to financial incentives. On the other hand, pull arises when employees fully understand the benefits of lean and improvement potential for themselves independent from management's support. However, the initial stimulation may be guided by management push, which is clearly the implementation strategy of Womack/Jones (2003) and Henderson/Larco (2000). These points clearly show the difficulty in leading this process: a strong top down approach may feel employees being forced to change whereas a bottom up, organically grown approach may not lead to the expected results.

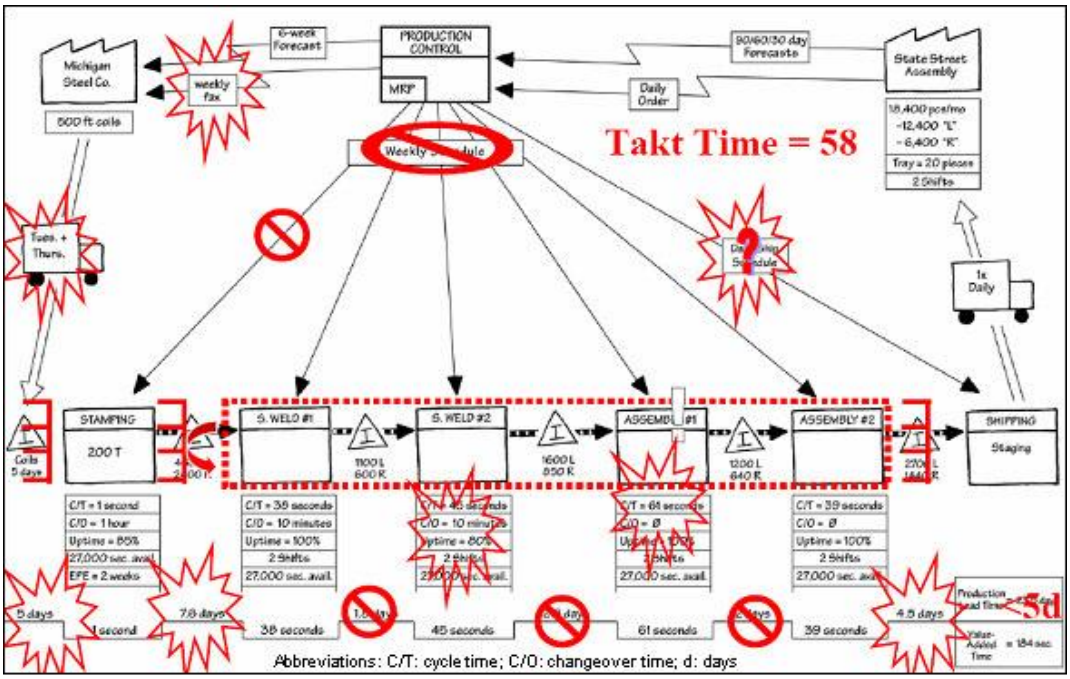
❑ Define lean initiatives

The TPS founder Ohno (1988) and Shingo (1989) concentrated on the production engineering point of view and both described in depth the tools and techniques. According to Womack and Jones (2003) the most important tool is the value stream map (VSM), which they call the second principle of lean.

A VSM is a simple diagram (see figure 7) showing every step involved in the material and information flows needed to bring a product from order to delivery and is therewith indispensable as a technique for visually managing process improvements. Mapping a process gives a clean picture of wastes that inhabit flow (Tapping, Luyster, Shuker, 2002).

Due to a high level of icon standardisation a VSM provides a common language for all personnel as bottlenecks and inventory are located and problem areas as well as wastes are identified (red Kaizen focuses in figure 7). As all relevant process data (number of machines and operators, machine cycle time, changeover time, scrap and rework and machine availability etc.) are additionally presented in data boxes, a Kaizen team gains inside into how the operation is truly running that day.

**Figure 7: Value Stream Map (VSM) based on Rother and Shook (2000)**




Afterwards mapping the current state, a future state, which identifies the opportunities to design a more efficient and waste-free value stream, is created.

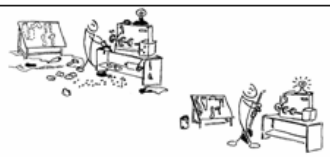
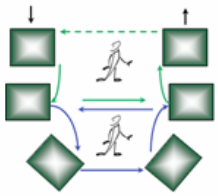
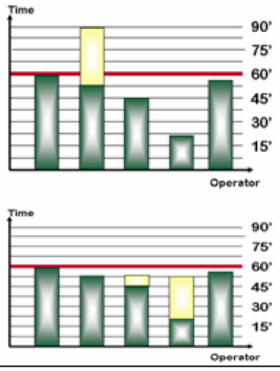
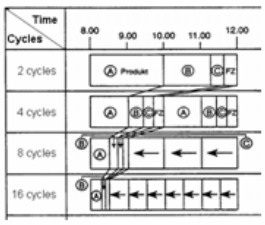
Unfortunately Rother and Shook (2000) do not deliver in depth comments how to choose a value stream for improvement. Overall value streams can be difficult to tackle due to their complexity and therefore prioritizing and targeting a relevant area of concern may be difficult for Kaizen teams. Tapping and Shuker (2003) have additionally developed a VSM concept to plan, map and sustain lean improvements in administrative areas. Figure 8 gives an overview about the other TPS tools that support JIT and Jidoka.

The TPS toolbox is used to implement flow and pull production principles, which Womack and Jones (2003) call the third and fourth lean principle.

In general it can be said that some of these tools lack applicability in certain environments, i.e. Takt time is only easy to be used in a one-product environment, because in most environments cycle times between different products in a cell may vary very much. Goldratt (1992) in his theory of constraints (ToC) suggests for that case adjusting operator cycles to the capacity bottleneck. However, the lean inventers do not prevent a tool for a typical batching environment like heat treating, mixing or painting were typically large lots have to be processed and tasks are not highly repetitive.

Additionally, it has to be criticised that Ohno (1988) says, that the TPS is implemented with Kanban but does not mention prerequisites for this at all, as Kanban only works in certain operational environments.

## Figure 8: TPS toolbox

| Tool | Sketch | Principle |
|---|---|---|
| **5S**<br><br>Sketch: Tempel/Holländer, 2001 |  | The 5S (sort, simplify, sweep, standardise, self discipline) describe workplace practices conducive to visual control and lean production.<br>They maintain the conditions in which products are made better and more cheaply, quickly and safely and are designed for organization of any workplace, including offices (Takeda, 2002). |
| **Flow and Cellular Production**<br><br>Sketch: Tempel/Holländer, 2001 |  | The TPS is an ideal system in which everything form raw materials to machining and assembly is linked in a coherent one-piece flow (Shingo, 1989).<br>According to Womack and Jones (2003) all activities (creation, ordering, and provision) of any good or any service should be made to flow: the advantages are short lead times, reduced inventory, highest possible flexibility during unplanned changes in customer demand and less quality costs. |
| **Takt Time**<br><br>Sketch: based on Rother and Harris, 2001 |  | "Takt" time is used to help match rate of production in a pace-maker process to the rate of sales. It answerers the question at which rate the customers are buying a product, i.e. one every 60 seconds (see red line).<br>It is equivalent to the total working time divided by the customer demand (Rother, Shook, 2000).<br>Cycle time is how frequently a finished unit actually comes off at the end of a cell.<br><br>When a company is chronically cycling faster than Takt time the company overproduces and uses more resources than required (Rother and Harris, 2001).<br>When the cycle time exceeds Takt time, a backlog is created and overtime has to be done. Therefore all work elements have to be balanced under the Takt time line. |
| **Production Smoothing (Heijunka)**<br><br>Sketch: Takeda, 1996 |  | Production smoothing means to break down the daily requirements into even smaller quantities (shift or hourly requirements, i.e. from every part every 4 hours to every part every 30 minutes)<br>A smoothed production is the most economical method of manufacturing by eliminating high fluctuations concerning quantity and product variety and by low work in progress (WIP) inventory (Takeda, 1996). |
| **SMED**<br><br>Sketch: Tempel/Holländer, 2001 |  | Order based and stockless production demands short setup times. SMED (single minute exchange of die) refers to the target of reducing changeover times to a single digit, or less than ten minutes.<br>The benefits of a SMED system are the reduction of finished goods inventories and WIP (work in progress) as well as a higher flexibility to fluctuating customer demand. |
| **Kanban: Pull Production**<br><br>Sketch: based on Ohno, 1988 |  | The American supermarket principle made Ohno (1988) thinking the production flow in reverse:<br>a later process goes to an earlier process to pick up only the right part in the quantity needed in the exact time needed.<br><br>Doing that, they people at Toyota experienced that the earlier process started only producing those parts that were withdrawn which led inventories and lead-time decrease and quality improve (Shingo, 1989). |

Both Ohno (1988) and Shingo (1989) concentrate on explaining the use of the above mentioned tools and call this the TPS, whereas Spear and Bowen (1999) argue that observers confuse these tools with the system itself. Drickhamer (2004) moreover asks to forget everything one knows about the tools as they are not a substitute for a good strategy to become lean. Demers (2002) adds that companies that do apply these tools in Kaizen workshops do not necessarily apply the whole TPS. In this sense the tools are just a means to an end and have to be adopted as necessary.

After the tools are used in the entire organisation, suppliers and customers have to be convinced to become lean, as JIT techniques affect the whole value chain. Therefore a long term, committed partnership is essential that in the case of success a win-win situation where savings can be shared is created (Tilson, 2001). However, this only works when resources from the companies involved form multi-disciplinary teams.

Paris (2000) proposes implementing Kaizen changes as quickly as one can. This is supported by Womack and Jones (2003) who suggest beginning as soon as possible with an important and visible activity in order to create a momentum for change in the organisation. A value stream map can be completed in only two weeks, after that changes should be implemented directly.

❑ Establish lean performance parameters

Before and after Kaizen improvements the results of the lean implementation have to be tracked. Henderson and Larco (2000) suggest the following performance measures beside the financial metrics: inventory turns, customer product returns measured in PPM (parts per million) and OTD (on-time-delivery) to customer want date.

Performance targets on these metrics should be set aggressively and raised as they are neared and an audit mechanism should be build to ensure that the lean program proceeds on track (Tilson, 2001). The question arises, if such a system of continuous pressure goes hand in hand with Kaizen team harmony.

Womack and Jones (2003) suggest using policy deployment (see figure 9). It summarises the goals, the projects for that year and the targets for these projects.

**Figure 9: Lean Policy Deployment matrix (Womack, Jones, 2003)**

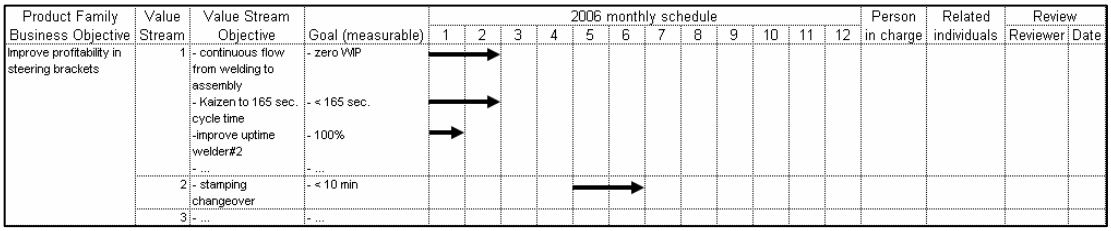
| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ★ | | | Reorganise by product families | | ★ | | ★ | | | | | | |
| | ★ | | Create productivity and quality improvement function | ★ | | | | ★ | | | | | |
| ★ | ★ | ★ | Create lean enterprises with suppliers | | | ★ | | | ★ | ★ | ★ | ★ | ★ |
| Identify value stream by product | Introduce continuous flow and pull | Dramatically improve quality | Selected Projects / Objectives / Improvement targets / Target $ results (current year) | Perform 6 major improvement activities / month | Form product teams within 6 months | Form lean enterprise within one year | Improvement teams: Product line reorganisation | Improvement function team | Product family A team | Product family B team | Product family C team | Product family D team | Product family E team |
| | ★ | | Reduce inventory by $30M | ★ | | | | | | | | | |
| | | ★ | Reduce inventory by $30M | ★ | | | | | | | | | |
| | ★ | | Reduce labour costs by $30M | ★ | | | | | | | | | |

### 2.2.3 Design the lean change process

- Setting a Kaizen agenda

Rother and Shook (2000) recommend that a value stream plan should be designed hand in hand with the value stream map: it contains step by step implementation plans on how to reach the future state value stream, including measurable targets, milestones and completion dates (see figure 10).

**Figure 10: Yearly value-stream plan (based on Rother, Shook, 2000)**



| Product Family | Value | Value Stream | | 2006 monthly schedule | | | | | | | | | | | | Person | Related | Review | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Business Objective | Stream | Objective | Goal (measurable) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | in charge | individuals | Reviewer | Date |
| Improve profitability in steering brackets | 1 | - continuous flow from welding to assembly | - zero WIP | | | | | | | | | | | | | | | | |
| | | - Kaizen to 165 sec. cycle time | - < 165 sec. | | | | | | | | | | | | | | | | |
| | | -improve uptime welder#2 | - 100% | | | | | | | | | | | | | | | | |
| | | - ... | - ... | | | | | | | | | | | | | | | | |
| | 2 | - stamping changeover | - < 10 min | | | | | | | | | | | | | | | | |
| | 3 | - ... | - ... | | | | | | | | | | | | | | | | |

However, this approach only delivers an implementation strategy for the operational level and lacks applicability if an organisation has to start at point zero. Ohno (1988) and Shingo (1989) do not deliver an overall approach a company could follow to become lean and Henderson and Larco (2000) only list the above mentioned tools (VSM, 5S, flow production, Kanban). Partly they add bullet points of key factors to success (management vision, strong leadership, lean expert training, setting performance targets and management impatience during the lean rollout) but do not really design an agenda for the implementation. Also Kobayashi (1995) only delivers the so called 20 keys to workplace improvement which are more a to-do list than a logical sequence.

### 2.2.4 Align the organisation

- Organisational structure

.As a lean factory shop floor does not make a lean enterprise Womack and Jones (2003) propose reorganising the company by value stream, which means rethinking the functional departments. Ohno (1988) does not go that far but clearly explains the function of internal customers and suppliers within the organisation.

However, also all supportive departments have active roles in the lean roll-out.

- Integration of engineering

As total lead time reduction is the overall goal, the introduction of new products (product-, process development, and industrialisation) has to be done in a very short period of time. Additionally, in order to produce zero defects it has to be ensured upfront that a product can be manufactured efficiently. Therefore engineers have to build mistake-proofing devices into the products and processes wherever possible and critical process parameters must be well understood. Tools for lead time reduction are simultaneous engineering, tools for quality assurance design for manufacturability and design for assembly (Voss, 1995).

- Integration of quality

In the TPS, quality personnel need to be highly skilled problem solvers. They take the lead in analysing defective parts that are rejected by customers and set up systems that help to ensure quality, i.e. decide on which parts require incoming inspection. They have to implement self-diagnostic test into processes to trigger immediate problem solving (Spear, 2002).

- Integration of finance

Most cost accounting processes involve standard costing systems. Industrial engineers and controllers, who usually create the standards include non value adding tasks like rework, walking or long setup times into work order documents and therewith into calculation and may feel comfortable when a cell is be working at 110% of standard. Maskell and Baggaley (2003) underline, that traditional standard costing systems actively motivate non-lean behaviours. As in there key measures are machine utilization and the amount of overhead absorbed by production it does not take long for supervisors and

operators to find out, that the best way to show good results is to batch quantities and to build inventory.

- Integration of HR

The HR function has to support the cultural change aspects of the lean transformation. As teams become empowered, managers have to work much more participative than in traditional organisations.

Traditional individual piece work incentive schemes usually educate workers to produce inventory; or sometimes, worse, bonuses are even paid for defective parts (Henderson, Largo, 2000). Therefore it is a critical HR task to develop systems where the team is paid for high productivity. As changing customer demand may lead to quicker manning capacity adaptation, a system that guarantees flexible personnel allocation has to be set up.

As lean requires fewer input resources, as mass production and business growth will not always absorb the entire workforce, companies may be forced to handle redundancies. HR has to set the policies, i.e. rightsizing upfront. However, looking at the Japanese plants in the US, job security is much higher than in the US car companies (Rothwell, 1994).

- Integration of sales and marketing

First of all sales and marketing have to produce a good forecast as production uses this to calculate Takt time. Very often, operations can not react on time to changing customer demands as personnel has to be trained or additional machine capacity has to be build or machines are waiting because of longer lead times of suppliers that were not informed early enough.

Additionally, they have to sell the lean advantages, such as shorter lead time or cheaper prices due to less inventory or higher productivity (Henderson, Larco, 2000).

- Integration of purchasing

The purchasing department takes a lead in developing suppliers, i.e. integrating them into the own value chain with Kanban systems. Therefore purchasing staff need to be experts in lean manufacturing, especially in VSM and Kanban. As not all suppliers respond to lean initiatives, a lean company ends up with fewer suppliers. However, as these may become long term partners, there will be benefits (Kobayashi, 1995). Simon and Schuster (1994) point bout that even Japanese have difficulties in introducing their suppliers due to

the recession and due to legal restrictions against excessively frequent deliveries of parts which resulted in traffic jams.

- Internal organisation: reward and incentive system

Paper (1999) adds that employees should have a reward structure that compensates team effort over individual effort. Keating (1999) et al. on the other hand denies additional compensation as they are mostly pushed by management in order to motivate the workforce to start with lean instead of being incremental in nature.

So the question arises whether organisation should compensate lean success stories or not.

- Skills, capabilities and resources

Lean change agents need to be 100% dedicated to lean implementation. Companies very often struggle to invest dedicated personnel towards continuous improvement.

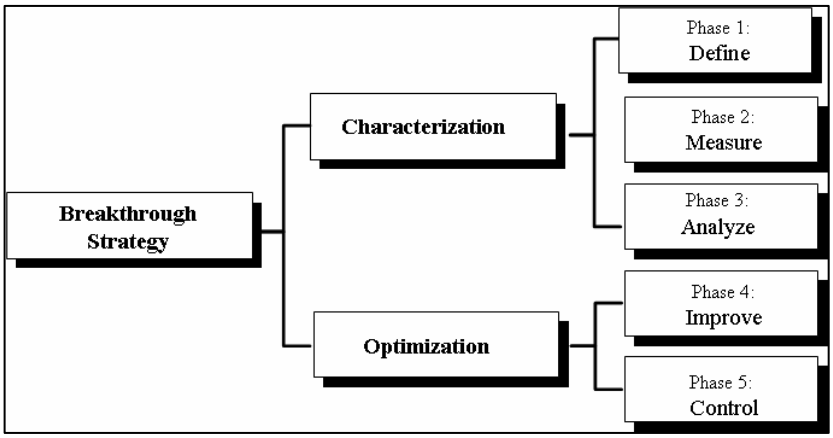
### 2.2.5 Organisational learning

- Build the learning organisation

Womack and Jones' (2003) fifth principle of lean is called perfection. Once completed, the whole continuous improvement process starts again from the beginning.

Therefore, some executives implemented Six Sigma programs (see figure 11) within their companies (Breyfolge, 1999). This initiative requires the use of more advanced statistical tools.

**Figure 11: Six Sigma methodology (based on Breyfolge, 1999)**



As one prerequisite for applying lean principles is process stability, the condition of equipment can not be a maintenance issue anymore. In a Total Productive Maintenance program (TPM), equipment operators help prevent machine problems through their knowledge and familiarity with their machines. The goal of a TPM initiative is to increase the overall equipment effectiveness (OEE). This measure shows how well a machine is running as it reflects machine availability, efficiency and quality (The productivity development team, 2004).

Another program is Goldratt's (1992) theory of constraints (ToC). It is a method for improving throughput, lowering expenses and managing material flow. In every manufacturing system there is always a constraint or capacity bottleneck that hinders lead time to be faster, which has to be identified. ToC focuses on improving the bottleneck and puts buffers right before the critical resources in order to guarantee continuous flow on the constraint.

Therefore successful companies carry out many programs simultaneously by overlapping groups in overlapping areas of focus in order to guarantee an organisational learning process.

- Manage innovation/knowledge and training

Training capacity includes qualified instructors, a specific set of tools and techniques, which has been developed for the needs of the company with customized materials. Organisations may not be able to directly use all above mentioned tools, as they may not be able to be applied in certain environments. Drickhamer (2004) suggests, to link training to direct application of learned tools and techniques in the trainee's organisation in order to adopt the lean tools.

Table 5 summarises critical success factors during the lean transformation process and links them to Convis' (2001) TPS model.

**Table 5: Critical factors for successful lean implementation during the transformation process**

| Henley Transformation Framework | Success Factor | Convis TPS Framework Category |
|---|---|---|
| Mobilise for change | **Stakeholder expectations** | |
| | - getting managers on board | Management |
| | - involving operators through empowered kaizen teams | Philosophy |
| | **Lead the change** | |
| | - strong top management leadership | Management |
| | - establishing a sense of urgency: find a lever by seizing the crises, or by creating one | Management |
| | - remove obstacles, i.e. managers who simply can not accept lean ideas | Management |
| | **What culture?** | |
| | - forming a powerful guiding coalition with managers acting as enablers | Management |
| | - building trust | Philosophy |
| | - customer first focus | Philosophy |
| Translate strategy into objectives and initiatives | **Determine the nature of change** | |
| | - convert from top-down leadership to bottom-up initiatives | Philosophy |
| | **Define initiatives** | |
| | - mapping the value streams | Tools and Techniques |
| | - applying standard tools and techniques: 5S, production smoothing, SMED, One Piece Flow, Takt time, Kanban | Tools and Techniques |
| | - convincing suppliers and customers to become lean | Tools and Techniques |
| | - planning for and creating short-term Kaizen wins | Management |
| | **Establish performance parameters** | |
| | - utilising policy deployment | Tools and Techniques |
| Design the change process | **Set implementation agenda** | |
| | - setting a kaizen agenda | Tools and Techniques |
| Align the organisation | **Organisational structure** | |
| | - reorganising the firm by product family and value stream | Philosophy |
| | - making the change stick: spread lean throughout the organization (engineering, quality, finance, HR, sales and marketing, purchasing) | Philosophy |
| | - internal customer - supplier relationships | Tools and Techniques |
| | **Internal organisation** | |
| | - reward and incentive system | Tools and Techniques |
| | **Skills, capabilities and resources** | |
| | - teaching lean thinking and lean skills to everyone | Philosophy |
| | - expert training and support: finding good change agents | Management |
| Organisational learning | **Build the learning organisation** | |
| | - striving for perfection | Philosophy |
| | **Manage innovation/knowledge and training** | |
| | - creating a lean promotion office | Tools and Techniques |

In the next section the approach and methodology used in order to answer the research question will be explained.

## 3 Fieldwork: Approach and methodology

### 3.1 Discussion of the research area and research question

Companies like Volkswagen, Porsche, GM, Opel, Bosch and many others have meanwhile developed their own production systems following the example of Toyota. Constant pressure on costs, quality and delivery time (especially in the automotive branch) forces organisations to continuously improve their business processes. They all have a common challenge in managing their operations in highly competitive markets and with that they are spending lots of efforts in becoming lean enterprises.

As the market basically dictates the selling price the only option to increase profits is to cut down costs.

Toyota has concentrated solely on improving its own efficiency, with a relentless focus on cost-cutting, quality improvements and lead time reduction. The author's employing organisation's experience in implementing lean transformations has shown that very often companies focus on purely cost reductions thinking they were copying the TPS, not taking into account that the TPS tools are only a means to an end. As the literature review has shown, that the tools go hand in hand with a change in philosophy and management system.

Having discussed these issues, the research question of this lean survey is:

- What are the critical success factors for sustainable lean implementation?

The further reading highlighted that lean is more a philosophy than just a toolbox; it is a fully integrated management and manufacturing philosophy and approach. However, it also made clear, that the tools are important, but the basic tenet of TPS is that people are the most important asset. Additionally, the strong balance among the key functions (operations and support functions), the top down approach and the role of continuous improvement teams for successful lean implementation was shown. Taking into account that cost pressure seems to force organisations to relocate work into low cost countries, an investigation of the status of lean practice implementation, success factors and pitfalls on the lean pathway will show, whether there are other possibilities like the Porsche example has shown.

### 3.2 Research objectives

Based on the theoretical discussion in the literature review the research objectives are the following:

- To find out if companies, which have started lean practices thoroughly understand the philosophy, the management paradigm and the principles of the TPS.
- To analyse if these companies incorporate the whole organisation (operations and supportive business processes) in their lean transformation.
- To identify and describe critical success factors for sustainable lean implementation.

In the following part the decision on the research approach will be made and a research strategy will be chosen.

### 3.3 Research design

#### 3.3.1 Research methodology

As theory has shown, sustainable and successful TPS implementation is based on various factors from a strategic, a structural and a cultural perspective.

In order to find out, whether organisations, which already have started implementing lean concepts, considered the theoretical aspects that have been explained, data was collected and theory was analysed regarding the application of the concepts in the sample.

Data gathered from the sample was used to verify if organisations apply lean ideas in the original sense of the TPS. Theory was tested against data, which is a deductive approach, in order to confirm or reject the applicability of the theory to the population.

Therefore a quantitative method was used. The survey strategy is usually associated with the deductive approach. Using this method allowed the collection of a large amount of data, which afterwards was analysed.

### 3.3.2 Sampling technique and source

As described above, a survey-based research was used to make interferences from the sample to the population. In order to answer the research question, probability sampling was performed.

- Identifying a suitable sampling frame

Looking at the research question, the population consists of all organisations that are applying lean tools in order to improve their business processes. The sampling frame consisted of customers (continuous improvement managers and general managers) of the author's employing organisation. The author's employer has been working in the field of continuous improvement and TPS since 1996 and since that helped 65 clients located in 170 different sites spread over 23 countries to introduce lean concepts. Therefore it can be said, that the sampling frame was relevant to the research topic. A sample taken out of this sampling frame was representative for the whole population, because these clients are organisations operating over the whole world. As TPS users in the automotive branch as well as general industry were represented in the sampling frame, and it included cases, in which the lean implementation was very successful and sustainable, but also cases, where TPS implementation struggled, it can be concluded, that the sampling frame was complete. It was moreover precise, because irrelevant cases were excluded as only organisations were represented which had made experiences with lean management applications.

- Deciding on a suitable sample size

A very important role in sample size selection plays confidence and the level of certainty that the characteristics of the data collected are representative for the total population. As the author's employing organisation is working in a special segment in the consulting business and clients select to work this employer because of the expertise in the TPS it can be said, that these companies had enough experience in lean management to use the data collected to draw useful conclusions. As at least 50 responses were needed, it was expected that roughly 250 people had to be asked to fill in the questionnaire (assuming a return rate of 20%).

- Selecting the most appropriate sampling technique and the sample

The quality of the sample is as important as its size (Gonick, Smith, 1993). As the data could not be collected from the unknown entire population, statistical inferences had to be made from the sample and as a suitable sampling frame was available, a probability sample was needed (Saunders, Lewis, Thornhill, 2003). In order to make sure that both automotive and industry respondents were represented in the sample, stratified random sampling was used. The survey was conducted via the internet and 270 operations -, continuous improvement - and general managers were invited via email to access a webpage and to fill in the online questionnaire. As all of them are customers of the author's employing organisation it was expected to receive at least 50 responses within a certain time frame.

- Checking the sample is representative of the population

As the organisations enrolled in this survey have on average more than 5 years of experience in lean practices it could be concluded that there is no statistically significant difference between the sample and the population (Toyota with more than 50 years is an exception, companies like Porsche or Daimler Chrysler started their production system efforts in the mid 90ies). Additionally question 3 was used to prove a generalization as colleted data could be compared to existing research data (see 3.5 Overall results of the fieldwork).

### 3.3.3 Questionnaire design

Afterwards a questionnaire with standardised questions had to be designed. As the respondents were geographically dispersed, a self administered online questionnaire, which included a combination of open and closed questions, was used.

In order to create a flow of questions, that was able to answer the research question, a set of questions was developed, which recorded opinions as well as behaviours. Therefore, the research objectives were subdivided into more investigative questions, which were needed to gather data: The use of structured questions was assumed to correlate strongly to the number of responses.

### 3.3.4 Validity (measurement errors), pilot testing and reliability

The reliability and validity of the data colleted largely depended on the design of the questions, the structure of the questionnaire and the rigour of the pilot testing (Saunders, Lewis, Thornhill, 2003).

When collecting opinions, behaviours or attribute data, the variation between two or more respondents is related to their real variation (they do have different opinions or behaviours) and to a certain extend to a variation resulting from different understanding or interpretation (measurement error) of a question (Breyfolge, 1999). In order to avoid measurement errors and to make sure that the data colleted was reliable, the repeatability error (only little or better no variation is expected when one respondent testes the questionnaire two times) was tested by having three test respondents filling the questionnaire in two times on different days and comparing the results. Saunders, Lewis and Thornhill (2003) call this repeatability test “test re-test”. Results of this re-test analysis allowed to understand that no major repeatability issues existed.

These lean experts also commented on the universal validity and the suitability of the questions. The questionnaire was piloted with 10 testers (respondents were individuals chosen from the sample frame as well as senior colleagues of the author, who have long experience in transforming organisations into lean enterprises), who where also asked to comment on the clarity of the instructions. The goal was to find out how long it took to complete it, and to test if questions were unclear, ambiguous or uneasy to answer. The test showed that completing the questionnaire in 10 minutes was easily possible.

Moreover, preliminary analysis using the test data was done in order to make sure that the data collected would allow the investigative questions to be answered.

## 3.4 Empirical fieldwork (data collection)

### 3.4.1 Questions testing the basic understanding of the lean philosophy

The first section of the questionnaire (see appendix 1) was used to collect data in order to analyse the understanding of the lean philosophy with descriptive statistics.

The questions testing the basic understanding of the lean philosophy (first section) were created by the author on basis of Ohno's (1988) and Womack and Jones' (2003) theories. In order to gain data concerning opinion and behaviour, list and category questions were used. A category of "other" was added to give respondents the opportunity to add valuable points.

### 3.4.2 Questions to analyse the usage of TPS tools and techniques

The second section sought after the usage and application of TPS tools and the third section was designed to assess the level and scope of lean implementation. As the goal was to analyse behaviour, category questions were used in order to understand the integration of supportive functions into the lean rollout. The questions were created on the basis of the literature review.

### 3.4.3 Questions assessing the scope of lean implementation

The purpose of the third section was to analyse the scope of the TPS implementation. The question seeded to find out if functions besides operations were strategically integrated into the companies' lean rollouts.

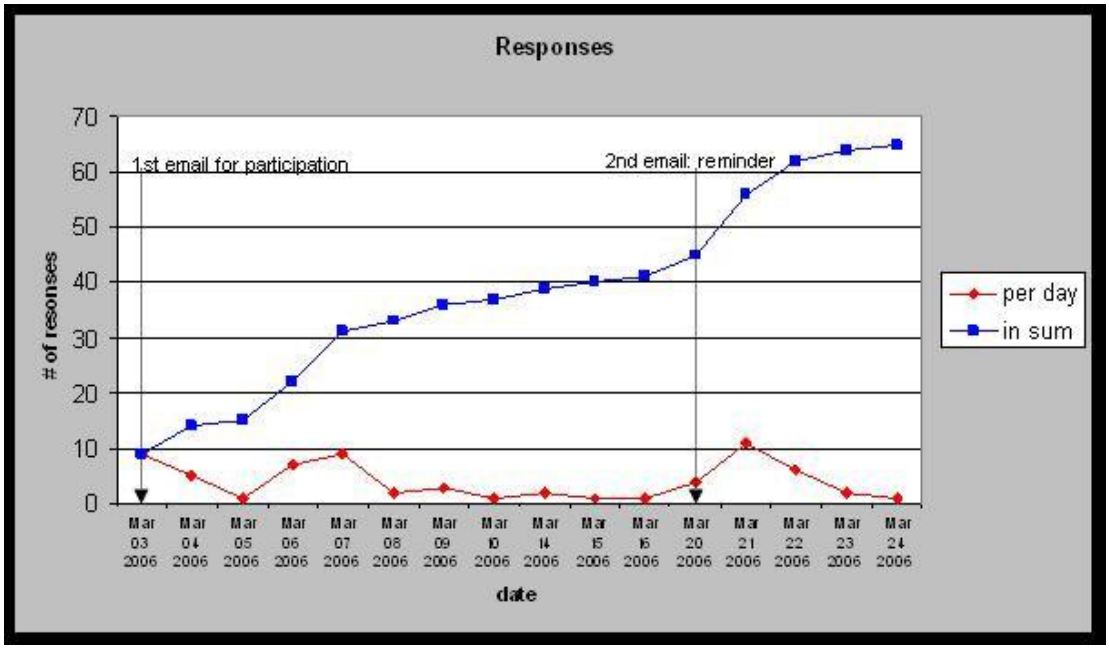
### 3.4.4 Questions testing the importance of critical management factors

In the fourth section, based on theories of Henderson and Larco (2000), Tilson (2001) and Womack and Jones (2003), scale questions were used to collect opinion data. A list question was also used to collect data on behaviour. In order to make sure that if an important item did not apply to a respondent and to hinder non-response due to uncertainty, a category of "other" was added.

### 3.4.5 Data collection process

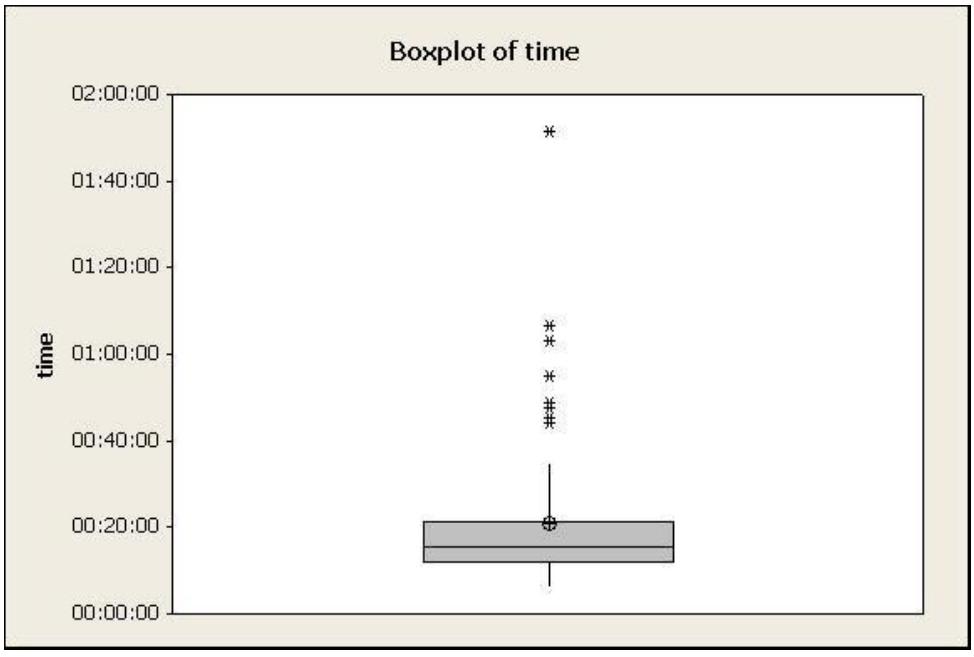
Figure 12 shows the data collection process. Participants were invited to take part in the survey on March, 3rd, 2006. Two weeks later, on March, 20th, 2006 a reminder was sent to all participants, which led to a second peak in response. The survey was closed exactly after 3 weeks. The response rate after 3 weeks was 18.5% (65/270). As the majority of participants asked were senior managers it can be said that the participation ran well enough to extract the data after three weeks.

**Figure 12: Data collection process**




Another additional 39 participants followed the "eQuestionnaire" internet link to the survey, but did not fully fill it in (only those participants were analysed who answered a minimum of 97% of all questions, which means all questions besides the open questions asking for "other"). The majority of these 39 stopped at the last question, which could indicate that it may have taken them too long to answer the whole questionnaire or the last question. However, the average time participants spent for filling in the survey was 20 minutes (see circle in figure 13), which was influenced by some outliers (see stars in figure 13). The majority was done below this figure.

**Figure 13: Finishing time on questionnaire**



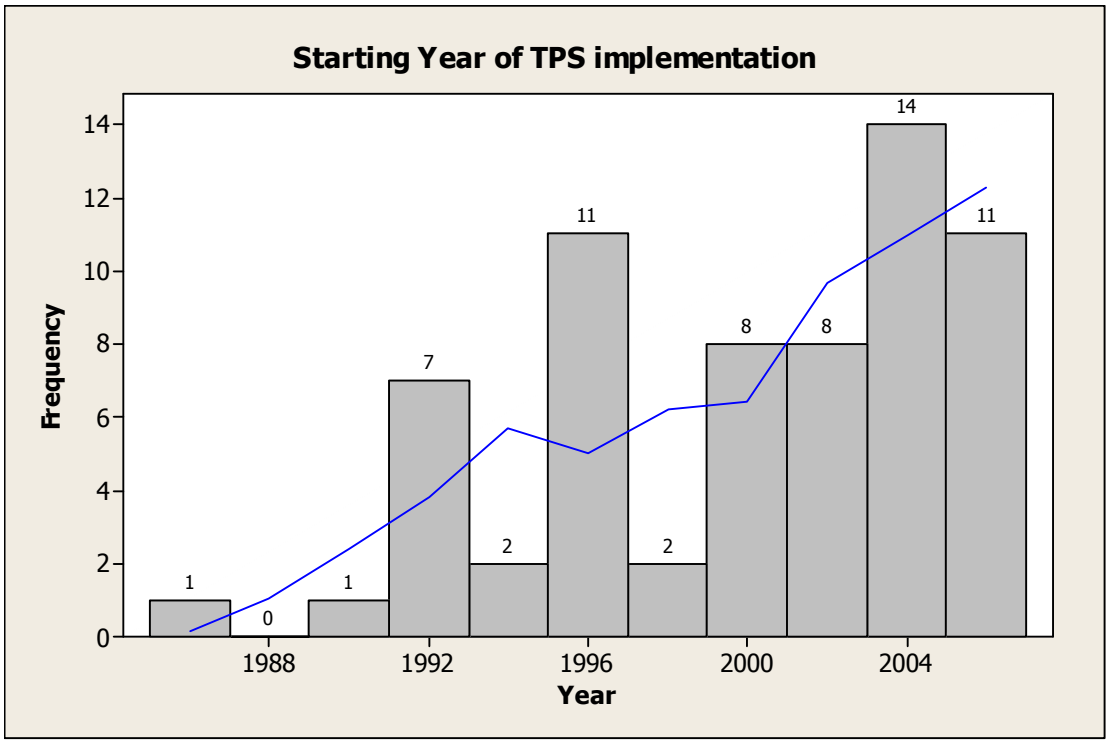
In the following part of the lean survey the overall results of the above described empirical fieldwork will be analysed.

### 3.5 Overall results of the fieldwork

- Question 1: When did your organisation start efforts to introduce lean principles?

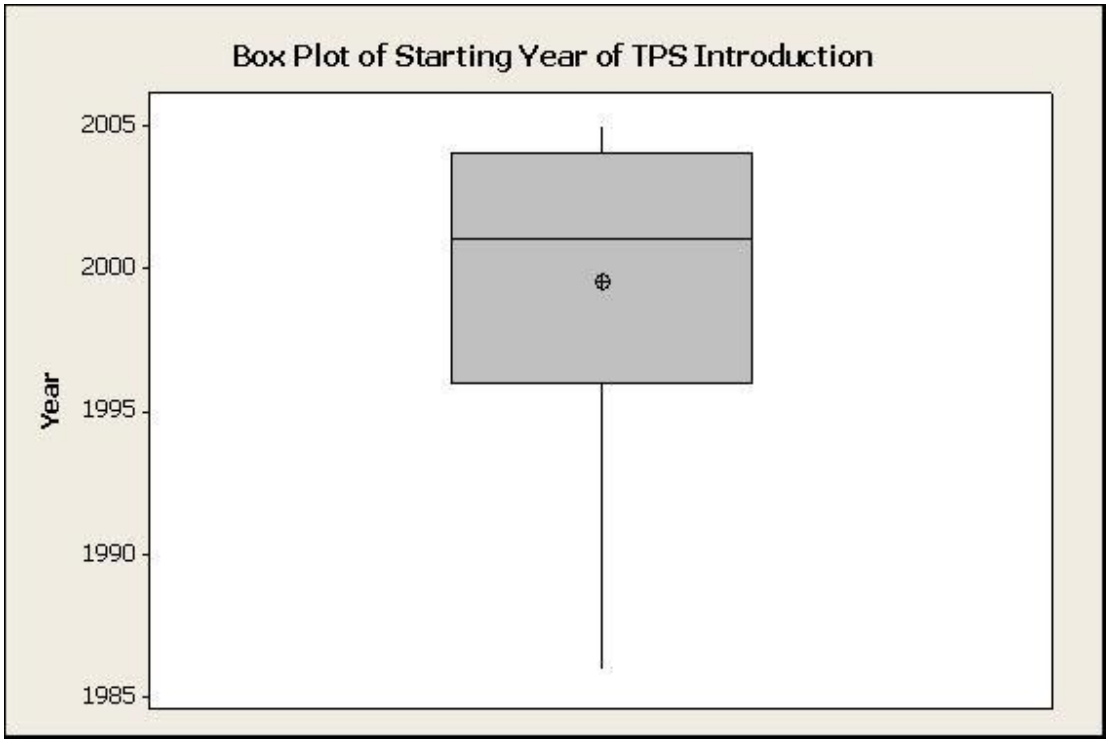
As shown in literature review Toyota engineers began creating their production system in 1949. The first question seeded to find out when the organisations in the survey sample started their lean efforts (see figure 14).

**Figure 14: Histogram – Starting year of TPS implementation**




The histogram (data were grouped in periods of 2 years) shows that the majority of the participants went on their lean path more than 50 years later than Toyota. On average, they started in the year 2000 with their lean efforts (see circle in box plot in figure 15). When looking at the distribution of the data one could argue that there is a trend (see blue line in figure 14) that more and more organisations are starting to apply lean principles. However, there is not enough evidence to prove this hypothesis as this seems to be influenced by a growing number of customers of the author's employing organisation and therewith survey participants.

**Figure 15: Box plot - Starting year of TPS implementation**

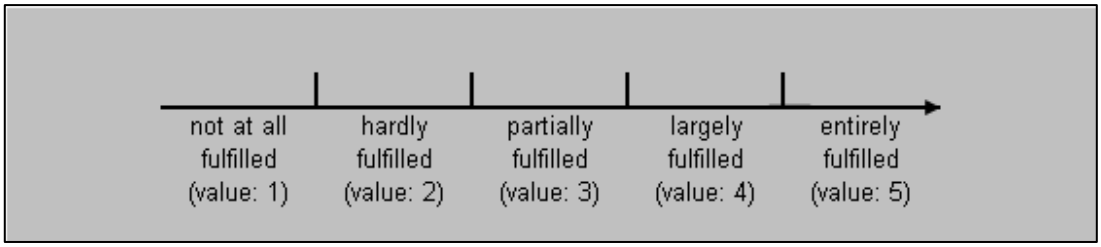



One could argue that in comparison to the 50 years of experience of Toyota the sample could not be representative regarding critical success factors of sustainable TPS implementation. Knowing that even Porsche started not before 1992 (see literature review) and seeing that some survey participants began in 1986 (see box plot whisker in figure 15) it can be said that this indicates that the sample is representative – however this could only be statistically verified by using a one sample t-test and comparing the sample mean of 2000 to the mean of the total population, which however is unknown. Therefore, when analysing the data, one has to know that from a purely statistical point of view there is not enough evidence to conclude that the sample is representative for the population, which is a limitation for the research.

Also, when comparing the length of TPS experience with the fulfilment of expectations it can not be concluded that time is critical for success.

To analyse this, the data was grouped and the starting years 2005 and 2006 where compared with the years 1986 to 1993 (first and last 11 data sets). Looking at the fulfilment of expectations (see figure 16) both data sets have a mean (3.6 versus 3.4) which lies between “partially fulfilled” (value “3”) and “largely fulfilled” (value “4”).

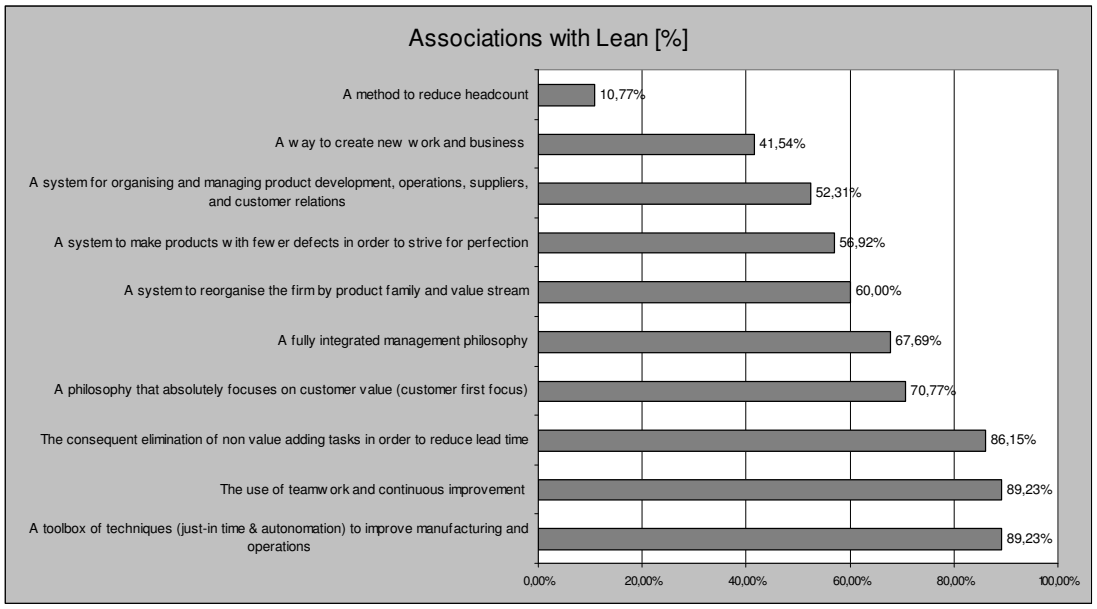
**Figure 16: Expectation fulfilment scale**




- Question 2: What do you associate with the lean philosophy?

Figure 17 shows the distribution of associations with the lean philosophy.

**Figure 17: Associations with Lean**

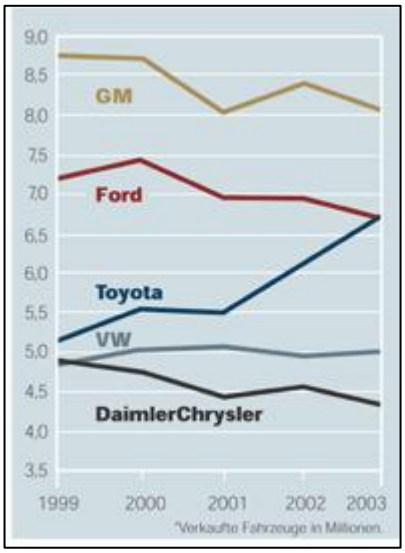



It is remarkable that still roughly 10% of the participants think that lean is a method to reduce headcount. Of course, the TPS toolbox can be used to analyse redundancies (i.e. Jidoka or Takt time) but the basic philosophy of lean is to use these resources for further improvement and growth. It is interesting to see that this group of participants still has a score of 3.3 on the above mentioned expectation fulfilment scale (see figure 16). The literature review has shown that all items listed except for the first ("a method to reduce headcount") represent aspects of the lean philosophy.

Another interesting aspect is that only 42% see the TPS as a way to create new work and business. Looking at the fact that through reducing the lead time this is the ultimate goal of lean it has to be said that quit a remarkable group in the sample does not yet fully see the chances and potential of TPS

implementation. Secondary data of Peters (Peters, 2004, see figure 18) clearly supports this Toyota idea with facts.

**Figure 18: Only one is growing – sold cars [in million] 1999 – 2003 (Peters, 2004)**



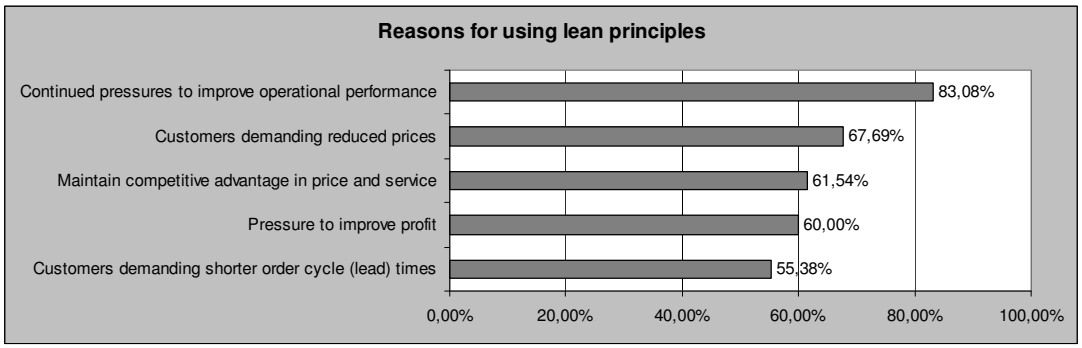

Although Toyota always tried to reduce production costs and eliminates also waste due to operator waiting time nobody recently lost jobs as the method supported the sales growth strategy and sales grew roughly by 30% within 4 years.

68% of respondents see lean as a fully integrated management philosophy which as the theory has shown is a presumption for success and sustainability. It will be interesting to see how well these participants were able to put this understanding into practice by analysing if their expectations on implementing lean were fulfilled or not.

❑ Question 3: Why did your company decide using lean principles?

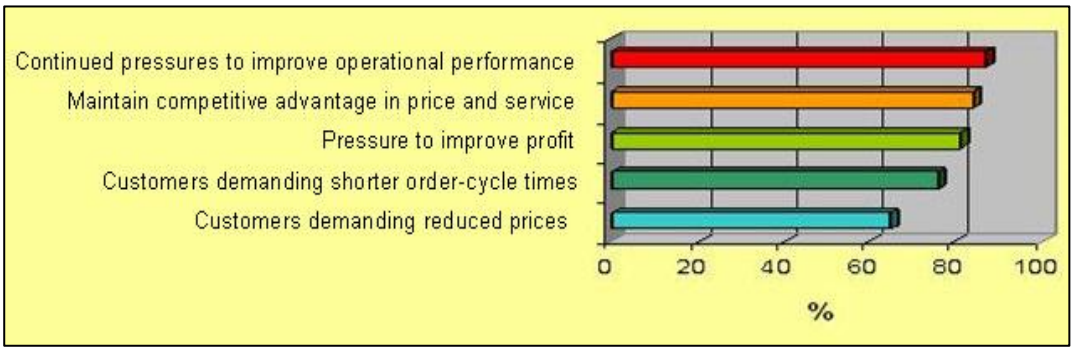
Question 3 was used to comment on the capability of the sample to draw conclusions on the total population. As shown in figures 19 and 20, results of the author's and Wheatley's (Wheatley, 2005) surveys are comparable. As Wheatley draws a conclusion from 200 respondents his survey is perhaps more precise. However, the two samples in the two questionnaires show that the main reason for implementing lean principles is "Continued pressure to improve operational performance" and the percentage is quit similar slight above 83%.

**Figure 19: Reasons for using lean principles**




Together with the dispersion of the other factors (all roughly between 60 and 80%) it can be concluded that the sampling frame is suitable enough to draw conclusions.

**Figure 20: Top 5 business factors for lean adoption (Wheatley, 2005)**




It is interesting to see that 68% of the interviewees in the sample indicate that their customers are driving their lean efforts by demanding reduced prices. According to the literature review this is the other way around in the TPS philosophy: companies should always ask themselves how much the customer

is wiling to pay and than automatically reduce waste in order to offer a competitive price.

In the open question at the end following reasons were also given (one answer each - equivalent to 1.33%):

- to make the lean philosophy culture of our company
- to increase customers' demand with the same equipment
- to increase people's awareness on processes
- to have a tool to implement organisational change
- to use cross-functional teams
- to do something that is "nice to have" because other companies are doing it also

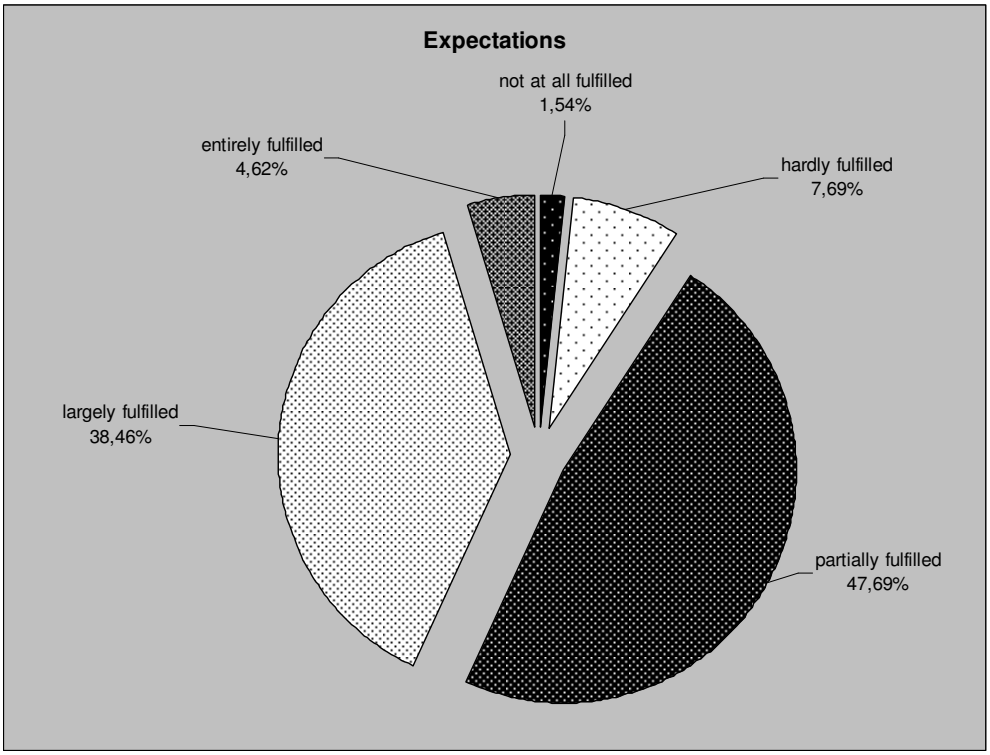
All aspects besides the last one are supported by the literature review and reappear more or less in the same words in the last question (cultural aspects, team involvement etc.). It would be interesting to see in further research if there are more organisations applying lean principles for "fashion" reasons and if they are successful.

- Question 4: Overall the expectations you had on using lean principles you had were not at all fulfilled, hardly fulfilled, partially fulfilled, largely fulfilled or entirely fulfilled

Purpose of this question was primary to select groups within the sample which were successful with their lean implementation and which were not. This data could later be linked to the success factors in the last question and with the help of contingency tables it was tried to verify the critical success factors which were mentioned by the participants.

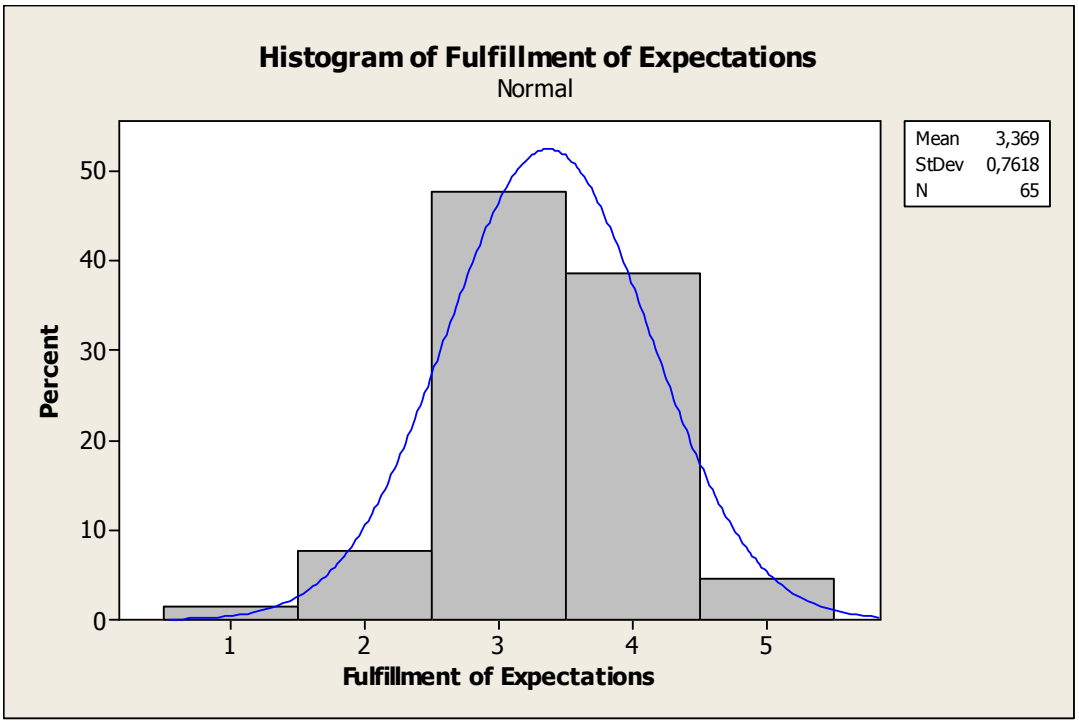
The fact that below 5% of the survey participants (see figure 21) are entirely fulfilled with their lean implementation shows that the TPS is not easy to apply and that it seems not be enough to only copy principles like the tools.

**Figure 21: Expectations on using lean principles**




However when looking at the whole dispersion of the data it can be said that the variation follows the normal distribution (see figure 22) which again is an indicator that the sample is representative for the whole population as one would expect this distribution type.

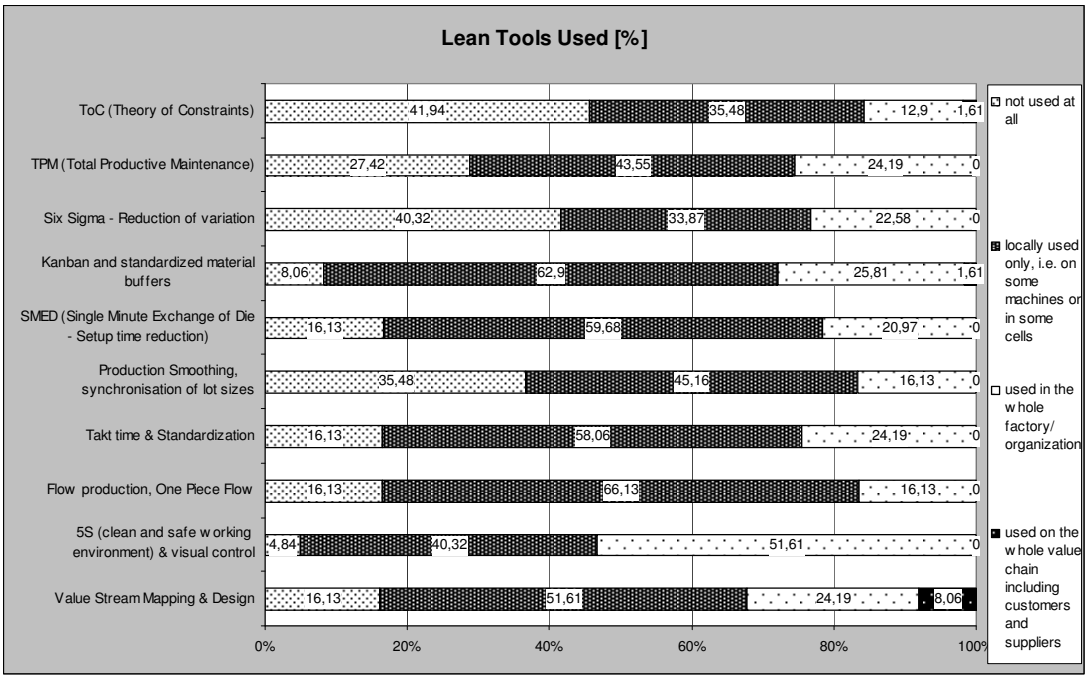
**Figure 22: Distribution of expectations (1: not at all, 2: hardly, 3: partially, 4: largely, 5: entirely fulfilled)**



- Question 5: Please tick the specific lean tools your organisation is using in order to become a lean enterprise.

As shown in the literature review the one pillar of the TPS is the use of lean tools. Question 5 seeded to analyse the application of the lean toolbox among the respondents asking which tools are used and where they are utilised. The literature review made clear that "Value Stream Mapping" is the most important medium and 84% of the interviewees are using it (see figure 23). Moreover it is the only tool that is significantly (>5%) used across the borders of the organisations as 8% are including their customers and suppliers in this exercise. Generally it can be said that if participants utilise a method then they use it locally on some machines or in some cells (34 to 66%, second bar from the left). As a VSM is normally the first tool to be used further research could identify if the application of the other tools will follow.

**Figure 23: Specific lean tools organisations are using in order to become a lean enterprise**




The top 3 tools which are not used are ToC (bottleneck identification and elimination, 42%), Six Sigma (40%) and production smoothing (36%). As especially production smoothing (lot size synchronisation; produce exactly the demand just before the customer is buying it) is a basic TPS concept (see figure 2) in order to reduce inventory and improve on-time delivery, a Chi-Square was used to find out if there is a correlation between the adaptation

of this method and the overall success of the TPS implementation. Therefore the survey data was grouped according to table 6.

**Table 6: Contingency table – Relation between use of production smoothing and TPS implementation success**

| | Production Smoothing | |
|---|---|---|
| Expectations on TPS implementation | not used at all | local use, use in the whole factory and value chain |
| expectations not & hardly fulfilled | 5 | 1 |
| expectations largely & entirely fulfilled | 7 | 21 |

Hypotheses to be tested are described below. If the test statistic is very low (usually p = 0.05 or lower), then there is a statistically significant relationship (Saunders, Lewis, Thornhill, 2003).

$H_o$: There is no relation between the adaptation of production smoothing and successful TPS implementation.

$H_a$: There is a relation between the adaptation of production smoothing and successful TPS implementation.

**Figure 24: $\chi^2$ Test – Relation between use of production smoothing and TPS implementation success**

**Chi-Square Test: not used at all; local, factory and value chain**

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

| | not used at all | local, factory and value chain | Total |
|---|---|---|---|
| 1 | 5 | 1 | 6 |
| | 2,12 | 3,88 | |
| | 3,923 | 2,140 | |
| 2 | 7 | 21 | 28 |
| | 9,88 | 18,12 | |
| | 0,841 | 0,459 | |
| Total | 12 | 22 | 34 |

Chi-Sq = 7,362; DF = 1; **P-Value = 0,007**

The p-value of 0.007 indicates that there is enough evidence to reject $H_o$, which means that there is a relation between the use of production smoothing and successes with lean production efforts.

The other TPS tools are applied among the interviewees. 95% use the 5S program, 84% use flow production, Takt time, standardisation and SMED and 92% apply Kanban.

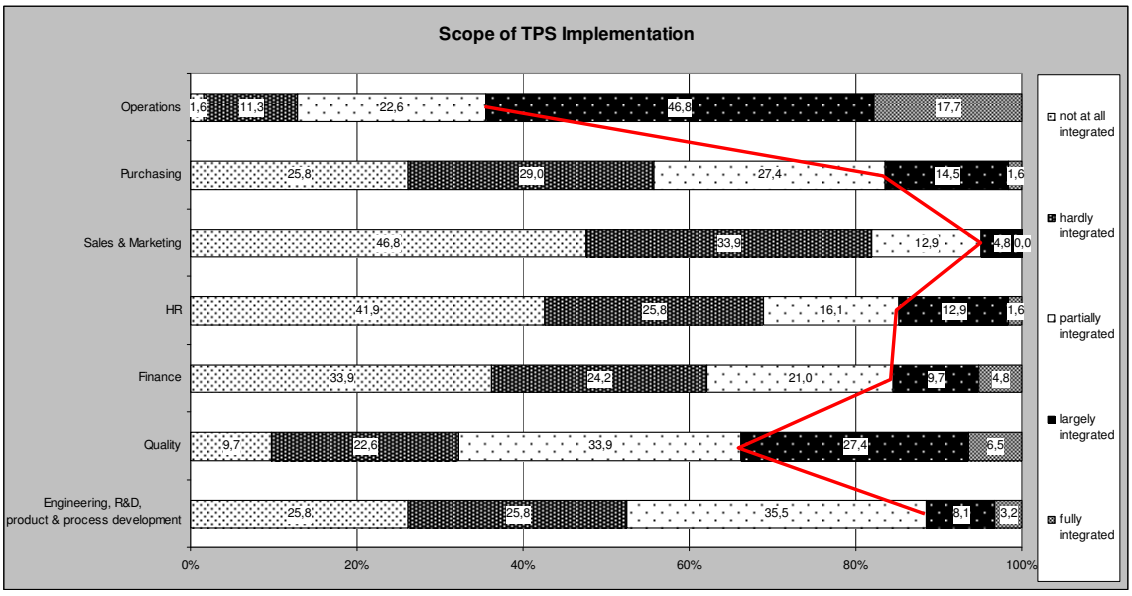
Other tools the participants are applying are (one answer each):

- 3P: Production preparation process to be lean before product launch
- Jidoka

- Question 6: Which of the following functions is strategically integrated in your company's lean rollout?

Summing up the categories “fully” and “largely integrated” it can be seen that the function operations is the area where most organisations apply lean methods (65%).

**Figure 25: Functions strategically integrated in the companies’ lean rollouts**




The literature review has shown that lean methods include a lot of quality tools. Therefore it does not surprise that the second biggest function that is at least largely integrated is quality (34%).

Contingency tables were used to find out if there is a relation between the integration of HR (TPS philosophy and culture) or engineering (Jidoka and simultaneous engineering tools) and successful lean implementation.

**Table 7: Contingency tables – relation between Engineering & HR integration and TPS implementation success**

| | Engineering | | HR | |
|---|---|---|---|---|
| Expectations on TPS implementation | not/hardly integrated | fully/largely integrated | not/hardly integrated | fully/largely integrated |
| expectations not & hardly fulfilled | 6 | 0 | 6 | 0 |
| expectations largely & entirely fulfilled | 11 | 4 | 18 | 2 |

The p-value for the relation between engineering integration and TPS implementation success is 16% (no relation between R&D integration and successful TPS implementation), the analysis for HR did not deliver a usable p-value as the chi-square approximation was invalid due a lack of enough data. This generally seems to be the problem. Most survey participants answered either that their expectations were partially fulfilled or that the functions were partially integrated and these data sets could not be integrated into the analysis. Based on the literature review a relation between these aspects would be expected. However, the limited sample size, and within this sample the limited number of interviewees answering in the above shown categories does not allow to draw statistically correct conclusions for the population.

However, it is interesting to see that only 18% of the organisations have integrated sales and marketing at least partially into their lean efforts. As shown in the theory section they are fundamental for applying concepts like Takt time in order adjust capacities and to be as productive as possible.

- Question 7: Which of the following aspects is or was considered during your organisational lean rollout and which one in your opinion (on a scale from 1 to 4) is critical for successful lean transformation?

Having analysed critical success factors for sustainable lean implementation in the literature review, interviewees were asked to answer which of the aspects concerning management behaviour, philosophy and tools were considered during their lean rollouts.

To summarize more than 50% of all participating organisations did take the mentioned points into account (with exception of the last four aspects, see table 8).

The data was grouped (<50%, 50% to 75%, and > 75% of organisations took aspect into account) for further analysis.

In total there were 6 aspects out of 30 which were taken into account by more than 75% of the participants. These 6 points deal with speed of implementation or action (#1 and 5), employee involvement (#2 and 4), communication (#3), and management behaviour (#6).

When analysing the concepts that were only used by less than 50% of the survey participants it is interesting to see that only 45% of the organisations are using a strategic tool like policy deployment to implement their lean competences and that only 32% related continuous improvement to monetary incentives. In order to find out whether this is critical or not, the data needed to be analysed in more depth by comparing successful and less successful survey participants.

**Table 8: Aspects considered during the lean rollouts**

| # | Success Factor | Yes |
|---|---|---|
| 1 | Beginning as soon as possible with an important and visible activity | 89% |
| 2 | Involving operators through empowered Kaizen teams | 86% |
| 3 | Communication of the transformation process, goals etc. | 85% |
| 4 | Getting shop floor commitment and employee trust | 83% |
| 5 | Planning for and creating short-term Kaizen wins | 80% |
| 6 | Board and top management actively driving and supporting change | 78% |
| 7 | Finding a good change agent | 74% |
| 8 | Strong leadership | 74% |
| 9 | Enrolment of stakeholders for commitment, i.e. workers' council | 72% |
| 10 | Managerial push (mandatory participation in workshops & training) | 72% |
| 11 | Building internal customer - supplier relationships | 71% |
| 12 | Demonstration of senior management impatience by regularly reviewing progress reports | 68% |
| 13 | Top management presence and availability on the shop floor | 68% |
| 14 | Avoidance of any linkage between lean practices and layoffs | 68% |
| 15 | Teaching lean thinking and lean skills to everyone | 63% |
| 16 | Lean champions removing blocks in the organization | 60% |
| 17 | Leaders and supervisors motivate, coach, train and facilitate the work of those adding value rather than to tell them what to do | 58% |
| 18 | Employee pull (employees fully understand the benefits on lean and improvement for themselves independent from management's support) | 57% |
| 19 | Executives join kaizen events on a regular basis | 55% |
| 20 | Setting a Kaizen agenda for the organisation | 54% |
| 21 | Striving for perfection | 54% |
| 22 | Resources freed up by productivity gains are reinvested into the search for still greater improvements | 52% |
| 23 | Creating a lean promotion office for organisation and training | 52% |
| 24 | Converting from top-down leadership to bottom-up initiatives | 52% |
| 25 | Availability of a crises that motivates the organization to change | 51% |
| 26 | Integrating suppliers and customers into the lean transformation | 51% |
| 27 | Employees are free to allocate time to improvement (empowerment) | 46% |
| 28 | Utilising policy deployment | 45% |
| 29 | Implementing a reward and incentive system for successful lean projects | 32% |
| 30 | Elimination of managers, who would not cooperate in order to get commitment to lean | 28% |

Therefore the data was than grouped based on the fulfilment of expectations on the lean implementation as afterwards further conclusions on the research question were drawn by comparing aspects considered in the group where expectations were fulfilled with the group where expectations were not fulfilled (see table 9).

Generally it can be said that the organisations in the first group did take these aspects more into account than the participants whose expectations were not met. Taking into account that most sources from the literature review emphasize the use of TPS tools it is interesting to see that the aspect of i.e. teaching lean skills does not appear in the top 11 (> 75%) in table 9.

**Table 9: Aspects considered in the group of "expectations on lean implementation largely & entirely fulfilled" and in the group of "expectations not at all & hardly fulfilled"**

| % of "expectations largely" and "entirely fulfilled" | Aspect | % of "expectations not at all" and "hardly fulfilled" |
|---|---|---|
| 93% | Communication of the transformation process, goals etc | 67% |
| 93% | Beginning as soon as possible with an important and visible activity | 83% |
| 86% | Strong leadership | 50% |
| 86% | Managerial push (mandatory participation in workshops & training) | 50% |
| 86% | Getting shop floor commitment and employee trust | 67% |
| 82% | Planning for and creating short-term Kaizen wins | 50% |
| 82% | Finding a good change agent | 83% |
| 82% | Board and top management actively driving and supporting change | 67% |
| 79% | Avoidance of any linkage between lean practices and layoffs | 50% |
| 79% | Involving operators through empowered Kaizen teams | 100% |
| 75% | Leaders and supervisors motivate, coach, train and facilitate the work of those adding value rather than to tell them what to do | 33% |
| | | |
| 46% | Employees are free to allocate time to improvement (empowerment) | 33% |
| 39% | Implementing a reward and incentive system for successful lean projects | 17% |
| 29% | Elimination of managers, who would not cooperate in order to get commitment to lean | 17% |

It is also remarkable that 100% of those interviewees who were not satisfied with the way of their lean implementation did involve operators through empowered Kaizen teams and perhaps emphasized that too much, while not providing sufficient management support or TPS philosophy training. When asking what were the aspects and concepts which 75% or more of those participants who were satisfied with their lean implementation considered it can be seen the top factors are the communication of the process and goals as well as the speed of the process. It can be seen that cultural and leadership aspects seem to play a far more important role than the TPS tools itself. And this, as shown in table 9, is where the biggest gaps between successful and not so successful organisations appear. Especially remarkable in that case, may be the fact that 50% of those whose expectations, which were not fulfilled had direct links between continuous improvement and layoffs. Referring back to the literature theory this should definitely be avoided.

In the second part of the question the participants were asked to rank these aspects concerning importance on a scale from 1 (not important) to 4 (very important for successful lean implementation).

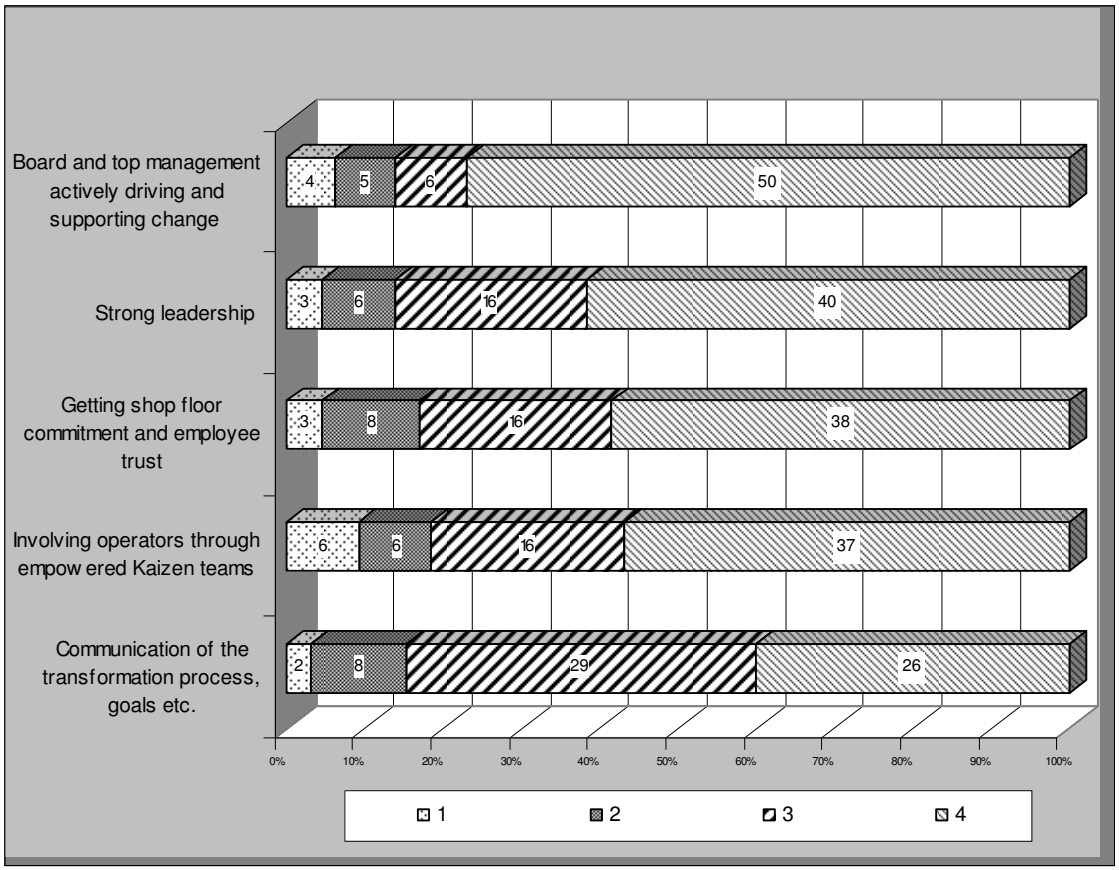
**Table 10: Critical management factors for successful lean implementation**

| # | Succes Factor | Score | % of Top Score |
|---|---|---|---|
| 1 | Board and top management actively driving and supporting change | 232 | 89% |
| 2 | Strong leadership | 223 | 86% |
| 3 | Getting shop floor commitment and employee trust | 219 | 84% |
| 4 | Involving operators through empowered Kaizen teams | 214 | 82% |
| 5 | Communication of the transformation process, goals etc. | 209 | 80% |
| 6 | Finding a good change agent | 208 | 80% |
| 7 | Beginning as soon as possible with an important and visible activity | 205 | 79% |
| 8 | Top management presence and availability on the shop floor | 200 | 77% |
| 9 | Enrolment of stakeholders for commitment, i.e. workers' council | 196 | 75% |
| 10 | Leaders and supervisors motivate, coach, train and facilitate the work of those adding value rather than to tell them what to do | 196 | 75% |
| 11 | Managerial push (mandatory participation in workshops & training) | 195 | 75% |
| 12 | Employee pull (employees fully understand the benefits on lean and improvement for themselves independent from management's support) | 192 | 74% |
| 13 | Teaching lean thinking and lean skills to everyone | 192 | 74% |
| 14 | Avoidance of any linkage between lean practices and layoffs | 189 | 73% |
| 15 | Building internal customer - supplier relationships | 189 | 73% |
| 16 | Elimination of managers, who would not cooperate in order to get commitment to lean | 186 | 72% |
| 17 | Lean champions removing blocks in the organization | 186 | 72% |
| 18 | Integrating suppliers and customers into the lean transformation | 181 | 70% |
| 19 | Employees are free to allocate time to improvement (empowerment) | 177 | 68% |
| 20 | Executives join kaizen events on a regular basis | 176 | 68% |
| 21 | Resources freed up by productivity gains are reinvested into the search for still greater improvements | 174 | 67% |
| 22 | Planning for and creating short-term Kaizen wins | 174 | 67% |
| 23 | Converting from top-down leadership to bottom-up initiatives | 173 | 67% |
| 24 | Availability of a crises that motivates the organization to change | 170 | 65% |
| 25 | Demonstration of senior management impatience by regularly reviewing progress reports | 166 | 64% |
| 26 | Striving for perfection | 162 | 62% |
| 27 | Setting a Kaizen agenda for the organisation | 157 | 60% |
| 28 | Creating a lean promotion office for organisation and training | 156 | 60% |
| 29 | Utilising policy deployment | 145 | 56% |
| 30 | Implementing a reward and incentive system for successful lean projects | 143 | 55% |

A score was used to build priorities and a ranking (i.e. fifty participants answered “4”, six answered “3”, five answered “2”, and four answered “1” – score: 50x4 + 6x3 + 5x2 + 4x1 = 232, see table 10 and compare with data distribution of first factor in figure 26). Afterwards a percentage of the theoretical top scoring 65 (participants) x4 was calculated (i.e. 232/[65x4] = 89%). The resulting data was used to rank the aspects and the datasets were grouped in data above 75% of the top score and below 75%. The fact that even the lowest score is far above 50% shows that all aspects are generally relevant for the research topic, therefore it could be concluded that the reality proves the significance of the factors that the literature review has shown.

Figure 26 shows the data dispersion of the top five aspects. Again the majority of survey participants have ranked leadership aspects, employee involvement and communication of the process and its goals highest.

**Figure 26: Dispersion of top 5 critical management factors**



Knowing which of the aspects the interviewees ranked highest it was again tried to statistically verify these results (top 3) with hypothesis testing (contingency tables). Therefore first of all the first hypotheses to be verified or rejected was built.

$H_o$: Board and top management actively driving and supporting change is not critical for successful lean implementation.

$H_a$: Board and top management actively driving and supporting change is critical for successful lean implementation.

Again those participants whose expectations were not fulfilled (line "1" in figure 27) were compared with those whose expectations were fulfilled (line "2" in figure 27).

**Figure 27: $\chi^2$ Test – Relation between top management activity and expectations on using lean principles**

**Chi-Square Test: top mgt. activity considered; top mgt. act. not considered**

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

| | top mgt. activity considered | top mgt. act. not considered | Total |
|---|---|---|---|
| 1 | 3 | 2 | 5 |
| | 3,75 | 1,25 | |
| | 0,150 | 0,450 | |
| 2 | 24 | 7 | 31 |
| | 23,25 | 7,75 | |
| | 0,024 | 0,073 | |
| Total | 27 | 9 | 36 |

Chi-Sq = 0,697; DF = 1; **P-Value = 0,404**

The p-value for the above mentioned hypothesis is 40%, which means that there is not enough evidence to reject $H_o$. So, from the survey data one can conclude that whether board and top management actively drive and support change during the lean transformation process or not does not make a difference for success. As far as the opinions of the sampled group are concerned this aspect does appear to be significant, but the statistical analyses do not

support this opinion. It is probable that the small sample size (especially the size of the group of participants that were not successful) that has caused this p-value and this can only be clarified by further research, especially with a stronger focus on organisations which were not satisfied with their lean efforts.

The second aspect (strong leadership) however shows more significance (see figure 28):

$H_o$: Strong leadership is not critical for successful lean implementation.

$H_a$: Strong leadership is critical for successful lean implementation.

**Figure 28: $\chi^2$ Test – Relation between strong leadership and expectations on using lean principles**

**Chi-Square Test: strong leadership considered; not considered**

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

| | strong leadership considered | not considered | Total |
|---|---|---|---|
| 1 | 2 | 3 | 5 |
| | 3,75 | 1,25 | |
| | 0,817 | 2,450 | |
| 2 | 25 | 6 | 31 |
| | 23,25 | 7,75 | |
| | 0,132 | 0,395 | |
| Total | 27 | 9 | 36 |

Chi-Sq = 3,794; DF = 1; **P-Value = 0,051**

Statistical significance means that a result is sufficiently unlikely to be due to chance only (The researcher makes the decisions to the greatest level of risk that is acceptable for a rejection of $H_o$). The p-value of this chi-square test is exactly at the selected significance level of 5%. This would mean that this hypothesis would need further research with more data as the risk of drawing wrong conclusions is too high. However, based on the data given by the interviewees one could argue that strong leadership during the lean transfor-

mation is more significant than the first aspect. However, the fact that the above analysed two aspects (management actively driving the change and strong leadership) are somehow linked one would expect roughly the same p-values. This fact again shows that the reliability of the data from the sample size must be questioned.

This fact is also confirmed when looking at aspect number three (getting shop floor commitment and employee trust). Survey participants have the opinion that it is critical for success but this can not be verified with the data (see figure 29):

$H_o$: Shop floor commitment and employee trust are not critical for successful lean implementation.

$H_a$: Shop floor commitment and employee trust are critical for successful lean implementation.

**Figure 29: $\chi^2$ Test – Relation between shop floor commitment & employee trust and expectations on using lean principles**

**Chi-Square Test: shop floor trust considered; trust not considered**

Expected counts are printed below observed counts
Chi-Square contributions are printed below expected counts

| | shop floor trust considered | trust not considerd | Total |
|---|---|---|---|
| 1 | 4 | 2 | 6 |
| | 4,70 | 1,30 | |
| | 0,105 | 0,381 | |
| 2 | 25 | 6 | 31 |
| | 24,30 | 6,70 | |
| | 0,020 | 0,074 | |
| Total | 29 | 8 | 37 |

Chi-Sq = 0,580; DF = 1; **P-Value = 0,446**

The p-value of 45% does not allow rejecting $H_0$.

Other aspects the survey participants considered (one answer each):

- Being constant and persevering for not letting the operators forget the learned things.
- Development of a tracking tool to link Kaizen/lean activities to individual goals and hence to the relevant bonus.
- Specific visual communication on shop floor.

In the next chapter the findings of the survey and the literature review will be used to draw conclusions and make recommendations.

## 4 Discussion

The research objectives were defined as follows:

- The analysis of participants' understanding of the philosophy, the management paradigm and the principles of the TPS.
- The analysis of the employee and function involvement in their lean transformation.
- The identification of critical success factors for sustainable lean implementation.

Assessing the critical success factors for sustainable lean implementation the literature review has shown the following:

- Lean is more a philosophy than just a toolbox.
- These tools are important, but the basic tenet of TPS is that people are the most important asset.
- It is a fully integrated management and manufacturing philosophy.
- The strong balance among the key functions (operations and support functions), the top down approach and the role of continuous improvement teams for successful lean implementation was shown.

In the last part of the lean survey the findings from the fieldwork will be discussed within the context of the literature review.

The questions to be answered are:

- Do the survey findings fit with or contradict existing theory or evidence?
- Do the findings shed light on the existing body of knowledge?

and

- What are the critical success factors for sustainable lean implementation?

Together with this discussion one can try to make recommendations for future business practise including hints for lean implementation.

### 4.1 Conclusions

Conclusions and recommendations will be drawn from the understanding of the TPS philosophy (see table 3) and from the application of the theoretical model of the Henley transformation framework (see table 5).

As roughly 90% of the interviewed persons associate the TPS with a toolbox of techniques to reduce waste and the use of teamwork (see figure 17) it can be concluded that this data supports the findings in the literature review.

Generally it can be said that the survey confirms the theories of recent literature. All critical aspects were more or less considered (only 4 out of 30 which were not taken into account by at least 50% of the participants, see table 8).

- Conclusions: Mobilise for change

As shown in the theory, a huge variety of different authors have underlined the need for a strongly supported top-down approach and the need for leadership in the process of lean change. As the top four aspects (see figure 26) fall in the first category of the Henley transformation framework (see table 5) it can be concluded that based on the survey data mobilising for change seems to be the most important step on the lean pathway. Based on the interviewees' opinions, thoroughly understanding stakeholder expectations and leading the change are those success factors which seem to be most critical.

Especially empowerment and building trust through the involvement of operators in Kaizen teams are both relevant for achievement based on the literature and the survey (rank 3 and 4, table 10). The basic TPS philosophy in which the human dimension is the single most important element for success is supported by the interviewees.

Whereas the TPS founder Ohno (1988) very much focuses on the application of the lean toolbox (in the sense of the Henley transformation framework category 2: translating strategy into objectives and initiatives, see table 5), recent Toyota managers like Convis (2002) do much more focus on the importance of the right management behaviour (category 1: mobilising for change) to implement the philosophy and the tools. The findings in the survey much more support the ideas written in recent literature than Ohno's theories. Seeing that the top two success factors are "board and top management are actively and supporting change" and "strong leadership" it becomes very clear that the research supports recent literature. "Teaching lean

skills and lean thinking", which is strongly supported by Ohno's theories however was placed on rank 13 by the survey participants (74% of top score, see table 10), which is still a high score but in comparison not as relevant.
It is remarkable that authors like Womack and Jones (2003) underline the need for a crises (examples like the Porsche story support this) but the sample in the survey in comparison does not give a very high priority to this aspect (rank 24, 65% of top score, see table 10). 51% of the participants (see table 8) had a crises that motivated them to start their lean efforts. As less than 10% of the survey participants were not successful (see figure 21), it can be concluded that it is also possible to successfully introduce lean principles without an organisational crises. However, when looking at the 30 survey participants whose expectations on lean were either entirely or largely fulfilled the majority of 60% had a crisis that motivated them to start.
The aspect that managers who simply not accept lean ideas should be removed (which was drawn from the literature review) is also mirrored in the survey (rank 16, see table 10).
To sum up, based on the opinions of the respondents those aspects which seem to be most critical can be found in the first category of the Henley transformation framework, which will be incorporated in the recommendation section.

- Conclusions: Translate strategy into initiatives and objectives

Not only starting the right initiatives but also the speed in which this is done seems to be a relevant factor which needs to be considered. The interviewees ranked this the 7th most important factor (see table 10).
Employee pull and management push concerning the initiative are placed on rank 10 and 11. The literature discusses both approaches and does also not come to a decision which one is more important. This fact is mirrored in the survey.

**Table 11: Which TPS tools were not used?**

| Tools used during lean transformation process / Expectations on using lean principles | Value Stream Mapping & Design | 5S (clean and safe working environment) & visual control | Flow production, One Piece Flow | Takt time & Standardisation | Production Smoothing, synchronisation of lot sizes | SMED (Single Minute Exchange of Die - Setup time reduction) | Kanban and standardized material buffers | Six Sigma - Reduction of variation | TPM (Total Productive Maintenance) | ToC (Theory of Constraints) |
|---|---|---|---|---|---|---|---|---|---|---|
| not at all & hardly fulfilled | 57% | 0% | 43% | 43% | 71% | 29% | 14% | 43% | 29% | 86% |
| largely & entirely fulfilled | 14% | 11% | 14% | 25% | 29% | 29% | 4% | 36% | 25% | 46% |

However, converting at a certain stage from top-down initiatives to a bottom up approach in order to create an incremental change is relevant in the eyes of the interviewees also.

The TPS founders Ohno (1988) and Shingo (1989) emphasised the use of lean tools in their theories. Table 11 analyses the use of TPS tools in two survey groups. The percentage values show how many respondents did not apply a certain tool (question 5 – answer: “not used at all”) during their lean rollout.

Generally it can be said that on average those organisations were the expectations on their lean approach were largely or entirely fulfilled were using more tools than the other group. However, also differences between these groups can be discovered. The literature review has shown that a Value Stream Map is the most important tool. The fact that 57% of those survey participants whose expectations were not fulfilled are not using this leads to the assumption that is seems to be critical for success. Therefore it can be said that these survey findings fit with the existing theories.

Only half of the respondents (51%) integrated their suppliers and customers into their lean rollouts (see table 8). Theory clearly says that a stable and lean supply chain must be built by incorporating them. However, the respondents are rarely using tools across the whole value chain (see figure 25). It must be questioned if it is possible, that 51% integrate their suppliers but only three TPS implementation tools with a very low usage are deployed with customers and suppliers (8.1% VSM, 1.6% Kanban and 1.6% bottleneck elimi-

nation with ToC, see figure 25). Again, the weakness of drawing data related findings from a survey that is mostly based on opinions limits the significance and explanatory power of conclusions drawn out of it. Inconsistencies like this can only be investigated by further research.
Additionally the findings from the further reading showed the need for establishing lean performance parameters and the use of a strategic tool like policy deployment for top-down planning. It can not be concluded that the survey results do verify this importance. On the table that shows the used aspects "policy deployment" has rank 28 (see table 8) and when looking at the respondents' opinions in table 10 it only has rank 29. However, this fact goes hand in hand with question 6. If the whole organisation is not incorporated into the lean transformation than the use of tools like policy deployment does not make sense.

- Conclusions: Design the change process

The fact that the literature did not deliver a sequence in which tools and concepts need to be deployed can be retrieved in the survey as most participants did not give the setting of a Kaizen agenda high priority (rank 27, table 10). Analysing the data and comparing again the two groups of respondents, 33% of those who were not successful and 58% of those who were successful, did not have a Kaizen agenda. Based on this it can not be concluded that this is not relevant for success although the reading supports this. However, there is no statistical evidence, as the data is only based on opinions, especially when asking if expectations were met or not. The participating persons may have defined success and their expectations in different ways which limits the conclusions drawn from the data.

- Conclusions: Align the organisation

The authors of lean books and articles have clearly shown the importance of the integration of all organisational functions in the transformation process. In comparison with the survey data this field is where the biggest gap between reality and theory exists. As shown in figure 22 the function operations is very well integrated into the process followed by quality. Only 16.1% of respondents did either fully or largely integrate purchasing and figures for HR, R&D, sales and marketing or finance are even below this.

However, this may also have to do with the time the organisations have spent on lean so far. Knowing that the survey participants on average did not start their lean efforts before the year 2000 it could still be the case that they are planning further integrations of these functions and with that be even more successful, which was however not asked in this survey. Only further research could verify or reject hypothesis on the correlation of success and the involvement of the whole organisation.

However, the fact that 71% of the participants built internal customer and supplier relationships (see table 8) could be seen as a first step into this direction. Looking at this aspect the survey data clearly supports the reading findings.

Whether a reward and incentive system is critical for successful lean implementation or not could not be clarified as the existing literature was twofold. The respondents however do have a clear opinion: they have rated this aspect on the last rank of the importance scale (see table 10). Therewith it can be concluded that the sample supports those authors who deny the need for additional compensation.

Analysing the need for skills, capabilities and resources, both the literature and the survey support the importance of the availability of a good change agent (rank 6, see table 10). This also applies for the need for teaching lean thinking and lean skills to everyone in the organisation (rank 13, table10).

- Conclusions: Organisational learning

Relevant TPS implementation literature aspects which could be linked to the category organisational learning were striving for perfection and creating a lean promotion office to manage knowledge and training. As shown in figure 21 roughly 60% of the respondents use Six Sigma as a continuous improvement tool in order to strive for perfection. However on the importance scale in table 10 these two aspects are rated at the end of the scale (rank 28 and 26). Again, this can be attributed to the fact that the participating organisations on average started their lean efforts in 2000, which could mean that they are not yet at the stage to transfer their top-down initiated continuous improvement processes into organisational learning.

To summarise it can be concluded that the survey findings fit with existing theory. The TPS philosophy on average is well understood (see figure 17),

the relevant TPS tools are practically used (see figure 23) and the majority of the management aspects shown in table 8 are very well considered (26 out of 30 have been noted by more than 51% of the participants). Especially the data drawn out of table 10 clearly supports the fit: all aspects have reached more than 50% of the possible top score (all participants voted “very important”). When building quartiles (<25% “not important”; <50% little important; <75% “important” and <100% “very important”) all critical aspects taken from the literature on average have at least been voted by the respondents to be “important” for successful lean implementation.

Based on the findings of the literature and survey the critical success factors for sustainable lean implementation will be summarised and implementation recommendations will be made.

## 4.2 Recommendations

### 4.2.1 Implementation recommendations

- Recommendation: Train the organisation and make sure that everybody thoroughly understands the TPS philosophy.

Before starting with the introduction of lean implementation actions it is strongly recommended to first of all make sure that the whole workforce understands that lean is more than just a toolbox, the use of teamwork and the elimination of non value adding tasks. Conducting lean training and explaining that a fully integrated management philosophy like the TPS does not seek tom reduce headcount but is a way to create new work and business which can clearly be proved by looking at actual Porsche figures. Especially it is essential that everybody understands that even if redundancies and excessive operator and machine capacities are shown, the TPS is not a tool for headcount reduction.

- Recommendation: Ensure that the board and top management actively drive and support the change with strong leadership.

Especially the survey has shown that the most important success factors are related to top management support during the whole change process. Strong senior manger availability on the shop floor, regular Kaizen event and lean training participation are mandatory if an organisation seeks to implement the TPS on a sustainable basis.

Those companies which were successful were driven by CEOs who spent up to 35% of their time on the lean rollout. Management should be aware of this responsibility and critically ask them if they want to contribute that amount of time.

- Recommendation: Do not only concentrate on TPS tools and techniques – everyone in the organisation (including all stakeholders) should commit to make it work.

It is critical to success that both the change agents and the functional managers have a good understanding of the relevant lean tools and TPS concepts. Moreover it is important that responsible persons do understand that this is a basic presumption and not the essence of the TPS. Once certain knowledge of these tools has been developed in an organisation it is essen-

tial that all stakeholders, especially the workers' council are involved. If the organisation struggles to commit, it is recommended to create a crises to enhance this.

- Recommendation: Find a good change agent.

As with the use of the lean tools waste in the sense of the TPS will come to the surface, which may generate fears among the workforce, it is critical that an experienced change agent is responsible for team facilitation and the rollout. A very good knowledge of the lean methodology and concepts is mandatory, good social and communication skills, the ability to integrate, to fascinate and to implement changes are attributes the Kaizen facilitator should either develop or have. If these resources are not dedicated 100% towards lean transformation, there is a big risk of losing speed, quality and support.

- Recommendation: Set a Kaizen agenda communicate it and involve operators through empowered Kaizen teams.

It was shown that the use of the untapped knowledge of process owners and operators plays an important roll in the Kaizen process. Therefore a Kaizen project sequence needs to be defined and the goals have to be communicated.

- Recommendation: Map the value streams, apply standard TPS tools and begin as soon as possible with an important and visible activity.

The above mentioned Kaizen project sequence should be developed with the help of a value stream amp and a value stream design. This should function as a vision of a waste free future state of the processes which can be communicated to the workforce. Once decisions on certain Kaizen events have been made it is vital to success that the first improvement is made visible and implemented quickly to convince doubters.

- Recommendation: Integrate the supporting functions into the lean rollout and build internal customer and supplier relationships.

As lean is a fully integrated management philosophy it is recommended that the idea of continuous improvement is also transferred into those organisational functions which support manufacturing and operations. It is relevant

that all departments understand their roll in the lean transformation process. The best way to do that is by creating internal customer and supplier relationships.
In the following paragraph recommendations for further research will be given.

### 4.2.2 Recommendations for further research

Both the results of the fieldwork and the discussion have shown that the analysis of the hypothesis quoted did not lead to statistically significant results. The small sample size and in that especially the data drawn from those survey participants whose expectations on lean were not met, has resulted in information that does partly not support the survey participants' opinions. Therefore it is recommended to conduct a similar research with strong focus on two data sets: on with a sample taken from organisations which were successful with their lean efforts and one with organisations which did not have success. However, in that case it would be necessary to define "success" with relevant performance parameters to make the data sets comparable. A sample size of 200 answering parties in each data set should allow one to draw statistically significant conclusions.
As shown, lean transformation is much more a pathway than a goal. Therefore it would also be interesting to conduct a similar questionnaire in 5 to 10 years with the same sample. As they on average now have 5 years of experience using lean it could shed even more light on the critical success factors when the average experience is even longer.
These and other limitations of the research will be discussed in the last paragraph.

## 4.3 Limitations of the research

The reflections in the fieldwork and the discussion sections have already shown the limitations of the research.
Summing up it has to be said that the conclusions drawn in this lean survey are more based on indications than on statistically significant results. As shown, the opinions of the respondents could not always be supported by statistics. Even where it was possible, the results should be looked at more

closely and considered to be more of a general indication rather than a statistical proof, that certain aspects are critical to successful lean implementation. However, as most of the findings of the literature review were reflected by opinions in the survey, it can still be said that the applicability of the theory to the population could be confirmed.

# Appendix

## Appendix 1: Questionnaire

Instructions

This survey is being carried out to find out how well organisations, which are implementing lean practices, apply the Toyota Production System's philosophy, implement the associated management systems and how well they are using the lean toolbox on the whole value stream.

The survey will be used to analyse the critical success factors for successful lean implementation.

Please answer the questions freely. You cannot be identified from the information you provide, and no information about individuals will be given to anybody.

All the information you provide will be treated in the strictest confidence.

The questionnaire should take about 10 minutes to complete. Please answer the questions in the space provided. Try to complete the questions at a time when you are unlikely to be disturbed. Also, do not spend too long on one question. Your first thoughts are usually your best!

Even if you feel the items covered may not apply directly to your working environment please do not ignore them. Your answers are essential in building an accurate picture of the issues that are important to improving the success and sustainability of lean transformation processes.

I hope you find completing the questionnaire enjoyable and thank you for the time to help us.

If you have any queries or would like further information about this project, please call me on +49-163-8318043.

Thank you for your help,

Thorsten Ahrens

**Section I: Questions testing the understanding of the lean philosophy**

**1**

**When did your organisation start efforts to introduce lean principles?**

quantity

| | | |
|---|---|---|
| 1 | Year | |

**2**

**What do you associate with the lean philosophy (any of listed items may be selected)?**

list

| | | |
|---|---|---|
| 1 | A method to reduce headcount | |
| 2 | A toolbox of techniques (just-in time & autonomation) to improve manufacturing and operations | |
| 3 | The use of teamwork and continuous improvement | |
| 4 | The consequent elimination of non value adding tasks in order to reduce lead time | |
| 5 | A fully integrated management philosophy | |
| 6 | A way to create new work and business | |
| 7 | A system for organising and managing product development, operations, suppliers, and customer relations | |
| 8 | A system to reorganise the firm by product family and value stream | |
| 9 | A system to make products with fewer defects in order to strive for perfection | |
| 10 | A philosophy that absolutely focuses on customer value (customer first focus) | |
| 11 | other (please describe) | |

**3**

**Why did your company decide using lean practices (any of listed items may be selected)?**

list

| | | |
|---|---|---|
| 1 | Continued pressures to improve operational performance | |
| 2 | Maintain competitive advantage in price and service | |
| 3 | Pressure to improve profit | |
| 4 | Customers demanding shorter order cycle (lead) times | |
| 5 | Customers demanding reduced prices | |

**4**

**Overall the expectations on using lean principles (only one response can be selected) you had were**

category

| | | |
|---|---|---|
| 1 | not at all fulfilled | |
| 2 | hardly fulfilled | |
| 3 | partially fulfilled | |
| 4 | entirely fulfilled | |

**Section II: Questions analysing the usage of TPS tools and techniques**

list

**5**

category

**Please tick the specific lean tools your organisation is using in order to become a lean enterprise (only one category can be selected per response)!**

| Response | Category | not used at all | local use only | use in the whole factory/ organization | used on the whole value stream including customers and suppliers |
|---|---|---|---|---|---|
| 1 | Value Stream Mapping & Design | | | | |
| 2 | 5S (clean and safe working environment) & visual control | | | | |
| 3 | Flow production, One Piece Flow | | | | |
| 4 | Takt time & Standardisation | | | | |
| 6 | Production Smoothing, synchronisation of lot sizes | | | | |
| 7 | SMED (Single Minute Exchange of Die - Setup time reduction) | | | | |
| 8 | Kanban and standardized material buffers | | | | |
| 9 | Six Sigma - Reduction of variation | | | | |
| 10 | TPM (Total Productive Maintenance) | | | | |
| 11 | ToC (Theory of Constraints) | | | | |
| 12 | other (please describe) | | | | |

**Section III: Questions analysing the scope of TPS implementation**

list

**6**

category

**Which of the following functions is strategically integrated in your company's lean rollout (only one category can be selected per response)?**

| Response | Category | not at all integrated | hardly integrated | partially integrated | largely integrated | fully integrated |
|---|---|---|---|---|---|---|
| 1 | Engineering, R&D, product & process development | | | | | |
| 2 | Quality | | | | | |
| 3 | Finance | | | | | |
| 4 | HR | | | | | |
| 5 | Sales & Marketing | | | | | |
| 6 | Purchasing | | | | | |
| 7 | Operations | | | | | |

list

**Section IV: Questions testing the importance of critical management factors**

**7**

category
scale

**Which of the following aspects is or was considered during your organisational lean rollout (only one category can be selected per response) and which one in your opinion (on a scale from 1 to 4) is critical for successful lean transformation (1: not important, 2: little important, 3: important, 4: very import**

| | Response Category | yes | no | | critical (1 to 4) | Scale |
|---|---|---|---|---|---|---|
| 1 | Enrolment of stakeholders for commitment, i.e. workers' council | | | | | |
| 2 | Availability of a crises that motivates the organization to change | | | | | |
| 3 | Elimination of managers, who would not cooperate in order to get commitment to lean | | | | | |
| 4 | Demonstration of senior management impatience by regularly reviewing progress reports | | | | | |
| 5 | Board and top management actively driving and supporting change | | | | | |
| 6 | Lean champions removing blocks in the organization | | | | | |
| 7 | Finding a good change agent | | | | | |
| 8 | Involving operators through empowered Kaizen teams | | | | | |
| 9 | Beginning as soon as possible with an important and visible activity | | | | | |
| 10 | Getting shop floor commitment and employee trust | | | | | |
| 11 | Communication of the transformation process, goals etc. | | | | | |
| 12 | Managerial push (mandatory participation in workshops & training) | | | | | |
| 13 | Employee pull (employees fully understand the benefits on lean and improvement for themselves independent from management's support) | | | | | |
| 14 | Strong leadership | | | | | |
| 15 | Top management presence and availability on the shop floor | | | | | |
| 16 | Employees are free to allocate time to improvement (empowerment) | | | | | |
| 17 | Executives join kaizen events on a regular basis | | | | | |
| 18 | Resources freed up by productivity gains are reinvested into the search for still greater improvements | | | | | |
| 19 | Leaders and supervisors motivate, coach, train and facilitate the work of those adding value rather than to tell them what to do | | | | | |
| 20 | Avoidance of any linkage between lean practices and layoffs | | | | | |
| 21 | Planning for and creating short-term Kaizen wins | | | | | |
| 22 | Utilising policy deployment | | | | | |
| 23 | Setting a Kaizen agenda for the organisation | | | | | |
| 24 | Building internal customer - supplier relationships | | | | | |
| 25 | Integrating suppliers and customers into the lean transformation | | | | | |
| 26 | Striving for perfection | | | | | |
| 27 | Implementing a reward and incentive system for successful lean projects | | | | | |
| 28 | Creating a lean promotion office for organisation and training | | | | | |
| 29 | Converting from top-down leadership to bottom-up initiatives | | | | | |
| 30 | Teaching lean thinking and lean skills to everyone | | | | | |
| 31 | other (please describe) | | | | | |

Thank you for taking time to complete this questionnaire. If you have any queries do not hesitate to contact Thorsten Ahrens by telephoning (+49-163-8318043).

Thank you for taking time to complete this questionnaire. If you have any queries do not hesitate to contact Thorsten Ahrens by telephone (+49-163-8318043) or email (thorsten.ahrens@lean-alliance.com).

Please add the webpage you will be guided to at the end of the survey to your favourites. You will be able to download the survey results from this source in a few weeks.

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