Maximising Profit with Short Production Runs…Lean Systems Thinking

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1. Introduction

From individual machines and processes to supply chains, all industries are beginning to apply the principles of lean manufacturing to both internal and external systems. This means both machinery and labour must be more flexible. In general, the application of these principles in large plant supplying product to the global market producing on long runs such as those operating in the USA or Japan, is a formidable task but the problems are even more difficult in Australia where plants operate on shorter runs with greater product variety. The reason for the greater complexity of product and process in Australia is a direct result of its small population and geographical isolation. In the automotive supply industry in the USA it is common for the plants supplying Toyota for example, to operate two shifts 5 days per week with 2 hours between shifts making only a small range of products (1). This break is to take up preventive maintenance and scheduled production shortfall in the previous shift. There is no doubt that Toyota plans the removal of this break.

The aim of this paper is to give guidelines to the application of Lean Systems Thinking to plant producing a wide variety of products on short runs…a challenge of great importance to Australian manufacturers.

2. Background to Lean Systems

A world-wide study of the automotive industry (2) clearly demonstrated the benefits of the Toyota Production System and Lean Thinking (3). In fact these studies clearly identified that the WIP (Work in Process) in USA plants was 1000 times greater than Japanese plants (2). Independent studies have also observed that Honda have synchronised body press shops and assembly lines which are not restricted to assembling only one variety of car at a time (4). This is a direct result of operating lean systems. The application of such principles must be however be backed up by a clear strategic plan and continuous innovation in both product and process (5). All this is meaningless unless it is supported and practised by the people through a supportive, flexible team based culture (6) It therefore requires that the staff and employees have a continuously supportive and improving cultural environment.

No one single person has a mortgage on ideas. Artful workforces harness their creativity through focused teamwork. In lean systems thinking applied to manufacturing, businesses concentrate on high quality, maximum value added, minimum waste, minimum working capital, short lead times and continuous improvement by innovation and kaizen.

Accounting methods still stifle manufacturing creativity because they are formulated to satisfy taxation and shareholder requirements using financial data that is usually collected after the event. As well, it is structured in such a way that real measurements of waste,

value added, and correct overhead allocation is lost. IT systems like SAP or Peoplesoft or Movex present an opportunity to help rectify this.

Manufacturing techniques in most Australian plant making to stock, have historically worked on forecast data with a 6 to 8 week manufacturing plan. Such plans will always be in error. In essence such forecasts are trying to satisfy the basic rule of making only what you can sell, but the errors in a mass production plant with machines and equipment with poor flexibility can lead to ***overproduction, high inventory, and high obsolescence***. These problems can be addressed with the application of lean system thinking.

Lean systems thinking was developed for manufacturing by Toyota from the very first time they decided to build cars. Mr. Toyoda sent Dr. Ohno around the world to study mass production techniques first developed by Ford. When Dr Ohno returned he proposed that Toyota manufacture cars like the USA runs its supermarkets. This idea was supported by Toyota and the Lean System was born. They rejected mass production in favour of lean system manufacturing. Paradoxically Dr. Ohno only had to look as far as the Tokyo sushi bars to see the principle at work.

The Toyota System follows a series of logical shop floor controlled rules with Kanban loops (7). The basic idea is to make the manufacturing system as flexible as possible and run with ***synchronized processes and maximum value added with minimum inventory.*** This means that the setup times must approach zero lost time.

In addition the waste should be minimized and the processes should operate at a capability level where the defect rate is measured in parts per billion, not percent. This has led to 6 sigma processes.

The basic aim of Lean Manufacturing is to introduce a ***pull system*** with a ***short lead-time***. This lead- time is made up of two main components, value added and non- value added time. Value added time is run time on a machine for example, non-value added time is storage time, setup time, idle time, breakdowns, inspection time etc. An ideal goal is to achieve 100% value added time. This is ***practically impossible.*** For many plants the value is probably 5% (limited measurements) – so the opportunity is very significant.

A Lean Manufacturing System will not work if the manufacturing processes and the machinery do not perform to their capability. The capability referred to here is that expressed by the statistical capability index C_p or C_{pk} This index measures the ratio of the difference in the upper and lower specification limits set for the attribute or variable being measured, and six standard deviations of the mean measurement.

Globalization has increased the fierceness of competition As companies grow they demand a greater return on capital and as a result the rules governing the accountability to shareholders are becoming more stringent. The value of the company is largely determined by its cash flow potential measured as a return on its capital investment. Its ability to generate cash will also determine the likelihood of further capital investment to aid further growth.

Australian companies can win by being more skillful and flexible and tapping the full creativity of it's people and applying the rules of Lean Manufacturing to all processes and systems. We all must lead and learn.

3. Principles of Lean Systems

1. Pull System
2. Production equals Demand
3. FIFO (First in First Out)
4. Prevention not rework
5. Minimise Variation
6. Reduce Inventory
7. Maximize Value Added by eliminating Waste
8. Send Demand to Pacesetter process
9. Manufacture EBET
10. Run Inventory Hold Points as Supermarkets
11. Even Mix at Pacesetter Load Leveling
12. Link and Match Processes
13. Use SMED principles
14. Run processes under Statistical Process Control (SPC)
15. Use the 5S system

3.1 The Pull System

Making to stock is a push system. Push systems were dedicated in the past to long runs with the ability to satisfy a range of orders by holding inventory at many stages of production. The pull system puts the emphasis on only producing what is sold and producing in ever decreasing response times till the value added time as a percent reaches levels as close as possible to the lead time. The amount of stock in the system is determined by the product range complexity and the time requirements of the customers.

3.2 Production equals Demand

All plants would claim that they only produce what is required. However, if this is produced on forecast it will always be in error. The further out the forecast the larger this error will be. With a pull system these errors can be minimized because the validity of the data on which the decisions are based is improved greatly.

3.3 First in First Out (FIFO)

This is a basic rule of good stock and manufacturing control. It also means not interrupting the plan with the plan operating on a short time basis.

3.4 Prevention not Rework

For anyone who has visited German and Japanese plants making similar products, it is clear that make-inspect-rework philosophy of the German plant is far inferior and more costly that the preventive philosophy of Japanese Plants (monitor as you make with processes possessing a high degree of statistical capability). The German plants are changing (Porsche, Audi), while others have already benefited from improvements as a result of the application of lean systems. (Ferrari, Harley-Davidson)

3.5 Minimize Variation

Ridding the process of variation by first eliminating the special causes and then addressing the common causes after Dr. Deming (8), is basic to the success of Lean Thinking. The increase in variation upstream of the real demand for consumer based products is illustrated in figure 1. and figure 2. This is sometimes called demand amplification.

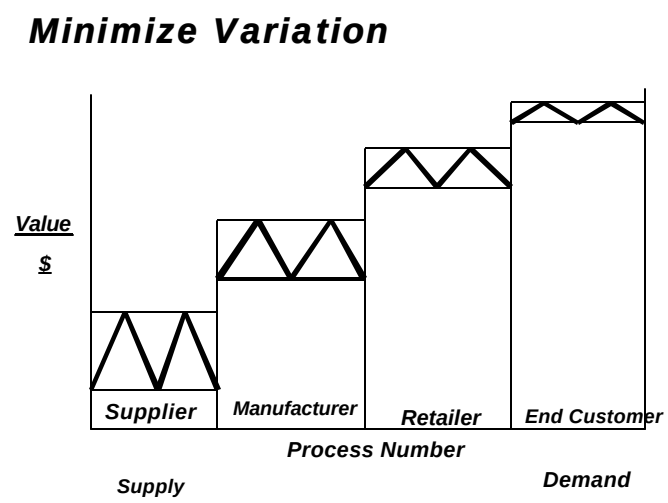

Figure 1 Variation of measurements along the supply chain. As we proceed upstream from the point of sale, the variation in attributes and variables increases markedly due to tampering caused by poor synchronisation of processes and a poor match of sales to production. (Schematic based on numerous consulting studies.)

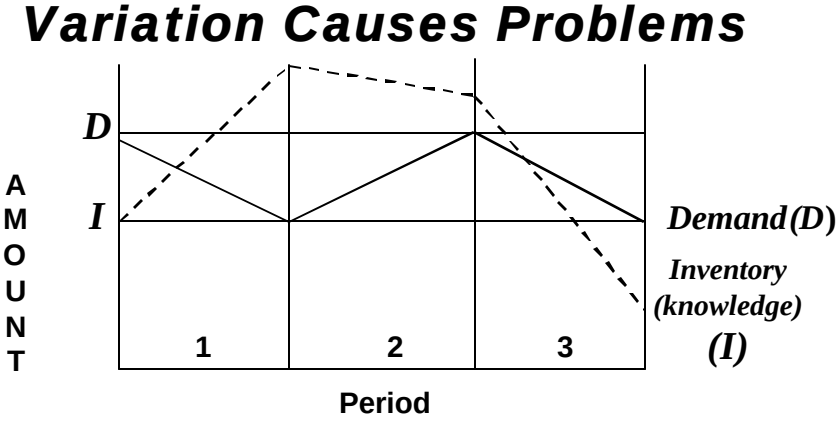

Figure 2 As the variation increases and the errors in data multiply up the supply chain the chances of problems arising increases. This is evident by increased overstocking, obsolescence or delays.(Schematic based on numerous assignments)

3.6 Reduce Inventory

Inventory is a waste in working capital, storage space, interest payments, possible damage, double handling, risk of obsolescence etc. Pull systems internally in a plant will lead to inventory points disappearing. Between plants the duplication of inventory will disappear.

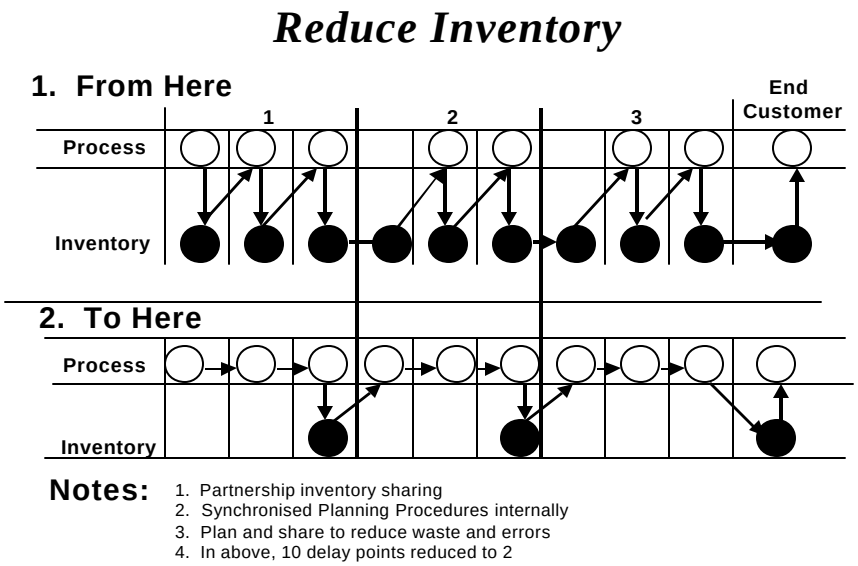

Figure 3. A Schematic Illustration of a Typical duplication of inventory in a supply chain both internally for mass production an externally between companies (schematic based on numerous assignments)

3.7 Maximize Value Added by Eliminating Waste

This means increasing the run percentage both absolutely and as a percent of crewed hours. Hence setup and clean up time must be reduced by off line set-ups, concurrent engineering, or SMED (Single Minute Exchange of Dies) (9) techniques using clever tools and jigs. Waste in this context is anything that does not add value.

3.8 Send Demand to Pacesetter process

The pacesetter process in a system is the bottleneck. Simply put, aim to pull from an inventory supermarket to the customer point and work to eliminate the bottleneck using SMED, flexible labour or concurrent engineering.

3.9 Manufacture EBET (Equal Batches Every Time)

This principle enables the correct quantity to be made consistent with the EPR (Economic production Run) the current levels of set-up and cleanup and sequencing through the plant. When the EBET's are determined, the methods of logistical control and movement can be optimized and statistical methods can be applied to data collected with greater rewards.

3.10 Run Inventory Hold Points as Supermarkets

The essence of this is to firstly determine the correct inventory points and then control them at shop floor level by replacement.

3.11 Even Mix at The Pacesetter

This is aimed at load leveling and smoothing the load to the optimum by judicious sequencing of products.

3.12 Link and Match Processes

The objective here is to keep the product moving by matching process run times and linking individual machines and processes if possible.

3.13 Use SMED principles

SMED is defined as the Single Minute Exchange of Dies. There are numerous rules here to reduce setups changeovers and cleanups and rid the process of non- value added time.

3.14 Run Processes under SPC (Statistical Process Control)

With linked processes with no inventory between processes, it is critical that the machine performance is predictable as breakdowns will cause chaos. Dr. Deming and Dr. Juran (10) are the two greatest advocates of SPC.

3.15 Use the 5S system

Originally designed as the 5 pillars of the visual workplace, the 5 S system has been developed. This is a useful place to start the total Lean System introduction(11)

4. Application of the Lean Systems Thinking

4.1 Approach

The approach to introducing lean system thinking must be strategic. For Lean Manufacturing to work, we must have a clear idea of our strategic objectives and translate these to clear measurements.

Running a successful business is about knowing which way to go and defining this in terms of goals (Strategy) and developing the procedures, systems, processes and products to achieve these goals (Capability)

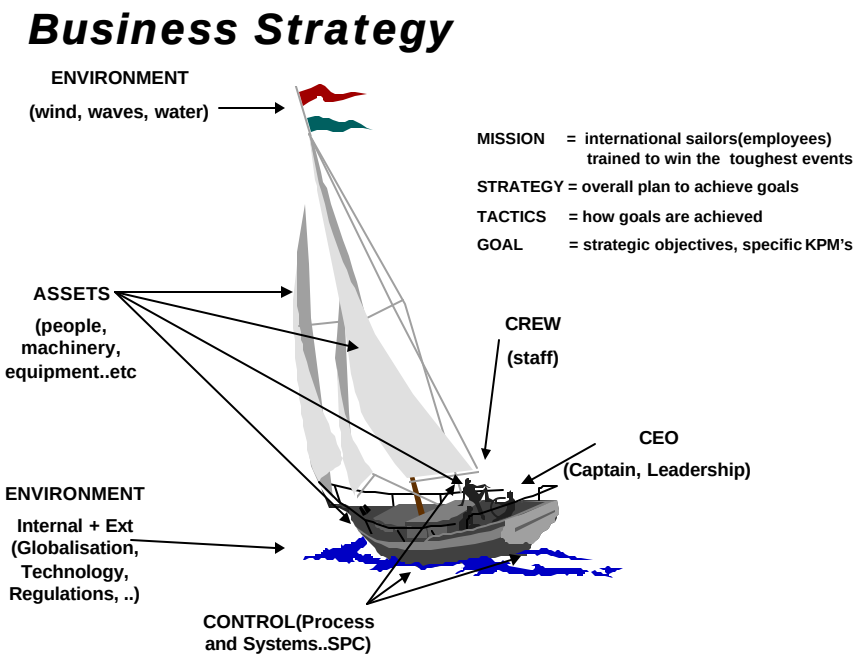

Figure 4. A Sailing Analogy of Business Strategy. To introduce Lean Systems Thinking it is necessary to have a clear definition of the goals and objectives of then organisation and develop the system capability to achieve these goals applying Lean Thinking.

Fig 4 illustrates the complex interaction of variables that must be controlled to achieve the predetermined set of goals.

Business can be likened to an ocean racing yacht. With constant surveillance of external forces (wind, waves, water) and internal factors (crew, hull, sails) and strategic

positioning (position with respect to goals) and competitive position (position in relation to competitors) we can continually improve our position by developing and improving products and processes (diligent tiller and sheet trimming). In business the assets are the people, plant and equipment. The wind waves and water are equivalent are the demand and all the forces affecting it. Control involves people, plant, systems and processes. Strategic objectives can be achieved by identifying the Key Performance measures and the core processes that will lead to the defined and desirable goals. Our measurements must be meaningful. All enterprises must embrace innovation to succeed in the global marketplace and "Think outside the Square" so that they can "Create" the future. However the first step is to formulate a vision and define a SAW, a Strategic Advantage for Winning (5). This must be used as a defining criterion for determining the direction and leadership of the business.

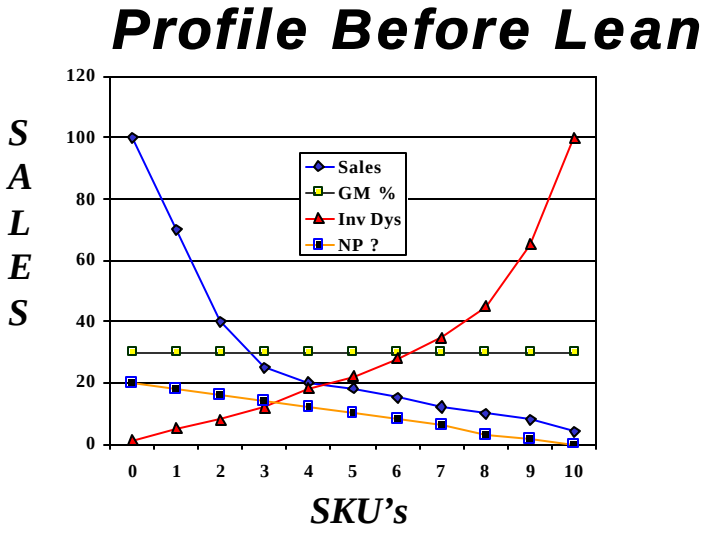

Figure 5. A typical sales and stock profile for a company producing to stock using forecasting techniques and mass production methods. Using lean thinking it is possible to change the profile of the stock to match the sales using pull techniques.

A typical sales profile for the product range for companies making to stock is as shown above in figure 5. It is clear that there are some products we sell a lot of and some we don't. [The SKU's (Stock Keeping Units) are in 100's].

The selling price for slow moving lines could be increased to recover the extra cost. The gross margin is usually the difference between the selling price and cost of sales (COS). The COS includes operational costs but does not include such things as inventory holding costs, obsolescence etc. for the usual case of the Profit and Loss account for manufacturing companies. The net profit curve includes all costs but unfortunately most of the overheads and inefficiencies are aggregated.

4.2 Measurements

The core measurements in a lean manufacturing system are all related to Quality Cost and Delivery. Lead times must be reduced to match the expectations of the customers.

Ideally, if we knew the exact delivery lead time to meet the customer expectations, and if we have the processes to produce in that time, then we could make every product to order (MTO) with no finished goods inventory. The obsolescence in this system would be zero. At the moment this is not feasible. However, for low risk high demand products we can afford some inventory. For higher risk products where the production lead time is equal to the sales in that period, we can phase our production to fit the expected demand based on the movements and sales from the previous period. This classification is largely dependent on sales volume, and the economic production run (EPR) for the total process plant and equipment. The economic production run is mainly set by the cost of setups changeovers and cleanups as shown in figure 6

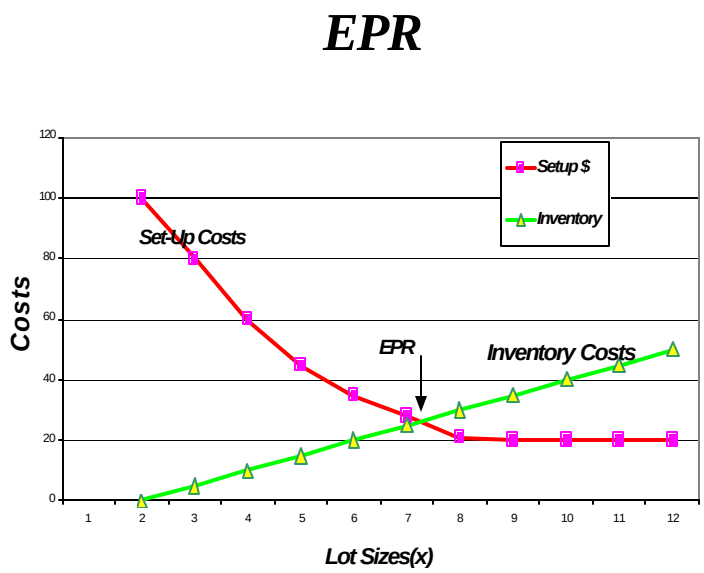

Figure 6. EPR (Economic Production Runs) and inventory costs. The key to reducing the minimum quantity to make and controlling inventory by pull methods is to reduce set-ups

The EPR for a plant with complex processing routes will be set by the production unit with the lowest value added time percent most probably but this is mainly determined by the cost of a setup or changeover compared with the cost to run (add Value). In a plant producing a wide variety of products on short runs, as a start, it will pay to isolate the appropriate inventory stage to hold product. For the case of most plants this will be the point at which there is the greatest increase in the variety of the product.

4.3 People

The most important asset in a business is it's people. As a first step along the way it is important to realize that in the near future the organization structure of successful companies will be core process based not based on vertical silos. A new structure is illustrated in figure 7.

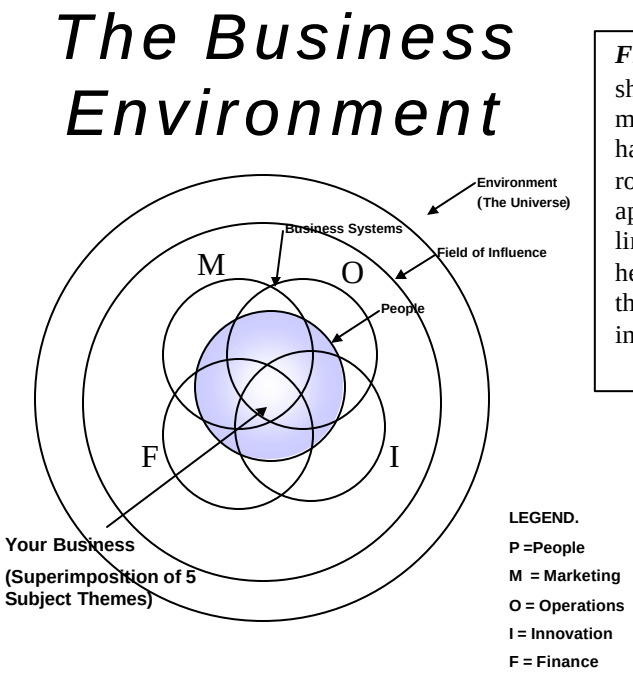

Figure 7 Organisations should recognise that all major functions in a business have to play a collaborative role. The vertical silo approach has serious limitations. the venn diagram here is designed to illustrate that no major function is independent of any other (5).

Many analysts have attempted to prioritize the elements of people power. The most likely acceptable priority of the people groups if the enterprise is to be successful is as follows;

1. The customer
2. The staff
3. The shareholder

The key issue in the future will be to Team up with your ***suppliers and your customers*** in a mutually beneficial partnership. Reward each team appropriately.

4.4 The Supply Chain

To be successful we must realize that we are probably only one step in a supply chain. We must create value for all participants. If your partners are unsuccessful then this will have a devastating effect on you. A section of the supply chain is schematically illustrated in fig 8.

Supply Chain Value Creation

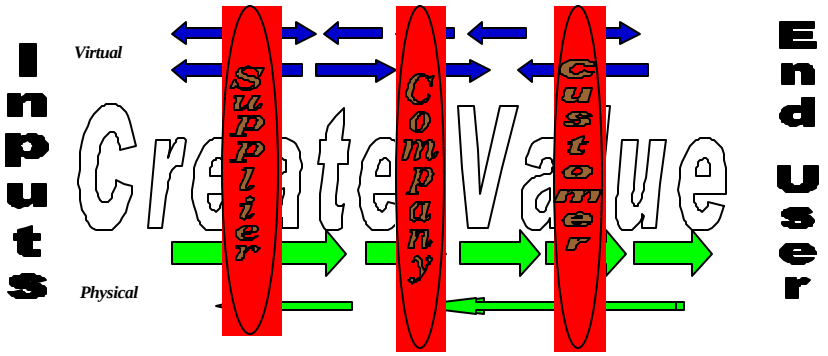

Figure 8. Links in the supply chain. All participants are dependent on each other. The objective is to collaborate to generate value for all

Note the two elements in the chain are virtual and physical. The virtual layer, which is information, can travel at the speed of light but the physical is restricted by mainly a low value added percentage. We must aim for a physical lead- time which is 100% value added. Service value is created and measured at the customer or buying decision interface. All elements or themes or functions influence the success or otherwise of this event.

All major functions in the business have a role to play at the buying decision stage. Once the decision is made to buy, the core processes of the enterprise must create a product or service delivering customer value for potential repeat business.

All systems are affected by the strategic decisions made to capitalize on ***opportunities*** to create a ***competitive advantage*** and improve ***organizational effectiveness.***

If we take a broad view of the value chain we can see that decisions in any one part of the chain, either internal or external, have very wide ramifications. The overall message is that the ***success of the total operation is dependent on all the steps in the chain.*** The aim is to satisfy the customers 100% of the time in Quality, Cost and Delivery. The more flexible the process, the shorter the lead-time, and the shorter our planning cycle can be. At 5% value added there is plenty of room for improvement. With the introduction of b2b in the future it may be possible to operate on an RPO system (Reverse Purchase Order). Plan to operate the production in the early stages on ***replacement*** and ***minimum stock levels using Kanban cards***. On the raw material supply side for long lead times, a forecasting system will still be used with a focus on removing variation and smoothing supply.

To optimize supply we must firstly establish agreements with raw material suppliers and then establish agreed lead times and apply either consignment stock, Vendor Managed Inventory or b2b connections to minimize inventory and risk.

The product streaming concept is based on continuous value adding, and an A,B,C product classification. At a future date we can focus on 26 two week periods instead of 12 variable months for financial control.

As consequence of analysis and the overall capability of various machines in a process chain, it is possible to link processes together and so have zero inventory between them. Ideally the Value added percent should be the same for each process but aim to minimize variation in production and supply.

The number one rule for continuous flow is matching supply with real demand. Too much inventory erodes profit and often gives rise to quality problems. Too little inventory can lead to a loss of sales which can be accentuated by long lead times.

4.5 Consequences of Poor Links in the Supply Chain

Figure 9 illustrates the variation in the sales of a common product measured at the point of sale. It thus represents the real demand. It has two major features.
These are 1) A background demand equal to 750 units per day and 2) a Point of Sale promotional strategy at 1750 to 2250 over 6 weeks.

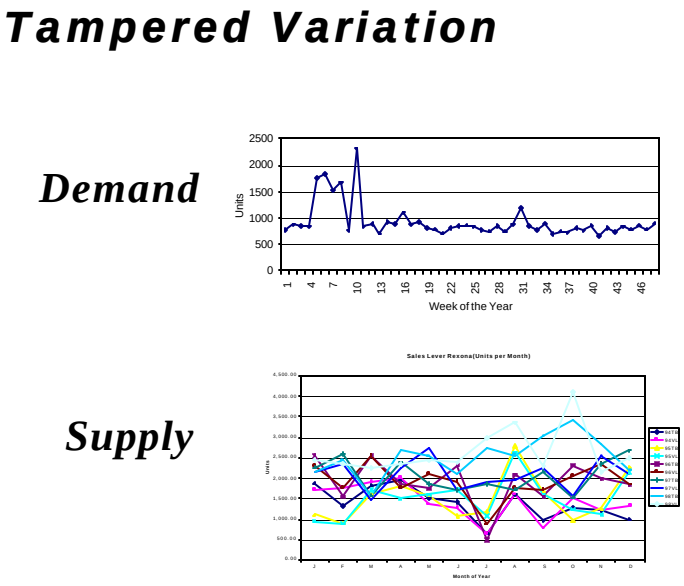

Figure 9 Tampered Variation caused by not applying lean thinking to the supply chain (Composite data)

Note that the promotional strategy did not increase market share. The bottom graph illustrates the increased variation in the manufacture of the product 2 steps upstream from

the point of sale due to tampering of the system by not applying lean production rules. ***This can be avoided with b2b and using the IT Lean Rules.***

The whole system must focus on creating a "Pull" system so that a continuous self perpetuating process is created and maintained. This will require that setups and waste time are reduced. Once we have added value to a product it has increased our working capital. It is necessary for us to keep it moving to the customer.

Product and service innovation and the speed with which new products and services can be introduced on to the market can be used as a strategic weapon Many manufactures link process and product innovation .It is not advisable to suddenly impose very strict rules on the planning and manufacturing processes. Instead the approach should be to gradually introduce the principles and if possible increase the number of MTO (Made to Order) lines and reduce the make to stock consistent with the delivery requirements of the customers. As well as all the benefits above, Lean Manufacturing will focus the company on forever improving its quality, manufacturing flexibility, costing systems, and response time to customers

4.6 Rapid Response and Short Lead Times based on Lean Systems.
Figure 10 is an example of how short lead times combined with accurate point of sale data in real time and a pull system operating on a fast short lead time, can assist in improving service performance with optimum inventory.

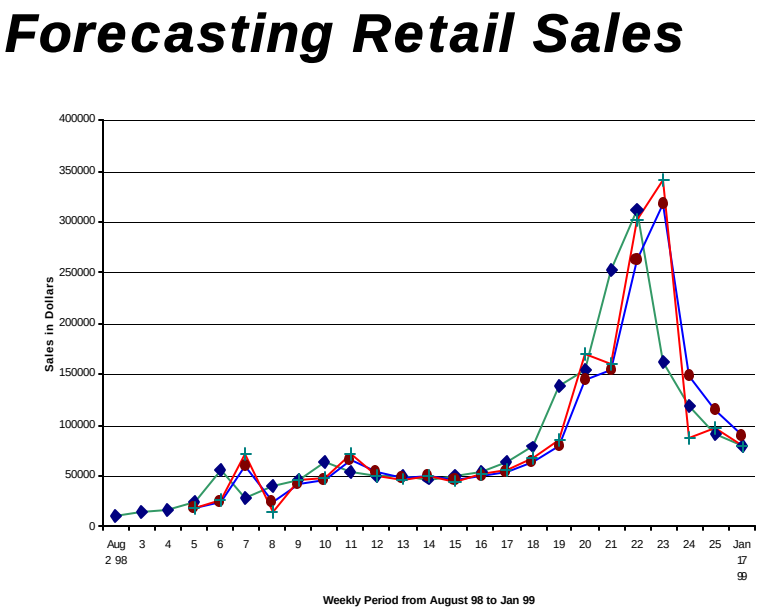

Figure 10 This figure illustrates how close it is possible to fit delivery profiles on short lead times to a highly variable demand if lean thinking is applied to the supply chain (Forecast Developed from real data)

The chances of the retailer in this case having redundant inventory at the end of the season have been minimized. In addition, the possibility of sales being lost due to insufficient POS stock will be minimized.

For most steps in the value chain we can link or pull by replacement for high volume low risk products. For high risk low volume products, to minimize waste and loss of profit, we should aim for short lead-times and an intermediate inventory holding point. The longer the forecasting period and the more tampered the data the greater the error in supply and the greater the waste.

5. Conclusion

Lean Manufacturing is a journey. The job will not be complete until the lead time is 100% value added time and we deliver to our customers the right quality at the right price 100% on time. An example of the application of Lean principles to internal processes in Pirelli resulted in the increase in output and decrease in defectives as shown in Figure 11.(Reproduced with Permission). The opportunity is there for all.

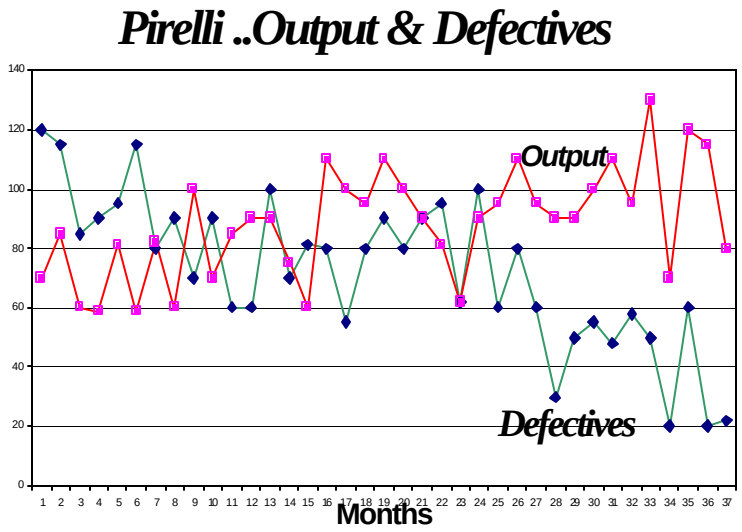

Figure 11 The results of a Three Year program at Pirelli Cables Minto

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