Lean manufacturing in the footwear industry

PHIL SHAW investigates the use of this production method.

The principle of 'lean manufacturing' has now been used for a number of years. Over a century ago, the Ford Motor Company experimented with techniques to improve efficiency, and some of this work may be recognised within current thinking. In the 1990s, Toyota formalised a number of ideas that became lean manufacturing as we now know it.

As the footwear industry has become increasingly dependent on outsourcing and distance manufacturing, it is worthwhile reviewing the progress of lean manufacturing – and, more appropriately, 'lean thinking' (defined as 'a business methodology that aims to provide a new way to think about how to organise human activities to deliver more benefits to society and value to individuals while eliminating waste') – to global supply chains.

The most basic concept of lean manufacturing is the application of a series of techniques that progressively reduce or eliminate waste. Proponents of lean manufacturing stress that waste reduction is not a 'once and for all' activity – it is a journey that continues, probably without end, as conditions and products constantly change.

What is 'waste'? Any activity that creates unnecessary or defective product, causes delay or misunderstanding, or incorrect information (see table 1).

While it is relatively straightforward to imagine waste occurring during the manufacturing operations, there are many instances of it being created in the transmission of information between companies. This can be caused by delays in decision-making and imprecise data, leading to unnecessary activities.

Thus, the process of designing, developing, planning, manufacturing and distributing footwear provides a significant number of opportunities to consider the application of lean manufacturing/lean thinking techniques to our everyday activities.

Lean manufacturing is basically the application of techniques that progressively reduce or eliminate waste

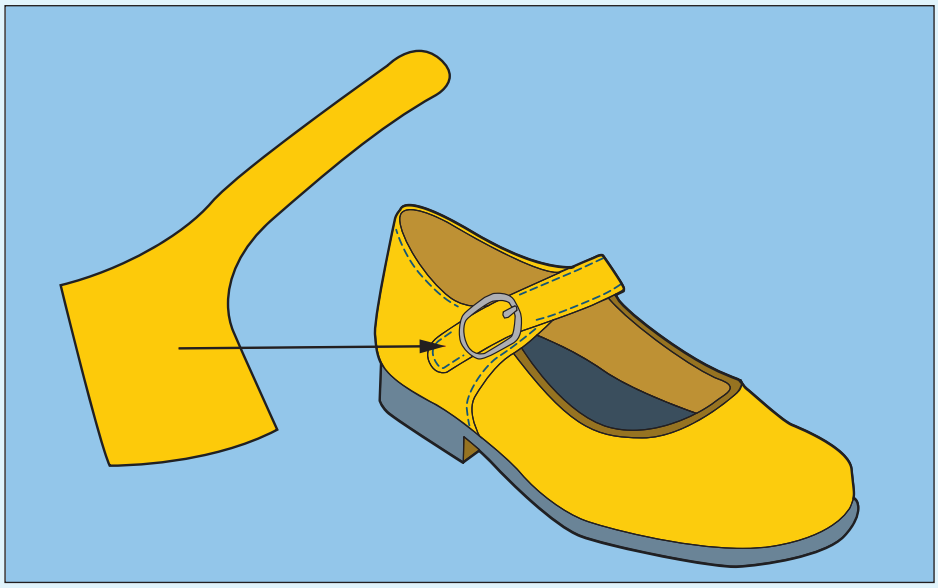

Figure 1: A child's one bar shoe

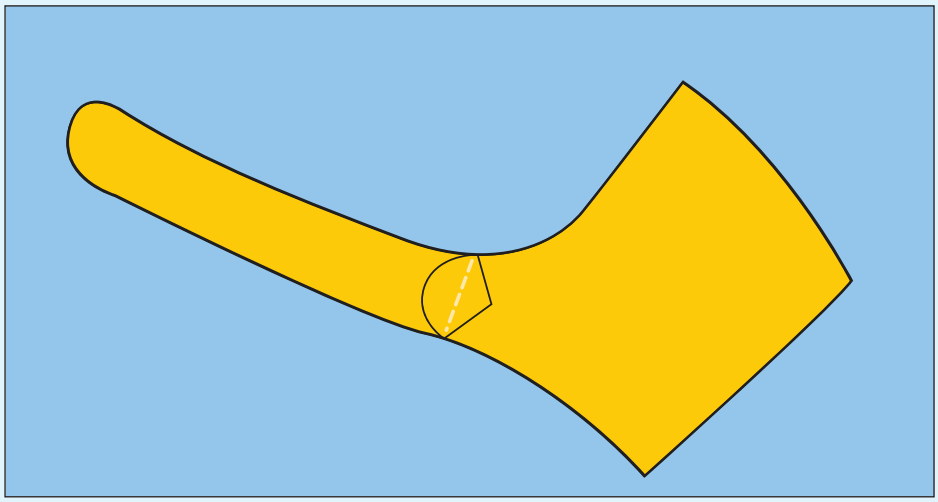

Figure 2: A modified pattern

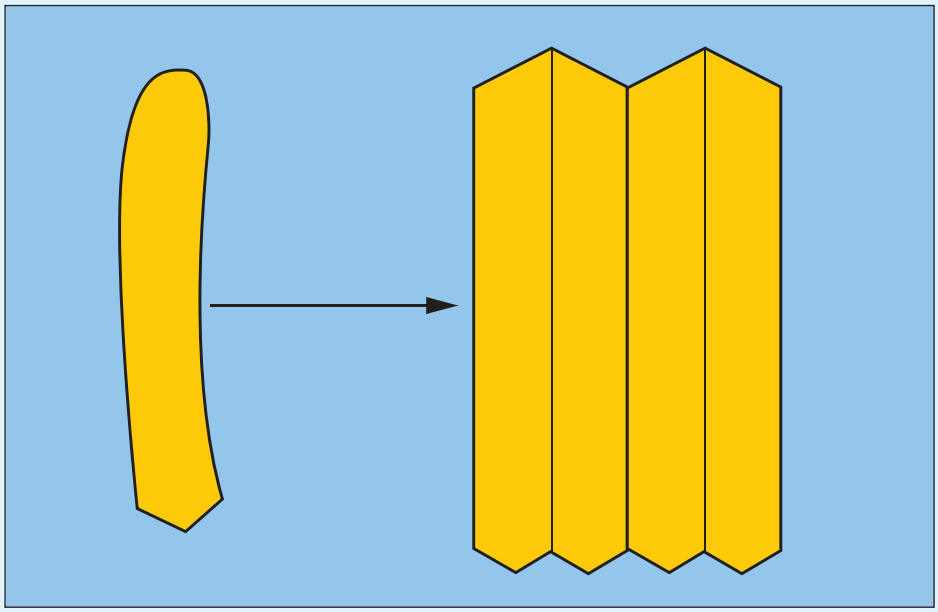

Figure 3: Multiple die

Box 1: Characteristics of a customer's needs and wants

'Must be': The quality characteristic that must be present or the customer will go elsewhere.

'Performance': The better we are at meeting these needs, the happier the customer is.

'Delighter': Those qualities that the customer was not expecting, but received as a bonus.

The customer

Underpinning the concept of any lean application is the absolute need to understand the requirement of the customer. We may consider the person who actually places the shoes on his or her feet, and pays for them, as the 'customer'. In reality, however, a customer can be anyone within the supply chain who interacts with, or receives information or a product from another person.

Knowing what this customer needs and wants – rather than what we think he or she does – is vitally important if these are to be met. The customer's requirements and desires can be analysed into three distinct characteristics (box 1).

How these levels apply to each customer will vary with the individual's needs. Consider the example in table 2 – members of staff at a hotel questioned both business people and holidaymakers staying with them to establish their needs, and then compared their responses to the services provided. This approach enabled the hotel to improve any element that was considered less than satisfactory, as well as building on its strengths.

This type of customer analysis is increasingly used by companies in the footwear sector to differentiate between customer types, and therefore reduce or eliminate products that are not required – thus significantly minimising waste.

Product design

The shoe designer has the opportunity (as well as a considerable responsibility) to minimise waste that may occur during the manufacturing phase. Working with engineering personnel, the designer can identify patterns that cause waste during the cutting operation, or could create difficulties in assembly. There may be a

slight conflict between the original, artistic design and the more practical version which results from these discussions, but this compromise is essential if the aims of lean manufacturing are to be achieved.

Consider the example in figure 1. This child's shoe has an extended bar to secure the product to the foot. However, the inside quarter pattern is difficult to interlock and results in significant waste of material. When the footwear engineer split this pattern into two, to create a separate bar (shown in figure 2), the quarter pattern became more efficient to cut.

A second modification straightened the bar so that this could then be cut with a multiple die, producing two pairs at one time (figure 3). There was a slight increase in the time and cost of cutting, skiving and stitching, but this was more than offset by the improvement in material efficiency.

This type of thinking – 'pattern engineering' – fits within the remit of lean manufacturing and is now widely used at the initial design stage.

While SATRA has noted many examples of this type, it is interesting that a number of the pattern modifications originated not only from the need to save costs, but also to make the volume production of the shoes slightly easier. This resulted in a reduction in quality issues, which is also an important contribution to lean manufacturing.

One further reason for the use of pattern analysis and engineering is the feedback from the final customer who will wear the product. Minor pattern changes can significantly add to the comfort and/or performance of the shoe.

Product development

Prior to the product being confirmed for bulk production, there are a number of steps to be taken to develop the designer's initial concept into a practical item that can be manufactured under production conditions and meet the customer's expectations. Although each of these steps can be considered as a discrete item, they should wherever possible be carried out simultaneous or in conjunction with some other steps. If each decision follows on from the previous one, the overall time can run into many weeks – most of which will actually be taken up waiting for information, reports or decisions.

Table 1: Types of waste

Symptom	Cause
Overproduction	Excessive batch size, producing to keep busy
Waiting	For materials, authorisation. Information and equipment
Transporting	Paperwork between departments, moving materials
Inappropriate, excess process	Unnecessary packing or wrong equipment for the task
Unnecessary motion	Poor workplace layout/lifting, bending and stretching
Defects	Rework, scrap, waste, paperwork errors and mistakes
Unnecessary inventory	Overstocking in warehouse, minimum order quantities too high

Table 2: Identifying the changing needs of hotel customers

Characteristic	Business client	Holidaymaker	How good are we?
Price	Performance	Must be	Satisfactory
Fast check-in	Performance	Performance	Weak
Express check-out	Must be	Performance	Weak
Location	Performance	Performance	Satisfactory
Comfortable bed	Must be	Must be	Satisfactory
Continental breakfast	Must be	Delighter	Satisfactory
Jacuzzi	Delighter	Performance	Weak
Internet	Must be	Delighter	Weak
Newspaper	Must be	Delighter	Satisfactory
Cable/movies	Delighter	Must be	Satisfactory
Exercise room	Delighter	Performance	Weak
Swimming pool	Delighter	Must be	Satisfactory
Restaurant	Performance	Performance	Weak

The availability of appropriate technology to link these actions and discussions – connecting existing 'islands of technology' (figure 4) – is often referred to as the 'internet of things'. Certainly, using this type of coordinated approach enables information to be transmitted instantly and decisions made much more rapidly. A number of companies in the footwear sector regularly share information with suppliers and customers, and many testing laboratories provide results electronically.

Producing a prototype of the intended new design was traditionally a time-consuming activity, as much of the work would be carried out by hand, including building sole units. The advent of three-dimensional (3D) printing has provided a significantly faster, and more reliable, method of creating these first prototypes.

Appropriate technology – such as 3D foot scanning (figure 5) – has also helped the move into both lean manufacturing and customisation. Recording the actual shape and dimensions of the intended purchaser's feet allows shoemakers to rapidly generate design options and actual shoes.

Production planning

The article 'Production planning in the footwear industry', published in the July/August 2017 issue of *SATRA Bulletin* highlights how some of the elements of lean manufacturing impact on the activities of the production planner. As manufacturing time has been progressively reduced (as detailed later), the planner has applied more efforts to preparing for the start of the shoemaking phase, ensuring that there are sufficient materials and components available, as well as calculating how much direct labour and machine time is needed.

In order to assist with these activities, and to identify any potential problems before production begins, shoemakers can now simulate the most likely scenarios. The availability of appropriate software to predict reliable operation times has enabled manufacturers to load selected products into a simulation module, identify the number and location

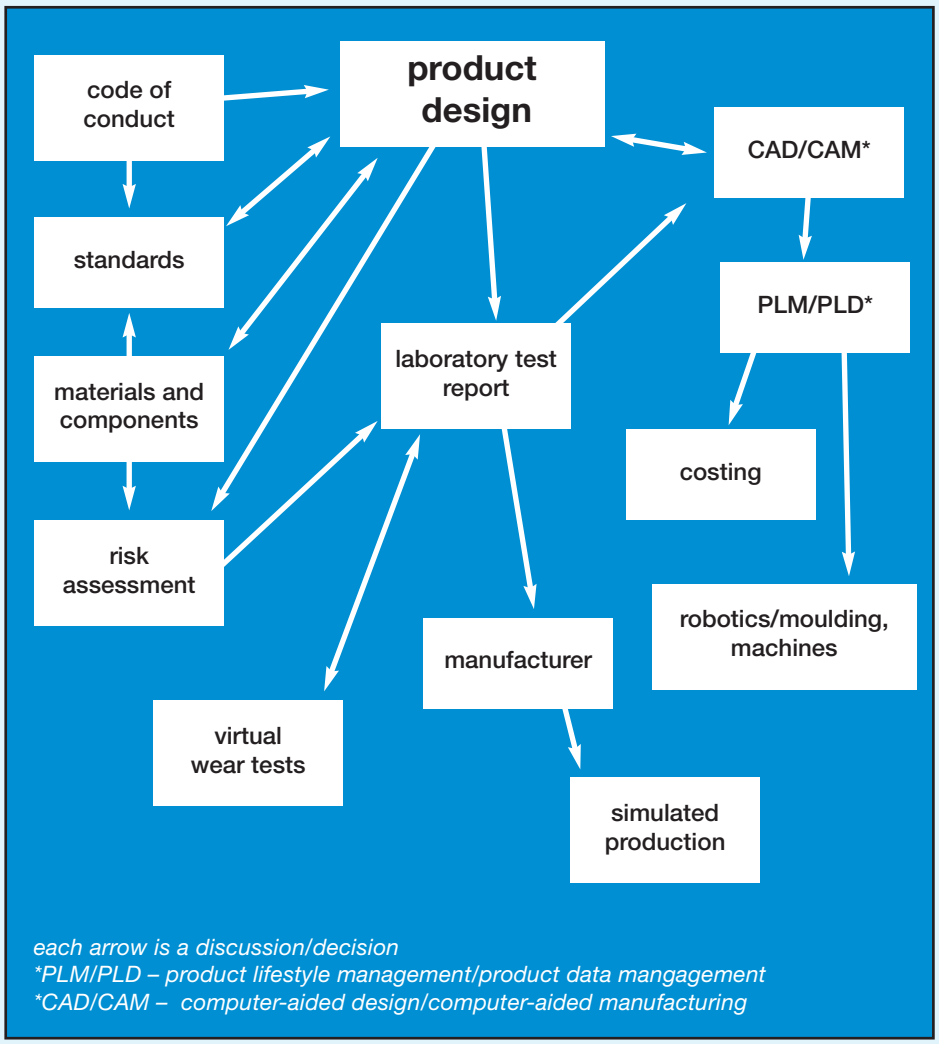

Figure 4: Connecting existing 'islands of technology'

of operatives and equipment, and then start the production run. This allows them to see if any imbalances will occur, which are often not visible until well into the production run. These imbalances can have significant effects on the efficiency of the manufacturing line, and cause serious 'bottlenecks' in output. Any lack of efficiency runs counter to the aims of lean manufacturing, as it creates waste – in time, space, quality and human resource.

The simulation module allows manufacturers to see problems before they occur, and therefore explore alternative scenarios or solutions. It provides managers with the opportunity to consider how to make best use of their skilled resources.

As shoemakers have moved away from the traditional 'high level of work in progress' model, fewer operatives with a single skill have been developed in response to the piecework system which pays purely on output. It is increasingly common to have multi-skilled operatives who, while unable to match the output of the previous workers, are able to move within the production environment wherever they are needed.

Manufacturing

Much of the lean manufacturing implementation that has taken place has been concentrated in the actual shoemaking phase. The overall time to make footwear has progressively fallen from weeks to days and, in some cases, only a few hours.

SATRA has identified the actual work content of most footwear to be in the range of 30 to 90 minutes – yet this was traditionally spread over a much longer period of time. The majority of this time was waiting – either for previous work to be completed, for machine or labour availability, for components or information or a decision. By applying some of the fundamental tools of lean manufacturing, shoemakers have been able to significantly reduce or eliminate this waiting time, removing waste for this part of the supply chain.

Manufacturers have also reduced the batch size. This has several advantages:

- lower levels of work in progress
- greater visibility of any line balancing issues
- increased awareness of quality problems.

In order to maintain a high level of production efficiency with such low levels of work in progress, manufacturers have invested in increased stocks of raw materials and components to ensure that the manufacturing line has no delays. In addition, regular maintenance of the manufacturing equipment is essential, as any breakdown will immediately impact on the entire production environment.

To manufacture footwear in a matter of hours rather than days or weeks, shoemakers have invested in the appropriate equipment – for instance, heat setters, chillers and drying tunnels. This type of technology can perform specific operations or provide relevant conditions to replace the extended time that was traditionally considered necessary to impart the relevant quality to the shoe. For example, a correctly maintained and operated heat setting machine will in less than ten minutes impart a similar level of shape retention to the lasted shoe as the traditional practice of leaving the shoe on the last for a number of days – even three weeks in extreme cases.

Lean manufacturing has certainly emphasised the importance of the bottleneck. In any series of discrete operations (such as the assembly of footwear), there will be an imbalance due to the varying times that each task will need in order to be completed. The operation with the longest time – due, perhaps to the machine cycle, lack of additional equipment or trained operatives – is therefore the bottleneck. This invariably sets the pace, and thus limits the overall output of the line. Because this bottleneck is working at effectively 100 per cent capacity, it is vital that any previous operations which experience delays or breakdowns are dealt with quickly. If the supply of work to the bottleneck is not

maintained, any time lost cannot be made up within the normal working hours. It will be lost forever.

The change from the traditional, high work in progress method of shoe production to a much leaner arrangement has also provided shoemakers with the opportunity to re-plan the physical layout of their manufacturing areas. Some have continued to use conveyors to move work between operatives. By contrast, other producers have experimented with a smaller arrangement, based on a limited number of operatives working in a team and specialising in the manufacture of a specific style. SATRA has recorded significant improvements in both productivity and quality where a carefully selected and balanced team has been set up with the appropriate equipment and training. If, for instance, the production planner can arrange for a specific style to run unchanged for several days (or even longer), a dedicated team can work with this.

The key to achieving high levels of output is to select styles with limited work content, or the team will need to be too big, will lose intimate interaction and cooperation, and will fail to meet its requirements.

Small teams are also being used to relieve the pressure on main production lines. For example, if a particular style is made in a wide range of sizes and colours, the constant changing of equipment needed to make these will significantly impact on the overall productivity. However, if a team can be tasked with making the extreme sizes (often required in low pairage) and less popular colours, this will allow the main production lines to maintain their efficiency. The team's output will be significantly lower, but manufacturers view this as a small price to pay when considering the overall picture.

In addition, flexible, multi-skilled teams are used to respond to specific customer requests, such as those generated from customisation (see the section on 'customer service').

Added value

Wherever an activity takes place within the supply chain, lean thinking demands that it is an essential one. Because of the complexity of the current global supply chains, involving many different companies, hundreds of people in a number of countries, speaking different languages and living in different time zones, it is essential to control the many individual tasks necessary to design, develop, manufacture, transport and sell footwear.

Table 3: Value/non-value-added activities

Category	Activity
Value added	Activity that the customer is willing to pay for
Non-value-added but necessary	Activities that must be performed for legal or regulatory/compliance reasons
Non-value-added: waste	Activities that the customer would not pay for

These activities can be categorised into those which add value to the product (and for which the customer is willing to pay), and those which they clearly should not (table 3).

Non-value-added activities are often regarded as unavoidable – for instance, moving batches of work between work stations or departments, multiple inspections throughout the manufacturing cycle and downtime when styles change.

Most of these activities can be minimised by the application of lean thinking, and a number of companies have repositioned equipment and storage areas to virtually eliminate much of the non-value-added time.

However, it is not simply a case of these two options. It is likely that there will be some activities that are necessary – for example. to show that the company, activities and products meet any legal requirements or to achieve product certification. These activities represent an additional cost and – equally importantly – can cause delays and a wasteful use of resources, and inhibit efforts to make the company lean.

If it is essential to carry out these activities, every effort should be made to minimise them. For instance, the testing and certification of materials and components used in manufacturing can be carried out by the supplier, before any goods are delivered. Testing the finished product can be subcontracted to a reliable, local laboratory or, ideally, tested in an approved laboratory located within the manufacturing company.

Transportation

There is little point in investing resources to reduce time in the manufacturing phase without reviewing the larger picture. When we consider that the actual time taken to make a pair of shoes is, on average, between 30 and 90 minutes, this is only a small part of the overall time for the products to arrive at the intended market.

It currently takes some 25 to 40 days to transport a container of finished goods from Asia to the USA or Europe by sea, plus a minimum of three days at the port of despatch and at arrival. Thus, the elapsed time for transportation could be as long as 46 days.

Sending the products by air is an alternative – albeit an expensive one – but this will reduce the travel time to three to seven days. Even if the fastest method is used, the manufacturing phase represents no more than 1 per cent of the total elapsed time.

In terms of cost, a typical comparison indicates that delivering by air can be up to six times that of sea freight.

Therefore, applying the principle of lean manufacturing – selecting the fastest method to minimise time and, therefore waste, could seriously conflict with any attempts to save money during transportation.

Some manufacturers have identified and use a compromise. The uppers are manufactured in bulk in Asia, then shipped to factories in the West, where they are stored and finished (such as by injecting on the sole unit), only as required to meet the market demands. In this way, they can use the slower, cheaper method of transporting uppers, but respond quickly to the demands and changes of their market.

Retail

In the traditional pre-lean manufacturing days, the longest individual period of waiting was perhaps when the footwear had been delivered to the retailer and was being stored, waiting for the customer to make a purchase.

It is now possible to manufacture and deliver footwear much more rapidly – in extreme cases, within a few days.

Figure 5: Foot scanning

However, lean thinking has had little impact on the time that the shoes remain with the retailer until purchased.

What has certainly changed, however, is the increasing effect of internet shopping. Mintel's *Online Fashion 2017* report highlighted the increased quantity and value of fashion items, including shoes, being purchased online. Sales were predicted to reach £16.2 billion in 2018 – up by over 17 per cent on the previous year. Online sales are now said to account for 24 per cent of all fashion purchases.

Why does this matter? For two reasons. Firstly, potential purchasers looking at a website can now see the entire range of products in all colours and variations, rather than having to select only from the limited choice in a retail store. Secondly, it is likely that not all of these items actually exist. They can be made, or sourced, on demand, relying on the rapid service from companies employing lean principles. As a result, the ability to source footwear products rapidly and reliably has provided retailers with the chance to offer a much wider range than those physically stored within a shoe shop. It is interesting to note that almost half of all 'millennials' (defined in the Mintel report as those aged 18 to 37) use a smartphone rather than a laptop or desktop computer when buying online. Thus, many online retailers now offer mobile-ready sites.

However, there is a downside to this level of online purchasing – over half (56 per cent) of online clothes and footwear shoppers returned some or all of the items purchased, and it is generally considered that this figure is an underestimate. The inconvenience of returning goods often leads to consumers keeping unwanted products.

Customer service

There is no doubt that technology has provided a significant boost to the gradual implementation of lean manufacturing/thinking within the footwear industry. The ultimate customer now expects the same level of service from footwear retailers as he or she can get from electronics and entertainment items. This means that not only must products meet their perceptions of quality, reliability and safety (although meeting the relevant legislation is rarely overtly considered by the customer – it is just expected to happen), but also that their choices will be available whenever and wherever they want.

The growing use of web-based purchasing is fuelling these expectations, and some retailers offer the option to purchase online, yet collect the selected products in a local store. This will raise expectations further, and we are already seeing companies offering return options as a drop-off at a local shop or even via home collection.

The offer of customised footwear has been available for some time, but the ability to produce small quantities of shoes rapidly has expanded this type of activity. As well as allowing the customer to choose from a limited range of styles and colours, and add extra features – for example, names, design features and small pictures, it is now possible (for an appropriate price), to purchase high-end footwear that is designed in conjunction with the customer. In order to offer this level of service, the manufacture and supply of footwear must operate at a very high level of responsiveness, employing lean thinking throughout the supply chain. Using the dedicated teams referred to earlier enables a customisation service that not only meets the customer's wishes, but also does not disrupt the main production effort on which the brand is based.

As previously mentioned, the continuous journey of lean manufacturing/thinking results in progressive, measurable and sustainable improvements in productivity, cost and quality – underpinned by the elimination of waste. No doubt future developments in technology will provide further opportunities for the implementation of lean principles.

However, ultimately, any change – any improvement across the global supply chain – will depend on the people employed. One of the key principles of lean manufacturing/thinking is that everyone is involved in, and supportive of, the preparation, implementation and success of any lean project.

If managers fail to understand this, and do not explain it and enthuse about it to their colleagues, lean manufacturing/thinking will not work.

How can we help?

Please email SATRA's footwear team for further information on the application of lean manufacturing in footwear design, production, delivery and retail.

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