"Understanding, Implementing and Exploiting Agility and Leanness"

Dr James Aitken
Managing Director
Celuform Limited
Kent

Professor Martin Christopher
Cranfield School of Management
Cranfield

Professor Denis Towill
Logistics Systems
Dynamics Group
Cardiff University

Summary

The latter part of the 20th Century saw the lean production paradigm positively impact many market sectors ranging from automotive through to construction. In particular there is much evidence to suggest that level scheduling combined with the elimination of *muda* has successfully delivered a wide range of products to those markets where cost is the primary order winning criteria. However, there are many other volatile markets where the order winner is availability which has led to the emergence of the agile paradigm typified by 'quick response' and similar initiatives. Nevertheless, 'lean' and 'agile' are not mutually exclusive paradigms and may be married to advantage as is shown in the lighting industry case study. The outcome of our review of the characteristics of lean and agile supply is the proposition of a model for enabling change to the agile enterprise. This incorporates the three levels of principles, programmes, and actions. We conclude by showing that the model encompasses the major factors executed within the Case Study, which covers agility throughout the Product Introduction Process (PIP) and Product Delivery Process (PDP). It appears to be a feature of the successful implementation of agility that it is an organisation-wide shift in culture and cannot be restricted to just a few activities.

1. Introduction

A key feature of present day business is that it is supply chains which compete, and not individual companies (Christopher, 1992), and the success and failure of supply chains are ultimately determined in the marketplace by the end consumer. Getting the right product, at the right price, at the right time to the consumer is not only the lynch pin to competitive success but also the key to survival. Hence customer satisfaction and marketplace understanding are crucial elements for consideration when attempting to establish a new supply chain strategy. Only when the constraints of the marketplace are understood can an enterprise attempt to develop a strategy that will meet the needs of both the supply chain and the end customer. It is the imperative of matching availability to actual customer requirements which is a distinguishing feature of present day business. Having the right product available, in the right place at the right time, enables the business to compete in this volatile marketplace.

Significant interest has been shown in recent years in the idea of 'lean manufacturing' (Womack, Jones & Roos, 1990), and the wider concepts of the 'lean enterprise' (Womack, & Jones, 1996). The focus of the lean approach has essentially been on the elimination of waste or *muda*. The recent upsurge of lean manufacturing can be traced to the Toyota Production systems (TPS) with its focus on the reduction and elimination of waste (Ohno, 1988). However, the origins of lean manufacture are certainly visible in Spitfire production in the UK in World War II, (Childerhouse et. al. 2000) and ***Keirutsu*** dates back to the US automotive industry in 1915, (Drucker, 1995). Furthermore JIT delivery with little waste was clearly evident in the construction of the Crystal Palace in London (Wilkinson, 2000). In the context of the present paper, it has been argued elsewhere (Christopher, 2000)) that lean concepts work well where demand is relatively stable and hence predictable and where variety is low. Conversely in those contexts where demand is volatile and the customer requirement for variety is high, a much higher level of agility is required.

So lean manufacturing has a long and distinguished past, and a thriving present. But for some years now it has been argued that it is not a universal recipe for staying ahead of the opposition (Richards, 1996). Indeed the cyclical nature of "order qualifiers" versus "order winners" (Hill, 1993) means that this year's competitive advantage becomes next year's price of entry (Stalk and Webber, 1993, Johannson et al 1993). Hence it is not surprising that having become competitive based on cost (a "lean" attribute) the supply chain is then threatened on its availability performance (an "agile" attribute), and responds by seeking to leapfrog to the next arena of competitive advantage, as has been so ably demonstrated in the PC marketplace (Christopher and Towill, 2000a).

In this paper we describe how a lighting manufacturer, where one of the authors was Managing Director, has made the transition from "traditional" via "lean" to "agile" supply, and how it copes with producing both commodities and customised products from the same site. The actions taken to achieve this substantial change management programme are then mapped onto an agile enterprise enabling model which has been proposed on the basis of the principles of both lean and agile manufacture. The methodology employed was a single case study which sought to provide tentative confirmatory evidence of this model. The model marries and exploits the virtues of both lean and agile paradigms, and the case study results indicate that the model may be used with confidence as a framework for effective supply chain change management generally.

2. What is Agility?

Agility is a business-wide capability that embraces organisational structures, information systems, logistics processes and, in particular, mindsets (Christopher and Towill, 2000b). A key characteristic of an agile organisation is flexibility. Indeed the origin of agility as a business concept lies in flexible manufacturing systems (FMS). Initially it was thought that the route to manufacturing flexibility was through automation to enable rapid change (i.e. reduced set-up times) and thus a greater responsiveness to changes in product mix or volume. Later this idea of manufacturing flexibility was extended into the wider business context and the concept of agility as an organisational orientation was born. Table 1 summarises the core characteristics the Iaccoca Institute have thus associated with agile manufacture (Goldman, Nagel, and Preiss 1995). It is clear from this table that enabling agility is much more than a technical problem.

Agility should not be confused with 'leanness'. Lean is about doing more with less. The term is often used in connection with lean manufacturing (Womack, Jones, and Roos, 1990) to imply a "zero inventory", just-in-time approach. In practice Minimum Reasonable Inventory (MRI) is a more relevant philosophy (Grunwald and Fortuin, 1992). Paradoxically, many companies that have adopted lean manufacturing as a business practice are anything but agile in their supply chain. The car industry in many ways illustrates this conundrum. The origins of lean manufacturing can be traced to the Toyota Production System (TPS) (Ohno, 1988), with its focus on the reduction and elimination of waste. Leanness may be an element of agility in certain circumstances, but by itself it will not enable the organisation to meet the precise needs of the customer more rapidly. Webster's Dictionary makes the distinction clearly when it defines ***lean as "containing little fat"*** whereas ***agile is defined as "nimble"***.

ACTIVITY LEVEL	AGILE CHARACTERISTICS
1. MARKETING	• **Customer enriching, individualised combinations of products and services**
2. PRODUCTION	• **Ability to produce goods and services to customer orders in arbitrary lot sizes**
3. DESIGN	• **Holistic methodology integrating supplies, business processes, customer and products use and disposal**
4. ORGANISATION	• **Ability to synthesise new productive capabilities from expertise of people and physical facilities regardless of their internal or external location**
5. MANAGEMENT	• **Emphasis of leadership, support, motivation, and trust**
6. PEOPLE	• **Knowledgeable, skilled, and innovative total work force**

TABLE 1
RELEVANCE OF CORE CHARACTERISTICS OF AGILE MANUFACTURE
(Source: Authors based on Goldman, Nagel, and Preiss, 1995)

Whilst the lessons learned from the TPS principles have had a profound impact on manufacturing practices in a wide range of industries around the world, it seems that the tendency has been for the benefits of lean thinking to be restricted to the factory. Thus we encounter the paradoxical situation where vehicle manufacture is extremely efficient with throughput time in the factory typically down to twelve hours or less, yet inventory of finished vehicles can be as high as two months of sales. Furthermore, as Marshall Fisher (1997) has demonstrated in spite of advertising campaigns to the contrary, the customer still has to wait for weeks or even months (and sometimes forever) to get the car of their choice!

3. Attributes of Lean and Agile Supply

Both agility and leanness demand high levels of product quality. They also require minimum total lead-times defined as the time taken from a customer raising a request for a product or service until it is delivered. Total lead-time has to be minimised to enable agility, as demand is highly volatile and thus difficult to forecast. If a supply chain has long end-to-end lead-time then it will not be able to respond quickly enough to exploit marketplace demand. Furthermore effective engineering of cycle time reduction ***always*** leads to significant bottom line improvements in manufacturing costs and productivity (Towill, 1996).

Lead-time needs to be minimised in lean manufacturing as by definition excess time is waste and leanness calls for the elimination of all waste. The essence of the difference between leanness and agility in terms of the total value provided to the customer is that service is the critical factor calling for agility whilst cost, and hence the sales price, is clearly linked to leanness. However, whereas the Total Cycle Time Compression Paradigm (Towill, 1996), when effectively implemented, is a sufficient condition for achieving lean production, it is only ***one*** necessary condition for enabling agile supply.

DISTINGUISHING ATTRIBUTES	LEAN SUPPLY	AGILE SUPPLY
Typical Products	**Commodities**	**Fashion Goods**
Marketplace Demand	**Predictable**	**Volatile**
Product Variety	**Low**	**High**
Product Life Cycle	**Long**	**Short**
Customer Drivers	**Cost**	**Availability**
Profit Margin	**Low**	**High**
Dominant Costs	**Physical Costs**	**Marketability Costs**
Stockout Penalties	**Long Term Contractual**	**Immediate and Volatile**
Purchasing Policy	**Buy Goods**	**Assign Capacity**
Information Enrichment	**Highly Desirable**	**Obligatory**
Forecasting Mechanism	**Algorithmic**	**Consultative**

TABLE 2
COMPARISON OF LEAN SUPPLY WITH AGILE SUPPLY : THE DISTINGUISHING ATTRIBUTES
(Source: Mason-Jones, Naylor and Towill , 2000)

Table 2 illustrates the comparison of attributes between lean and agile supply. In the volatile unpredictable marketplace for "fashion" goods, both stockout and obsolescence costs are punitive. Consequently the purchasing policy moves from placing orders upstream for products moving in a regular flow to that of assigning capacity to finalise products in rapid response mode. As Fisher et al, 1994 have indicated this means forecasting via "intelligent" consultation so as to maximise inputs from "rich" marketplace insider sources. Our view (Mason-Jones and Towill 1997) is that "information enrichment" i.e. immediate sharing of marketplace data throughout the chain is not merely desirable, but obligatory. This is necessary both to reserve future capacity as well as for satisfying current demand.

4. An Integrated Agile Enterprise Enabling Model

Our contention is that lean methodologies can be a powerful contributor to the creation of agile enterprises. In particular where product ranges can be separated according to volume and variability and/or where the de-coupling concept can be applied, a real opportunity existing for employing hybrid lean/agile strategies (Christopher and Towill, 2000c). There is also one important sense in which lean precedes agile, and which has been advanced by Victor & Boynton (1998) in the context of moving towards mass customisation. This is because real and effective change requires the mapping and understanding of all the relevant business processes in the value chain from customer need identified to customer need satisfied. Thus in an industrial engineering scenario the lean knowledge base is there to be exploited in enabling further performance improvements including building in agility (Childerhouse et al, 2000).

Figure 1 is based on our supply chain experiences and suggests a three level framework summarising our view of the agile enterprise. The concept of such a framework was first advocated by (Werr et al. 1997). We have found it extremely useful in bringing together the various strands which contribute to the agile enterprise. In this integrative model, Level 1 represents the key principles that underpin the agile supply chain; i.e. rapid replenishment;

and postponed fulfilment. Level 2 identifies the individual programmes such as lean production, organisational agility, and quick response which must be implemented in order

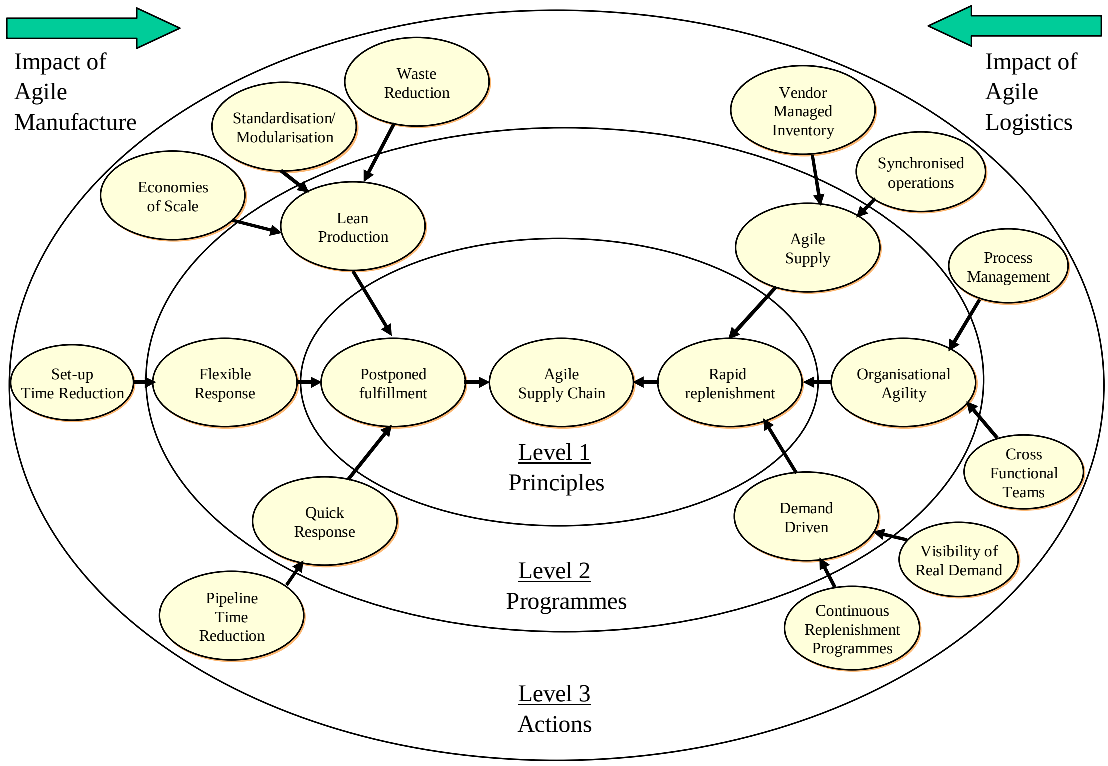

FIGURE 1
AN INTEGRATED MODEL FOR ENABLING THE AGILE ENTERPRISE
(Source: Christopher and Towill, 2000c)

for the Level 1 principles to be achieved. Finally Level 3 specifies individual actions to be taken to support Level 2 programmes, for example, time compression, information enrichment, and waste elimination. These actions apply equally to the Product Introduction Process (PIP) and to the Product Delivery Process (PDP), Towill, 1997a. Not all the characteristics shown in Figure 1 may be necessary in any one specific market/manufacturing context, but it is likely that the agile supply chain will embody most of these elements. What is certain is that much of the conventional wisdom concerning manufacturing strategy, supplier relations and distribution will have to be challenged if real agility is to be achieved from within the supply chain.

Rapid Replenishment, for example, requires agile suppliers, organisational agility, and a demand driven supply chain (Lowson et.al. 1999). Similarly, postponed fulfilment enables the adoption of lean production principles up to the de-coupling point supported by agile capabilities beyond that point (Harrison et. al.1999). Nor must the cultural side be forgotten, since it may be the single biggest barrier to effective change. For example, in moving into an agile scenario in the pharmaceuticals sector, it was found that the anticipated IT problems did not arise. Instead, the real stumbling blocks were the human obstacles to be overcome in the creation of an understanding of the new system, and to the creation of a customer based regime ~ in other words people problems, (Belk & Steels, 1998). Such reasons could also help explain why successful industrial implementation of quick response programmes is more patchy than expected, (Kohzab,2000). This is just further supporting evidence for the view previously expressed by Andraski (1994) in commenting on the in-effectiveness of many

real-world supply chains. He suggested that this is because in practice '80% of problems that arise are due to people, not technology'.
The importance of people management during effective BPR change programmes is evident in the industrial case study which will now be described in detail (Aitken 2000). It explores the actions taken by and options open to a major UK lighting company as it addresses the ever increasingly volatile and competitive architectural lighting market. The continually growing pressure to globally supply products more cheaply, quickly, and to a higher standard has resulted in the company experiencing shorter product life cycles and reduced lead-times. Managing this diverse and challenging environment has meant the development of a multifaceted supply chain strategy. At the conclusion of the case study we shall return to our Integrated Model of Figure 1 and see how successful the model is in providing a framework for effective change.

5. The Need for a Lean and Focussed Lighting Factory

Before 1996 the company's organisation and management of its internal and external supply chains was based on a traditional functional approach. Manufacturing managed its material flow on a push principle driven by MRP and there was no differentiation between low and high volume products and between regular or irregular demand items. Productivity was low as manufacturing orders ranged in size from 1 to 1000. Each production order was preceded and followed by changeovers and downtime. All seven forms of Ohno's (1988) seven wastes (or muda) were apparent in the internal supply chain and material conversion operations. Management of the external supply chain was at an arm's-length contractual basis (Sako, 1992). The supply base was broad as the strategy of the buying function of the company operated on the principles of lowest price wins. Buyers routinely moved the source of components to a new supplier if the price was lower. New suppliers would be assessed on the basis of price and component quality only. No obligation for repeat transactions was anticipated if the supplier did not retain the lowest price.

During 1996, the company developed a new strategy to manage its internal and external operations. Manufacturing was restructured to improve customer service and increase profitability. Following an extensive program of data collection and analysis, the production facility was segmented into two distinct sections. One section became a low volume, irregular demand factory employing operators with broad product knowledge. The other area became the high volume, and regular demand factory with focused, repetitive build tasks. These two areas were also designed to operate their internal supply chains in distinctly different formats. The low volume area continued with a push (**MRP**) strategy whilst, the high volume section operated a pull (**Kanban**) strategy. This dual approach is well established in material flow control (Parnaby, 1988).

6. Re-Engineering the Supplier Base

Due to the significant impact of suppliers on the profitability and flexibility of the company, it was decided to acknowledge vendors as being an intrinsic part of the organisation. Hence improving the performance of the suppliers and the efficiency of the exchange between the firms was recognised as being key to the success of the company. Reducing the number of direct suppliers was seen as essential to maximising use of the limited time and resources available both to the company and its suppliers. In order to lower the number of directly interfacing suppliers, elimination and tiering activities occurred. Existing suppliers were assessed for their suitability against the following criteria:

- Quality performance (PPM)

- Ability to operate with Kanban system (delivery performance)
- CAD/CAM facilities (new product development)
- Geographical location (new product development & delivery performance)
- Price

If a supplier could not or chose not to operate against the quality, logistical or product development criteria laid down by the company they were either delisted (and the components switched to another current supplier) or became a second tier supplier. The result of these activities was a reduction in direct supplier numbers from 267 to less than 100. Such a move has many benefits (Lamming, 1993) including risk reduction. However there are total costs benefits also. The acquisition costs may increase marginally, but there will be a significant reduction in the "managing the supplier" costs, especially when properly valuing scarce Executive time (Towill, 1997b).

Following the segmentation of the manufacturing plant and the reduction of the supply base it became possible to simplify the ordering and communications system between "players" in the chain. The high volume factory introduced with the assistance and agreement of its suppliers a two-bin, Kanban material ordering system. The support of the suppliers in introducing the simple material ordering system was an early example of greater integration of working practises within the supply chain. Only through effective partnering was it possible to stop posting weekly MRP schedules. Muda previously observed in these operations included inappropriate processing, unnecessary inventory, unnecessary motion, excess waiting time and unnecessary transportation. All were reduced following Kanban installation.

Lead-times for new product development in the lighting industry in 1996 were typically 18-24 months. For an industry that had become more and more fashion conscious, the time from concept to product delivery was proving costly in terms of pay-back and market leadership. One of the principal driving forces for the company's new approach towards suppliers was the desire to reduce time and cost to market drastically. Hence suppliers within the new partnership ethos became involved at the new product design stage. Product development activities thereby became concurrent as opposed to sequential. Supplier's designers and engineers used CAD and CAM technologies to interact directly with the company's designers and engineers at each stage of development. By early 1999 the result of these changes reduced the development lead-time for standard production products from eighteen months to fourteen weeks. The lighting company is therefore becoming a fast innovator with many consequential benefits, not least because no pain lasts too long (Stalk and Hout, 1990).

7. Performance Changes in the Lean and Focussed Lighting Factory

Restructuring the company's approach to its management of suppliers would have provided limited benefits if it had not occurred in conjunction with major changes to the internal operations of the organisation. The improvements in the efficiency of the supply chain in terms of introducing a concept such as Kanban would not have been as effective without the restructuring of the manufacturing function. Simultaneous internal and external changes propelled the company's performance forward in terms of product development, cost and lead-time reduction as shown in Table 3.

These very creditable performance improvements were achieved through the efforts of both supplier and buyer alike. Integration of supply chain activities and information flows accelerated the implementation of lean practises such as Kanban. Operational improvements followed a consistent and deliberate strategy of developing trust and openness in the relationship between supplier and buyer. Suppliers working in partnership with the company to develop improvements gained additional sales volumes, which in turn increased the interdependence of both parties to the exchange. Improvements in the relational as well as operational performance developed a virtuous circle for both parties in the exchange. In other words the effective design and operation of business interfaces played a vital role in enabling effective change as highlighted by Towill (1997a) in adopting a systems approach to supply chain design.

PRODUCT ATTRIBUES	LOW VOLUME PRODUCTS	HIGH VOLUME PRODUCTS
PRODUCT CODES	5000	850
MATERIAL FLOW	PUSH	PULL
MATERIAL CONTROL	MRP	KANBAN
DEMAND PREDICTABILITY	LOW	HIGH
MINIMUM ORDER QUANTITY	1 UNIT	PALLET
SERVICE OFFERED	MADE TO ORDER	EX STOCK
DELIVERY LEAD-TIME	2-4 WEEKS	0-2 WEEKS
PRODUCT DEVELOPMENT TIME	6 MONTHS	6 MONTHS
COSTS (1998/1995 BASELINE)	85%	73%

TABLE 3
PERFORMANCE CHARACTERISTICS OF THE FOCUSSED LIGHTING FACTORY AS AT 1998
(Source: Authors based on Aitken, 2000)

8. The Subsequent Move to Embrace Agility

The supply chain and manufacturing improvements that occurred between 1996 and 1998 provided the platform for the next stage of development for the company which was finding that leanness alone was no longer a guarantee for success. The 1999 re-engineering phase addressed the constant growth of customised, non-standard, product demands from the market. This increasing market challenge meant a further review of the company's supply chain and manufacturing strategy. Agility and leanness were identified as necessary attributes for a company serving a customised product market. Linked to an ever-increasing architectural demand for customisation was the continual drive by customers for shorter lead-times. Both these factors forced the company to add another two strategies to managing its supply chain. In addition to the focused factories of MRP and Kanban, it became necessary to develop a **packing centre** and a **design-and-build division** to improve the agility of the organisation. These are related in the product variety/volume predictability matrix shown in Figure 2.

With increasing globalisation of the lighting market, several parts of the company's product portfolio had become commodity in nature. Customers in the UK now had the opportunity of purchasing their lighting products from low labour cost countries such as China. However, supplying the lowest price product was not the UK answer to this challenge. Instead of competing on price, the company had to find an alternative way of retaining its customers. One way forward was via the improvement of customer service. The strategy adopted by the company reducing delivery lead-times to days or hours through delaying the completion of production until the last possible moment. Delivering product on a very short lead-time would allow customers to improve their cash flow thereby countering in part the lower prices of Far-East suppliers. Obtaining the necessary lead-time reduction was to be enabled through the establishment of a Packing Centre. Some of the products in the Kanban factory would in future be part assembled. The completion of the production process will then occur in the warehouse when the customer placed an order. The practical application of postponement linked together and exploited the lean approach of the Kanban factory with the agility of the Packing Centre. This confirms the importance of postponement in the context of the particular business strategy (Pagh and Cooper 1998, Shewchuck 1998, Feitzinger and Lee 1997 and van Hoek 1998).

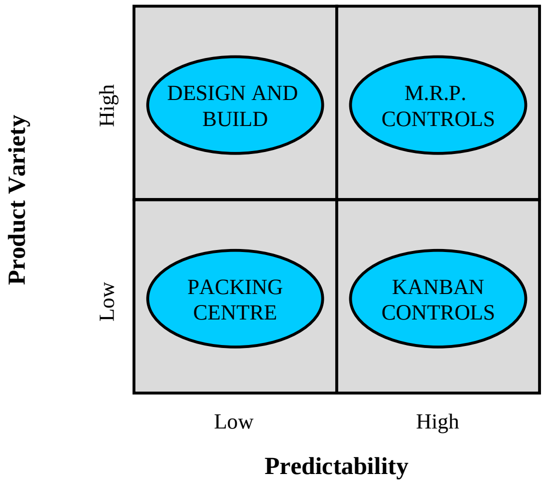

Fig. 2 LIGHTING FACTORY SUPPLY CHAIN STRATEGIES
(Source: Aitken, 2000)

9. Enabling Customisation

The final new supply chain strategy of customisation (Victor and Boynton, 1998) was achieved through the opening of a new design-and-build facility specialising in product design and tailoring items to specific customer requirements. Such customisation meant a change in the existing lean approach to utilising resources in the manufacturing, product development and supply base. The new agile facility was planned to have a different *modus operandi* way from the more rigid lean operation of the standard product factory. One of the critical areas for success in the new division was in its management of knowledge. At the outset of the strategy it was realised that the business would only succeed if its intellectual capacity was sufficient to accommodate the dynamics of the market. Capacity was viewed in terms of design, engineering, assembly operator, and supply management experience. The skill mix of the custom design-and-build was viewed as being similar to the lean factory. However, the frequency of its application, the time scales it works against and its physical location were very different.

Within the lean factory designers develop products which meet general market (i.e. commodity) needs. The products are designed for easy assembly, material handling and storing. Tooling is "hard" in nature and expensive. The total design and tooling time is measured in months. In contrast the design-and-build division needs to be able to design and deliver product in terms of weeks or days. The ability of this division to meet these needs was met through the use of a design capacity that exists within the network of sub-contractors and internal employees. Several designers co-operate and concurrently work on the same project hence increasing the intellectual capacity of the division and compressing lead times. The ability to link and exploit the tacit knowledge of designers and suppliers provides the custom division with a competitive advantage.

In order to compete in the customised market the company decided to integrate its assembly processes. Fabrication, cutting, drilling and welding tasks meant that the company would have to vertically integrate backwards into activities that until recently, were the domain of sub-contract or first tier suppliers. Such backward integration only became possible through the support of the supplier base and also required a change in the ability of the operators and supervisors in the custom division compared to the lean factory. Within the latter facility operators and supervisors followed a prescribed and routine assembly operation. The skill and knowledge required for assembly was codified in order to simply co-ordinate and control the business. Within the custom design-and-build division lean principles are utilised as mush as is practically possible to minimise waste and costs. However, the uniqueness of each customer order requires the manufacturing personnel to use their experience and discretion to ensure on-time delivery.

VALUE STREAM ATTRIBUTES		VALUE STREAM CATEGORY	
GROUPING	**DETAILS**	**“LEAN”**	**“AGILE”**
PRODUCT	1. TYPE	STANDARD	DESIGN/BUILD
	1. CREATION	MARKET DEMAND	CUSTOMER SPECIFIED
	2. DEVELOPMENT STAGES	PRE-DEFINED AND CODIFIED	CUSTOMER SPECIFIC
MANUFACTURE	3. QUALITY CONTROL	1S0 9000	1SO 9000
	4. PROCESSES	PRE-DEFINED	ORDER SPECIFIC
	5. OPERATIONS	LEAN	LEAN AND AGILE
	6. PROCUREMENT	KANBAN	DISCRETE ORDERS
VENDOR INVOLVEMENT	7. SUPPLIER BASE	NARROW	BROAD
	8. SUPPLIER INVOLVED AT:	DESIGN STAGE	CONCEPT STAGE
	9. ROLE IN PRODUCT DEVELOPMENT	CONSULTATIVE	INTERPRETATIVE
TOOLING	10. TYPE	HARD, EXPENSIVE	SOFT, LOW COST
	11. LEAD TIMES	MONTHS	DAYS
PROFESSIONAL ENGINEERING	12. DRAWINGS	CAD	CAD/SKETCH
	13. STIMULUS	PERFORMANCE IMPROVEMENT	CREATIVITY
	14. KNOWLEDGE EXCHANGE	CODIFIED	PART CODIFIED PART TACIT

TABLE 4
YEAR 2000 VALUE STREAM CHARACTERISTICS OF THE LIGHTING FACTORY LEAN AND AGILE SUPPLY CHAINS
(Authors, based on Aitken, 2000)

Due to the complexity and unique paths of fabrication and machining before assembly, it is not possible to codify each process step. The tacit experience based knowledge of the personnel involved in manufacturing within the custom product division is essential in order to provide the necessary agility in the supply process and its management. This highlights the importance of knowledge management in agile supply chains and the importance of ensuring that tacit knowledge is captured and shared in the most effectove way (Metes, Gundry & Bradish, 1998). In this case it was felt that 'insourcing' was the appropriate strategy. The differences and similarities between the two lighting factory supply chain management strategies of lean and agile are summarised in Table 4. So as to achieve agility via flexibility the management of the Lighting Company ensured that personnel who operate in the design-and-build division have a background in the lean factory. The knowledge and experiences gained in the lean factory provide a firm base from which to develop an agile and profitable business. This confirms our view that in practise being "lean" will precede becoming "agile". (Victor and Boynton, 1998 Christopher and Towill, 2000) A major reason is that agility is best achieved by fully understanding and mapping the process, which is a necessary condition for lean operation

10. Mapping the Lighting Company Actions onto the Integrated Agile Enterprise Model

It is clear from the foregoing description of the lighting company change programme that it has successfully passed from "traditional" to "lean" manufacture, and is now in a position, where appropriate, to respond to the customised agile marketplace. At the heart of the business strategy is the product variability – volume predictability matrix with the four delivery channels via MRP Push: Kanban Pull: Packing Centre for postponed assembly: and the Design-and-Build Centre. Each of the businesses are cognate with the others, and the lighting company has determined that they are complementary in maintaining their UK base and international competitiveness.

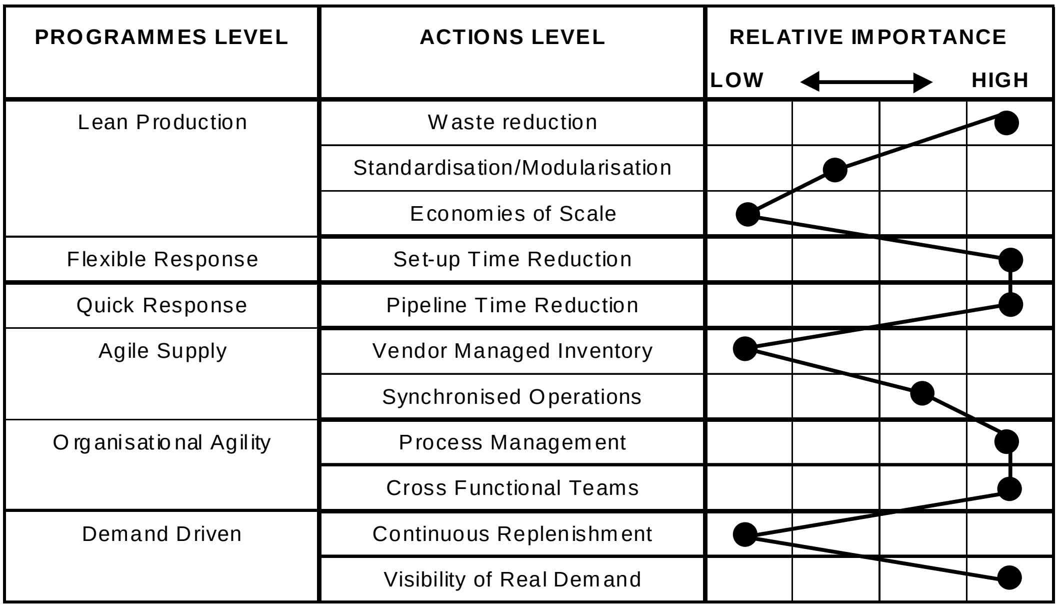

Fig. 3 HOW THE ACTIONS OF THE LIGHTING COMPANY MAPS ONTO THE INTEGRATED AGILE ENTERPRISE ENABLING MODEL

Are these generic lessons to be learned from this successful transition? To establish if this is indeed the case we have *a posterion* mapped the actions of the lighting company onto the previously proposed Integrated Agile Enterprise Model. For each of the eleven actions listed in the lowest level of the model, their relative importance in the change programme has been assessed on a 4-point Likert Scale. Here 4 points have been awarded for high relative importance, and just one point for low relative importance. The outcome is the Likert score profile shown in Figure 3, which appears extremely interesting in identifying tools for effective change.

For example, at least one action is rated highly important at each of the programmes level, as follows:

- Lean Production ~ Waste reduction
- Flexible Response ~ Set-Up Time Reduction
- Quick response ~ Pipeline Time Reduction
- Agile supply ~ Synchronised Operations
- Organisational Agility ~ Process Management
  ~ Cross Functional Teams
- Demand Driven ~ Visibility of Real Demand

As we indicated at the time the Integrated Agile Enterprise Model was proposed, we do not expect that each action identified therein will be equally important in every application. What is pleasing is that the model clearly does provide a suitable framework for planning and implementing change in support of business strategies which require range of response channels which span the spectrum from commodities to combined products. In fact, the lighting company has proven to be a good example of total enterprise design (Kidd, 1995). This requires the active consideration and integration of people, technology, and organisation, with both suppliers and customers forming part of the infrastructure.

11. Conclusions

The current marketplace environment in which organisations conduct their business is both dynamic and complex. To compete in such a turbulent scenario requires companies to adapt and change in order to thrive and grow. No single paradigm can provide a universal answer meeting all possible market demands. The lighting industry Case Study company described herein addressed these problems by tailoring its manufacturing strategies according to the needs of various supply channels. It is very much a market sector where in value stream terms "one size definitely does not fit all" (Shewchuk, 1998).

Meeting customers needs requires that all of these selected strategies be integrated so that the total business may operate successfully. The mixing of approaches has been possible through the support of multi-skilled employees, suppliers and sub-contractors linked through co-operation, trust and openness. Through the complimentary partnership of relevant lean and agility practices the Case Study company is gaining a significant competitive advantage. By mapping the actions taken by the company onto the proposed Integrated Agile Enterprise Model, some generic lessons may be learned and transferred to other companies and to other market sectors. It is demonstrated herein that in order to compete in volatile markets to be lean is not enough. Visibility of demand, flexible and quick response, synchronised operations, and organisational agility are each necessary, not just sufficient conditions for international competitiveness, and must be designed into the agile enterprise.

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