Lean New Product Introduction: a UK Aerospace Perspective

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Abstract (250 words)

Purpose

Lean thinking has revolutionised the approach to manufacturing and there are indications that it can do the same for New Product Introduction [NPI] processes. This paper explores the question “Is the application of Lean principles to NPI sufficient for best/good practice and has this been proven by the work of the UK Lean Aerospace Initiative [UK LAI]?” Focussing on the eight years of research into Lean and NPI in UK aerospace by researchers of the UK LAI the work also looks more broadly and asks if the application of the Lean principles to NPI is sufficient for good/leading practice?

Methodology / Approach

A case-based methodology is chosen by considering the form of research questions and the exploratory nature of the investigation (Yin, 2003). Primary data was collected from industry and forty four UK based aerospace companies have contributed towards the research over the eight years of the research programme of the UK LAI.

Findings

The examination of the case study material from the research has revealed that many practices for achieving good/leading practice do not derive from the Lean principles. This study has however demonstrated that Lean is necessary but not sufficient for achieving good/leading practice. It concludes that lean thinking is necessary for the effective implementation of NPI processes, in particular in the role of coordinating at a high level the existing change initiatives.

Originality

The work is able to present a unique overview of a long running research programme, focused on UK aerospace, but with findings broadly applicable to other sectors.

Keywords: Lean, New Product Introduction, Business Process

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Introduction

This paper explores the question “Is the application of Lean principles to New Product Introduction (NPI) sufficient for good/leading practice and has this been proven by the work of the UK Lean Aerospace Initiative [UK LAI]?” Focussing on the eight years of research into Lean and NPI in UK aerospace by researchers of the UK LAI the work also looks more broadly and asks if the application of the Lean principles to NPI is sufficient for good/leading practice? The research area of this study is NPI, which “is the set of activities beginning with the perception of a market opportunity and ending in the production, sale, and delivery of a product.” (Ulrich and Eppinger, 1995). In this study, it is assumed that New Product Development [NPD] and New Product Introduction [NPI] are the same process. NPI is important for both the customer and for industry. Consumers make greater demands each year. Products are always expected to improve in quality [delivered satisfaction] and to cost less. Also, consumers are eager for new innovative products, with breakthrough technologies, which will appear from time to time to make their life easier and create new needs. All these products have to go through an NPI process to reach their market and in order for the products to reach the market at the right time, at the right price and with the desired characteristics, the NPI process has to be world-class. NPI is one of the main sources of competitive advantage for businesses. In a global survey conducted during 2004 by The Manufacturer (2005), with a sample of 790 executives from mid-sized and large firms in the US, UK, Germany, Mexico and Brazil, executives were asked where the majority of their growth [market share or revenue] came from, and the respondents agreed it was NPI / innovation. In the 1980s McKinsey produced a model that showed in electronics a late entrance to the market by six months can lead to 33% reduction in profits over the product lifecycle whereas a cost overrun of 50% in product development only results in a 3% loss (Gupta and Wilemon, 1990). Similarly KPMG report that in the less technical world of fine china the profit loss for late introduction is 5% compared to a 2% loss caused by a 50% development cost overrun. These findings illustrate time-to-market is an important issue and the only cost effective way to reduce time-to-market is by improving the NPI process. What is more, studies have shown that with a world-class NPI process (Stalk Jr., 1988) companies can achieve reductions in cost and improvements in quality.

Lean Thinking

After World War II, the management of Toyota needed to invent different manufacturing techniques than the mass production systems that were widespread in the West because of the very limited financial resources of the company and the difficulties of the local market which was small and fragmented with scarce natural and human resources and the limited land available was expensive. Workers' unions were also strong. At Toyota, Eiji Toyoda and chief engineer Taiichi Ohno managed to delineate and apply the concept of the Toyota Production System by the 1960s [also called in the West Lean manufacturing (Womack et al., 1990)] . Japanese companies copied this paradigm and the result was that Japan rose to economic eminence in the 1980s. The strengthening Yen damaged Toyota and the other Lean producers in Japan, but not enough to handicap them as they internationalised their production facilities. In the late 1980s the benchmarking study of

Womack et al. found that Toyota was superior to the competition on practically every benchmarking exercise that they conducted (Womack and Jones, 1996). The same study argued that Lean manufacturing could, and should, be implemented in Western countries. By the 1990s many Western companies were beginning their transition to Lean. In 1996, Womack et al. reported that there had been significant convergence in productivity and quality across the world, showing that Lean was capable of relocation to the very different social milieu of the West (Wells and Rawlinson, 1994) but that Toyota and its suppliers had retained their superiority. Today, The Manufacturing Research Centre (2005) surveyed more than 200 UK manufacturers on their Lean manufacturing activities and concluded that Lean manufacturing has secured its position as an essential factor in UK manufacturing's prosperity. What is more, current world uncertainties including potential supply chain disruptions and economic and monetary factors, were reckoned to have made Lean manufacturing more important than it was a year ago for more than 80 per cent of manufacturers (2005) because of its ability to increase responsiveness. During the last decade Toyota has nearly doubled its revenue and redefined competition in key parts of the automotive business (Shirouzo, 2004). Toyota's profits exceeded those of GM, Ford and Daimler Chrysler combined and the company announced plans for maintaining their position as market share leader until 2010 (Womack and Jones, 1996). In January of 2006 Toyota's market value exceeded $200bn, taking it into the top 10 most valuable companies in the world, worth more than twice as much as General Motors, Ford Motor and DaimlerChrysler combined. The Lean paradigm has proved its supremacy.

At Toyota, the transformation of product development processes by multi-project management indirectly implies that one of the limitations of the lean principles is a single-project focus, which can cause wasteful designs and products (Cusumano and Nobeoka, 1998), contradicting the concept of eliminating waste. It is possible to criticise Womack et al. for their selective use of data (Wells and Rawlinson, 1994) but above all, there has been criticism about the universal applicability of the Lean paradigm. Womack et al. are short of case studies from service industries and the concept does not seem easy to apply outside manufacturing -apart from retailing- (1996, Womack and Jones, 1994, Womack and Jones, 1996, Womack et al., 1990). Their books are heavily biased towards manufacturing environments (Haque et al., 2000). Another argument against Lean is that it lacks in innovation. An article in the Economist (1996) argued that: “Toyota makes a car only when a customer asks for it, and suppliers make parts only when Toyota needs them.” And the article continued: “No one asked for 3M's Post-it notes or Sony's Walkman; they were created by imaginative designers, and ‘forced’ on consumers”. The same article concluded that Lean may be a superior way to make things, but not to invent them as it has no effect on the process of coming up with new products. The authors have found that these beliefs are quite common in academia and industry. Similar comments are made for Toyota’s NPI process: a recent article indicated problems at Toyota in developing the right products resulting, perhaps, from the technical leadership in product development (Bremner and Dawson, 2003). Toyota has become a market share leader globally without needing to be a dramatic innovator (Womack and Jones, 1996). It is true that Toyota has been a glacial follower in the new market segments with highest growth. This strategy has worked and continues to work for Toyota because of their world-class core processes. They are in a situation similar to that of GM, in the period 1920-1960, when Sloan declared that gambles on product technology were not necessary as long as GE could swiftly match the innovations that the competition introduced (Womack and Jones, 1996). Some critique is made of the kaizen-philosophy [continuous improvement]. It is true that many-local-improvements is not the way to improve the entire business and this idea has been extensively described in the Theory of Constraints [TOC] by Goldratt (Goldratt, 1997). This critique of lean assumes that Lean equals kaizen and therefore the Lean is flawed, but this overlooks the fact that Lean is much broader than the performance of numerous local improvement activities as it also includes the element kaikaku, or radical improvement.

The New Product Introduction Process

A business process can be described as “a number of interrelated activities needed to accomplish a specific task” (Garside, 1998). The fundamental processes that are essential to every manufacturing company to secure long term existence are identified as the following: New Product Introduction, Manufacturing, Support and Supply, Management [planning, execution and control] and Learning – “the fifth discipline”. The importance of the business process has been highlighted by the success of Lean companies, originally in Japan, which replaced the traditional ‘functional view’, previously a characteristic of mass-production, with the ‘process view’ and tried to continually improve their processes. A number of studies have identified the efficient execution of the NPI process, or particular activities within the development process, as critical to the success of the new product. In 1988, Cooper et al. used a framework process taken from a variety of models developed by other authors and discovered that the probability of commercial success is bigger if all the activities of the process-model are completed (Cooper, 1988). While it may be desirable to have a completely mapped process of NPI, each activity may extend the overall development time and could be unnecessary in some cases. Therefore there is a trade-off to be made between carrying out all the recommended activities in the NPI process, the risk inherent in selecting activities, and the time which the whole process will take.

It has been argued that the relationship between rates of new product failure and the use of NPI procedures may not be an important contributor to success in high-tech industries (Karakaya and Kobu, 1994), which leaves a question over the application of NPI processes in aerospace. However, the authors believe that process, and hence models, are necessary to embed knowledge and communicate understanding and they require further study.

Models of the New Product Introduction Process

Models are a useful aid to communication and understanding when studying a process. There are various NPI process models, the most common of which are: Departmental-stage models, Activity-stage models, and Decision-stage models (Saren, 1984). The Departmental-stage models are the oldest and are characterised by the ‘functional’, ‘sequential’ and ‘over the wall’ approach for NPI. The focus is on the functions [departments] that are responsible to carry out each stage. Product development is a reactive process by its nature (Kennedy, 2003), the design teams naturally react to what is learnt in the previous step. In other words, it is not unusual that the results from one step drive the actions of the next step, which may suggest that this process is appropriate. The literature suggests that these models are outdated and should be discarded. The Activity-stage models of NPI offer a better view of the process since they focus on the activities that are carried out. Activity-stage models and their extension, decision-stage models, are the models that have been most rigorously investigated and used. One of the first examples of activity-stage model was described by Booz, Allen and Hamilton (1968, quoted in (Ehmke and Boehlje, 2005). The Decision-stage models have various names in practice: Phased Project Planning, Gating System, Stage-Gate Systems or Phase-Gate Systems etc. Their characteristic is that the process consists of Stages [where the activity takes place] which are always followed by Gates [which are review points with specific input, exit criteria and a go/kill/hold/reiterate decision as output]. The first model was the Phased Project Planning [PPP] model of NASA which is based on a similar US-DoD practice initiated in 1965 (PSU, 2005). This system reduced technical risk, but it made the whole process cumbersome. It worked well for NASA and Cooper emphasised that NASA did manage to put a man on the moon in less than a decade using the system – but it wouldn’t work for the companies which where influenced by uncertain market conditions (Cooper, 1994). Strangely enough, the solution came again from the US DoD in 1988. They commissioned an insightful study which came up with the new popular term of Concurrent Engineering (Dimancescu, 1996). This was what Cooper referred to as Parallel Processing (Cooper, 1988). It is also made obvious that the NPI process is closely related to Project Management. The project leader drives the project from stage to stage, gate to gate (Cooper, 1990). One of the most recognized decision-stage models is the Stage-Gate System developed by Cooper. The main difference from the PPP model is that the Stage-Gate System is multi-functional and consists of parallel activities, carried out by people from different functional areas (Cooper and Kleinschmidt, 1993). Garside described a stage-gate model with formal reviews and overlapping activities, which is applicable to an engineering business. The model is based upon four interconnected stages: product and process design and development; concept validation; process implementation and verification; and manufacturing support (Garside, 1998). Garside defines the starting point of the NPI process just after a Bid; that is after the Opportunity Evaluation Phase [i.e. bid and proposal phase]. It was this model that forms the basis for the UK LAI's NPI process model, described later.

Lean and New Product Introduction

Once a process has been modelled and understood it can be more intelligently changed. Work in an office based process can be divided to creative work and transactional work; the latter can be standardised and the lean principles applied. A study by General Motors has found that the majority of new product introduction work is transactional (Venables, 2004). In their first book Womack et al argue that Lean production vs. mass production requires "1/2 the time to develop new products" (Womack et al., 1990). As Haque et al. (2000) reported, "there are very few examples of published lean product development research literature from Europe" (Haque et al., 2000). When Womack et al. released their book about Lean Thinking in 1996 (Womack and Jones, 1996) the research was very limited in the field of Lean NPI (James-Moore, 1996) with the work of Karlsson being most closely related (Karlsson and Åhlström, 1996). In the following years, the application of manufacturing principles in NPI was covered in seminal books by Reinertsen (Reinertsen, 1997) and Goldratt (Goldratt, 1997).

Published at around the same time as the work of Womack et al. gained recognition, the study of Karlsson did not contradict their research (Karlsson and Åhlström, 1996). Some useful interrelated techniques used in Lean NPI were identified and include: supplier involvement [including black box engineering], simultaneous engineering, cross-functional teams, integration of the teams rather than coordination, heavyweight team structure [instead of functional or lightweight], strategic management of the whole project via visions and objectives instead of detailed specifications. The selection of project teams and leaders has a strong influence on the project, particularly when new technology is used (McDonough III and Barczak, 1992). The authors understand that Toyota have returned to a more lightweight, functional leadership because of worries around loss of core competence in the functions leading to stagnation of innovation. However, they could not have done this if they had not been through the strong project leader period first, as today the functions realise that adequate resources must be provided when project leaders need them.

Karlsson et al. don't overlook the fact Lean NPI cannot be achieved by simply implementing several techniques: 'A successful move towards lean product development requires approaching these interrelated techniques as elements of a coherent whole'. Karlsson et al. make a comparison between lean manufacturing, where removing the buffers can reveal hidden problems and help-provoke their solution, with Lean NPI where, as they claim, 'if buffers, in terms of time left to deadline, are removed and heavy pressure is put on the project, the results improve'.

The subject of buffers in NPI has also been discussed by Goldratt (Goldratt, 1997). Buffers of time and buffers of resources and the application the theory of constraints [TOC] in a project environment is presented. Goldratt states that the critical task must be protected by putting just enough buffer before it and only one contingency buffer must be made, calculated to protect the whole project, since all the tasks that constitute the project must be stripped off the exaggerated "safety padding". Among the three outputs of NPI, quality, cost and time, many believe that time is the most critical. Goldratt identified the root cause of the delays in time-to-market. First, it is a common belief that the only way to protect the whole project is by protecting the completion date of each step. Second, a margin of safety is put into the estimations of each step mainly because the time estimates are based on pessimistic experience [human nature or individual interest] and, the larger the number of management levels involved, the higher the total estimation because each level adds its own margin. The estimators protect their estimations from a global cut. The project will also be delayed through three mechanisms: the 'student syndrome'- if you know the deadline you are subject to procrastination until the last minute; the self-fulfilling prophesy - if you add some more 'padding' in your estimation, just to be safe, the risk of being late will simply remain the same because the task will take the longest possible time; the fact that delays accumulate but advances do not.

Reinertsen initially presented an application of manufacturing principles in NPI with an emphasis on tools, rather than rules (Reinertsen, 1997). He gives details on batch size, capacity utilization and queue and information theory and supports the 'do it, try it, fix it' approach to NPI, which by implication means that 'right first time' is of less importance.

In 2005, Reinertsen et al. published an article covering issues that are similar to those discussed in the previous work, but this time utilising the term Lean (Reinertsen and Shaeffer, 2005). For managing NPI, Reinertsen (1997) suggests a number of steps that included 'pay attention to batch size', as discussed by Womack et al. (1990, 1996), the smaller the batch size the better. Reinertsen extended this to NPI by introducing the term DIP [design-in-process] inventory. He explains that 'it's not uncommon to find phased development systems where 100 percent of work is transferred to the next phase on a single day'. Until that day, the work done is waiting, like physical inventory waits in a warehouse. 'Like the level of WIP [work-in-process] the level of DIP [design in progress] is a sign of the health" of the NPI process. In fact, Reinertsen argues that DIP-costs are much larger than WIP-costs. Reinertsen proposes 'modularity' - the decision to make the product modular or not, is complex, and it interacts with organisational structure and NPI process design. According to Murman et al. (Murman et al., 2002) platform and modular designs are commonly used to rationalise work in the aircraft engine sector, a sector that relies heavily on product design, with well defined product family strategies.

Reinertsen et al. (2005) question if Lean is applicable to R&D; the same issues are equally applicable to NPI. They note that although there are similarities between manufacturing and R&D, the differences are substantial as manufacturing is a repetitive, sequential, bounded activity that produces physical objects whereas NPI is a non-repetitive, non-sequential, unbounded activity that produces information. Risk-taking, 'good variability', is important for adding value in NPI and unlike manufacturing an NPI process doesn't add value if it does exactly the same thing twice. However, Reinertsen et al. (2005) believe that Lean approaches can still be used in NPI. Because of the differences just mentioned, some Lean approaches might ruin NPI, but others, such as time compression, can produce even greater benefits than they do in manufacturing.

NPI at Toyota

The traditional product development process consists of iterations on one initial good concept; that is making modifications-improvements in series, until an acceptable design emerges (Ward et al., 1995). This design practice works perfectly with the ‘over the wall’ NPI process. What is more, it is considered a ‘good’ practice to freeze the specifications as early as possible, as it is recognised that time to market is critical, though managing quick-response product development is difficult (Gupta and Wilemon, 1990, McDonough III and Barczak, 1992, McDonough III and Spital, 1984, Thomke and Fujimoto, 2000). This practice can not guarantee that the best design will be achieved, not to mention the schedule overruns.

At Toyota and, following them, across Japan the product development process is very different (Stalk Jr., 1988). They begin by broadly considering sets of possible solutions [in parallel and relatively independently] and gradually narrow the set of possibilities to converge on a final solution, overlapping development problems solving activities and leading to shorter lead times (Clark and Fujimoto, 1989). For this reason, this process has been named Set Based Concurrent Engineering [SBCE] (Sobek et al., 1999). By gradually eliminating weaker solutions, they increase the likelihood of finding the best or better solutions. According to Sobek (article edited in (Fleischer and Liker, 1997)), the distinctive attributes of the Toyota NPI organisation/process that differ from best practice principles include: a matrix organisation with strong functional groups; individual engineers are assigned to functional groups, they are reporting to a functional manager and are called by chief engineers to participate in development teams; design and manufacturing are separate divisions; QFD is rarely used. Instead the chief engineer captures the customer benefits; written communication is preferred to oral; there is not a very structured NPI process. The chief engineer determines a timeline with strict deadlines for each project. The traditional product development process consists of iterations on one initial ‘good concept’, that is ‘making modifications-improvements in series, until an acceptable design emerges’ (Ward et al., 1995). This practice can not guarantee that the best design will be achieved or provide a limitation to schedule overruns.

An expected Lean NPI process, following the lean principles, would capture the customer requirements [identify value], create one concept that satisfies these requirements and optimization of the value stream so that the product will be delivered to the customer, on demand, in a short lead-time. However, at Toyota, instead, they develop and prototype a wide range of alternative designs of related product components/sub-systems simultaneously. One would think that this is a wasteful practice since it results in lots of information being generated and then discarded. However, this information is considered as knowledge that is recorded and re-used, a ‘value adding waste’ that adds no direct value to the final product but the knowledge acquired may add value to future products. It seems that at Toyota they have identified that NPI processes need waste to enhance value and not restrain creativity, whilst traditional Lean practice is applied in the appropriate transactional processes, bringing balance to the ‘added’ waste. The authors support the Toyota view and have coined the phrase “right on time”, not right first time, as the important measure in the NPI process where time to market is key.

The literature therefore would imply that the lean principles as applied in manufacture do not directly benefit NPI and from this it is the author’s opinion that a process based on lean thinking may better be called ‘NPI based on the Lean principles’ or ‘NPI enhanced by the Lean principles’.

Methodology

The research question proposed was “Is the application of Lean principles to NPI sufficient for good/leading practice and has this been proven by the work of the UK LAI?”. A case-based methodology is chosen by considering the form of research questions and the exploratory nature of the investigation (Yin, 2003). Data collected for this research came from two main sources: academic input and industrial input. Academic input included mainly secondary data; a literature review and document analysis of relevant areas. Primary data was collected from the eight years of UK Lean Aerospace Initiative [UK LAI] study (James-Moore et al., 2001), working collaboratively with forty five UK aerospace companies using a combination of working party meetings, workshops, on-site visits and interviews. A working party of UK aerospace industry domain experts was established by the UK LAI to assess the suitability and application of lean beyond manufacturing, to the broader enterprise.

A number of structured meetings were held and included a two day residential workshop in 2005 to discuss the status of Lean New Product Introduction, and was attended by twenty eight domain experts from across the aerospace industry, including twelve different organisations from airline operators and OEMs to second tier manufacturers. Following this workshop there was a period of extended consultation as well as follow-up email exchanges with representatives from leading aerospace companies.

UK Lean Aerospace Initiative - Lean NPI

Over the past eight years the UK Lean Aerospace Initiative [UK LAI] has been examining the application of lean to New Product Introduction. Early work examined the nature of lean in manufacturing, the associated tools and techniques and how these may be translated to the NPI environment. Later work focussed on areas of detail and strategic issues such as core competence. All of this work was done in close collaboration with industry.

Early UK LAI research suggested that Lean is applicable to NPI (Haque, 2003, Haque and James-Moore, 2004a, Haque and James-Moore, 2004b). During this early work a different approach to Lean NPI was taken by Haque and James-Moore than that taken by others (Goldratt, 1997, Reinertsen, 1997, Reinertsen and Shaeffer, 2005). In order to answer the question 'how can Lean be applied to NPI?' they chose to rethink the five Lean principles and redefine them within the context of NPI stating 'one of the benefits of these principles is that they are in fact a series of steps that need to be carried out to implement lean, thus providing a simple structure for building a detailed route map for anyone wanting to apply lean to a business process'. Characteristics and the enablers/enabling tools of a Lean NPI system were identified by Haque and James-Moore (Haque and James-Moore, 2004a). The researchers concluded that the five Lean principles are applicable to NPI with two modifications, the seven types of waste from Lean manufacturing (Ohno, 1978) were reworked to fit the NPI environment, giving ten types of waste and the perspective of value was changed from the lean manufacturing definition of value as the reduction of waste as in NPI this is not the case. The definition of waste and value in NPI is unclear because actually some types of waste can enhance value. For example, prototypes may show that some solutions are unworkable, adding value to the final product by excluding these features.

The traditional Lean manufacturing tools, the first tools to be used in a Lean transition, were identified as valuable in NPI environments. Commonly found tools that carry over into NPI include the 5C's, which provide the logical order in the workplace, the 7 wastes identified by Ohno, visual control [andons, shadow boards, etc.] to rapidly gain an understanding of project status, and standardisation of processes for simplifying the working practices and reducing variability. One more tool that should be included is Value Stream Mapping and analysis which is a description of a business process at a high-level, used to analyse the as-is state, to identify waste, and to help develop the to-be state (Rother and Shook, 2003). Haque and James-Moore defined the value stream in NPI as 'tasks that transform information and allow for convergence of segmented information to the final design' and through case studies, explained how to implement another two key tools from Lean manufacturing: single piece flow and takt time (Haque and James-Moore, 2004a).

To facilitate communication of NPI a model was developed, with input from aerospace firms and academia, as a tool to visualise the NPI process and facilitate communication. The process has wide scope, from business strategy to product support, and incorporates four levels which are viewed concurrently: Supply Chain Development and Management, Capability Acquisition & Deployment [technology, process, people], The Product Life-Cycle [which is what most of the models describe], and Programme Management (Haque et al., 2002). The UK LAI chose to use an extended version of the model presented by Garside, due to its simplicity and ease of understanding, as a tool to communicate with the aerospace industry when discussing the different aspects of NPI. Garside’s model, developed and extended upstream to include the Bid and Proposal phase by Haque and later modified by Parry, is shown in figure 1.

Take in Figure 1. UK LAI NPI process model

The UK LAI has identified a list of areas of development that are considered to be necessary for Lean NPI in the aerospace industry. Project Management [PM] research is considered to be necessary because PM has spread out with the introduction of project teams to aerospace and at the same time the role of the project manager is not standardised yet. Risk Management is linked to PM and they are both important for NPI, but further analysis was not undertaken because it doesn’t contribute to the discussion of the hypothesis. Integrated Project Teams [IPTs] have a central role in every Lean initiative [as well as in Concurrent Engineering]. The topic has been discussed by Womack et al. [1990]. Knowledge/Data Management is an important part of Lean -

particularly continuous improvement. The UK LAI has identified three types of knowledge that have to be managed: (a) Past knowledge [contained in the Lessons Learned database], (b) Current knowledge - product Data Management has to deal with abundance of information, and (c) Future knowledge [which can be mapped using a technology roadmap] (Turner, 2004d). Requirements Capture is also a fundamental part of Lean thinking; it is about the first principle of value identification. The UK LAI has to pay particular attention to this issue because in aerospace, in contrast to automotive, the customer's requirements are changing regularly. Enabling tools include Configuration Management, and formalised requirements management processes (Haque and James-Moore, 2004a).

Core Competence

In 1957 Phillip Selznick raised the idea of organisations having functional character traits that facilitate it in achieving its aims (Selznick, 1957). This line of thinking was developed over the years (Andrews, 1971, Hannan and Freeman, 1977, Hitt and Ireland, 1986, Penrose, 1959, Snow and Hambrick, 1980, Snow and Hrebiniak, 1980, Teece, 1982, Wernerfelt, 1984) leading to the paper by Prahalad and Hamel that popularised the notion of core competence (Prahalad and Hamel, 1990). According to Prahalad and Hamel the core competence of an organisation provides potential access to a wide variety of markets, makes a significant contribution to the benefits of the products as perceived by the customer and is difficult for competitors to imitate (Prahalad and Hamel, 1990). In manufacturing, to achieve flow, an identification of the individual process steps that deliver value is required. Taking this thinking into NPI requires knowledge of the core competences that are used by an organisation to deliver its product or services

(Venkatsen, 1992), making it focus in its area of competence, succeed and win new business (Bettis, 1992, Fine and Whitney, 1999, Krause et al., 1998, McIvor, 2000).

This moved the focus of work within the UK LAI in the direction of understanding core competence and strategy and, as it was found much of the previous work was based on interviews and not empirical internal and external validated data (Hannan and Freeman, 1977, Hitt and Ireland, 1986, Javidan, 1998, Kak, 2004, Lewis, 2003, Snow and Hambrick, 1980, Snow and Hrebiniak, 1980), developing a methodology for core competence evaluation (Parry, 2005a, Parry, 2005b, Parry, 2002c, Parry et al., 2005a, Parry et al., 2005b). The work found that companies usually do not have written definition of their core competence, making it a moving feast. Initial work focussed on the development of an understanding of core competence and resulted in an agreed definition: Core Competence is a skill/asset/technology that underpins the growth of the business and differentiates the business from its current and future competitors.

Core competencies may be validated in numerous ways and there was a need for a simple formal process of core competence knowledge capture. Using the agreed definition an outline process was developed, based on lean tools and principles, with which to analyse a company in order to reveal core competences (Parry, 2005a, Parry, 2005b). Four work packages were proposed, each with a different focus: market place, value stream, customer, and finance, to produce reports that, together, facilitate an understanding of company resources and core competence and how they may be used to better deliver customer value. The process was trialled and developed using an action research approach in a sponsor company. The combination of the four process steps revealed the companies core competences as we defined them and, in addition, implementing the process yielded many benefits that included an increase in market share for the product stream studied from 5 to 50%. The work yielded a number of results about the relation of strategy and value of competence: [a] To achieve growth, strategy and core competence must be aligned [b] Growth may be achieved by conscious strategic planning around core competence [c] It is difficult to connect strategy to core competence as current strategies are not always available for analysis [d] It is concluded that the link between strategy and core competence is complex as each will influence the other to drive growth. [e] Core competence protection is complex.

It is clear that the value derived from core competencies leads to the growth of a business, but the individual competence value-add is not straightforward to measure. Core competence is a subject that is not discussed in the Lean literature. However, it is estimated that this research is necessary for the UK LAI for three reasons.

Firstly, a close relationship with the suppliers is of outmost importance in Lean, but Womack et al. failed to give a solution to the problem of protecting core competence (Womack and Jones, 1996, Womack et al., 1990) which may be threatened by close supplier involvement (Parry et al., 2005a). Practical suggestions for core competence protection may take a person-centred approach [i.e. staff retention or training programmes that help transfer of knowledge through the company] or a knowledge centred approach i.e. limited access of staff to knowledge or data capture-storage.

However, Teece proposes that core competences may not survive when transferred outside an organisational boundary as, when taken out of context, an individuals knowledge or routine may become quite useless (Teece, 1982). Secondly core competence is linked to strategy and, because Lean does not provide change driven for strategic reasons, the topic had to be researched for achieving good/leading practice. Thirdly, the investigation of core competence is interconnected with the Make vs. Buy decision which is a “sine que non”. Hence, it is concluded that the research on core competence is something that the UK LAI has had to do, even though it is not related to Lean per se.

Bid & Proposal

“The process for Identifying customer needs and winning orders is probably the least well-defined business process.” (Garside, 1998).

The work on bid and proposal flowed on from that done in the core competence area and, at first, the bid and proposal process seemed an area that could benefit from the application of Lean principles as it is a process with defined phases, with many crucial decisions and a specific end. However, the findings from the research had little to do with the application of the five Lean principles (Parry, 2002a, Parry, 2002b). Of importance was the process behind the decision to take the project, answering the questions can we do the job? Should we do the job? Is it likely to win? What is the competition?

Our findings stated that bid and proposal work should have defined processes that differ according to the degree of novelty they require, and may be divided into the categories of runner, repeater and stranger. Simultaneously the financial concerns needed to be addressed, including the time and money invested balanced against the predicted returns likely to be generated. There are many risks involved in the decision phase of bid and proposal work, many of which, whilst unavoidable, can be mitigated. A primary risk taken during bid and proposal work is the potential for loss of intellectual property when contracts are lost. It was found that the no bid decision was increasingly difficult to make as new revenue was always championed, but if analysis does not show an upside, it is wasteful to continue. Key amongst our findings was that proposal work often focuses on producing levels of detail which far exceed that which is required, and is a source of waste. It was proposed that a new proposal could consist of a single piece of paper detailing what would be done differently from the past to meet customer value. Past experience of bids won and lost should be examined first. To drive this behaviour rewards for quality proposal work need to exceed those given for problem solving and fire fighting if the current cycle is to be broken. Insufficient resources are allocated to early specification, which leads to decisions being made without sufficient information or understanding. The bid and proposal process is dependent on the goodwill of the workforce. Although multiple bidding is common, we found only very few companies with a formal process for prioritising amongst them.

Few of the findings are related to Lean principles, some are related to Lean/best practice and most of them are about good practice. Concepts such as competition assessment, risk and return on investment are all irrelevant to Lean but crucial to NPI. Consequently, there are many things that have to be done to improve bid and proposal processes, but applying Lean principles is just a small part and indeed the benefit of applying lean may be limited. Eliminating waste in the bid and proposal process was not seen as critical to a business because the process does not last for long and does not demand huge resources. However, the bid and proposal process influences greatly the future of the business, thus it is very important to have an effective process.

Make vs. Buy Decisions

Work was done that examined the make vs. buy decision as this was seen to be a fundamental part of the NPI process for the sponsor companies involved (Parry, 2003a, Parry, 2003b, Parry, 2003c). Initial work examined the flow of the NPI process, effects of timeliness on that process, and financing. Key issues identified included vendor competence analysis, strategic competences and cost analysis (Parry, 2003a). Work progressed to examine the customer supplier relationship and discussed models used by companies. Processes of customer supplier relationships were examined, and potential pitfalls discussed (Parry et al., 2005a) and a number of case studies from participating companies were presented (Parry, 2003b). The findings of the two years of research highlighted that a formal make vs. buy process is necessary to deal with such complicated decisions. Core competence and strategy must be examined in depth. Value stream mapping can facilitate make vs. buy decisions and help in identifying hidden processes and competencies. It was found that companies are currently more involved in examination of what may be brought back in house, in sharp contrast to the apparent drive towards outsourcing. Financial and process benefits can still be derived from outsourcing commodity parts of the procurement function (Parry et al., 2005b). Complications exist around outsourcing within the global aerospace market, caused by the fact that some contracts are not awarded on the basis of product value, but instead on offset agreements, making implementations focussed on customer value very difficult.

There is no evidence that make vs. buy stems from the Lean principles. It can be argued that make vs. buy decisions have to be done anyway by a company, regardless of the NPI process and its leanness. Also, the topic of make vs. buy is directly associated with core competence and strategy, which we have identified as not directly part of Lean thinking. What is more, Womack et al. argue that the make vs. buy is not such an important issue as may be thought in NPI "Whether the supplier comes from inside the company or out makes surprisingly little difference" (p140); what is important is the level of actual cooperation with the suppliers (Womack et al., 1990). This is contrary to the work of Fine who described the 'ultimate core competency' as the ability to choose which components to keep in-house and which to purchase outside (Fine, 1998) and cites Toyota's development of leading capabilities to respond to a threat from Chrysler (p172). Thus, it is not clear if make vs. buy derives directly from the Lean principles, from the actual need of the companies to achieve leading/good practice or, in a worst case, to cut internal costs through outsourcing at the risk of loosing both capacity and knowledge.

Set Based Concurrent Engineering

Investigations into set based concurrent engineering [SBCE] yielded several findings (Turner, 2004c, Turner, 2002). Initially it was found that there is a general lack of understanding of the process of SBCE, resulting in its apparent lack of use within UK aerospace product development. The overall understanding of the SBCE process was low coupled with a general belief that it was a process that would be too expensive to implement with the commonly expressed sentiment “multiple prototypes are too expensive in aerospace”. Many did recognise that it was an iterative process where a number of design solutions pass through a selection procedure until a solution is found. Initial impressions revealed doubts reflecting opinion that it would require a larger workforce than available, the cost would be too high and full scale working models would have to be made as part of the process. The major barrier to SBCE was the perceived cost of implementing the practice and in particular the large workforce that would be required. SBCE is generally seen as too costly and too much of a drain in resources within the NPI procedure. However, within areas where design lead times are longer and resources are more readily available it was considered a good concept. Typically areas such as shelf engineering, where design concepts are developed and tested over longer timescales, could benefit more widely from SBCE. The current capability of computer systems which enable full digital mock ups and concurrent communications along the supply chain make an approximation of this approach even more possible. Toyota are reported to have developed a car from market concept to launch in 19 months using no physical mock ups – the car was only launched in Japan and reportedly had problems, but was part of Toyotas culture of process experimentation.

As it has been discussed earlier, SBCE does not derive from Lean practice. This would be the most obvious argument that Lean thinking is not sufficient for achieving good/leading practice, but this is not accurate. However, it is important to point out that SBCE doesn’t contradict the five Lean principles. The use of multiple designs might be viewed as part of the process of value-identification. A process map was produced that introduced the concept of bringing lean and SBCE together in a process sense (Turner, 2004b). It adds some local-waste, but it leads to enhanced customer value. Thus, in the author's view, SBCE is complementary to Lean. Therefore, the fact that the UK LAI included SBCE in its NPI proposal will not be used as an argument that Lean principles are not sufficient for good/leading practice.

Measures of performance

Since the success of any lean change tool or technique can only be measured by using the correct metrics, the UK LAI dedicated a significant part of its research to developing NPI metrics (Haque and James-Moore, 2004b, Haque and James-Moore, 2005, Turner, 2004a). Metrics are used for process evaluation and they are often believed to be crucial for continuous improvement, thus they are often seen as an important link in a Lean system. According to Haque et al., there is a basic problem when trying to develop Lean metrics for NPI (Haque and James-Moore, 2005). In manufacturing environments the process can be measured directly from the product itself and give immediate results, whilst in NPI the quality of the information produced can only be fully assessed when it has been used to manufacture a product. This means that NPI is measured indirectly and with a time-lag. Most of the aerospace companies in UK are trying to make a transition to Lean, and they are also very concerned with measuring performance (Jones et al., 2001). Nevertheless, it's not clear, yet, how to design performance measures which support and are supported by Lean principles. The UK LAI attempted to fill this gap by proposing sets of metrics for enterprise and process levels (Haque and James-Moore, 2004b, Haque and James-Moore, 2005). It is worth noting that although these metrics were developed with agreement from industry, in practice industry decided that it was too complicated to gather the data and only two of the metrics were ever used (Turner, 2004a). This was surprising as the metrics were derived by the industry working group and also as later research found that more than one company had over two hundred metrics for a single process (Turner, 2005, Wong, 2004). The data was poorly kept and often not reported so the results were mostly ignored, or the “keeper” of the metrics moved on and it was abandoned. An evolving solution in many organisations was to have visual management which revealed the hidden management processes and flows of work. A number of case studies were gathered and reported demonstrating how visual signals were being used to control processes, based on systems developed on the shop floor (Parry and Turner, 2006). One company no longer used metrics to manage their processes, but kept three only as a means to report to the board of directors. The authors believe that metrics are useful to demonstrate progress and may act as a driver for change, but do not provide change and are therefore external to Lean Thinking.

The Lean Enterprise Self Assessment Tool [LESAT]

“Assessing the enterprise against this subset of leading indicator practices will provide a good ‘snapshot’ of how well an organization is progressing along the lean journey.”

(Nightingale and Mize, 2002)

A tool that has been used extensively and is becoming industry-standard in the USA, particularly for defence companies, is the LESAT. The LESAT is used to identify or review the current status of the enterprise with respect to Lean and its readiness to change. Its users are exhorted to ‘step back and think’ about the current processes and practices in their company and, thus, they can identify opportunities for improvement. It can be used at most levels of the enterprise, yet it is most suitable for the top levels. The current version of the Lean Enterprise Self-Assessment Tool (LESAT), released in 2001, has been developed by the Massachusetts Institute of Technology (MIT) and the Warwick Manufacturing Group of the University of Warwick with the support of the UK LAI and US LAI respectively (Womersley et al., 2001). Its utility, effectiveness and practicability have been demonstrated by field-testing in more than 20 companies in both countries.

Summary

After examining the Literature, the following conclusions have been reached. New Product Introduction is a different kind of process to manufacturing, but the Lean manufacturing principles can be applied to NPI and the application of Lean to NPI is valuable. However, in many cases Lean and the manufacturing approach is not directly applicable to NPI, requiring some adaptation or reinterpretation of the original meaning. The role of Lean is to coordinate the existing initiatives and make them more effective. After examining the case study material, the conclusion that is emerging is that the direct application of Lean Thinking alone in NPI is not sufficient to achieve good/leading practice. The evidence is presented as follows. Modelling the NPI process is useful in communication, but not a direct relation to the lean principles or Toyota Production System [TPS]. It has been concluded that the research on core competence is something that the UK LAI had to do in order to promote good/leading practice, even though it is not directly related to Lean. Although bid & proposal issues can be related to Lean, the analysis has shown that there is limited benefit from applying lean principles. In practice, it is estimated that bid and proposal had to be included in the research because it is crucial for achieving good/leading practice. Womack et al. noted that who makes the components is of little importance (p140) (Womack et al., 1990), though this point is debated by the work of Fine (Fine, 1998). The analysis has shown that the make vs. buy issue doesn't derive directly from the Lean principles, but from the actual need of the companies to achieve leading/good practice or cut costs to maximise shareholder value. Although the NPI Metrics & the LESAT are both exemplary applications of Lean thinking in NPI, for the purpose of this study only some parts of them –which are considered 'additional' to the Lean thinking, yet contribute to achieving good/leading practice– will be highlighted. The metrics cover various performance measurement issues such as quality, cost, delivery, design re-use and innovation. The latter metric is of special interest for this study. It is aimed to measure innovation as a way of measuring "value creation". It is clear that innovation is connected to value. Value, however, in the traditional Lean-view, is about the customer's needs in terms of quality, cost and delivery (Haque et al., 2000) This metric goes beyond that; it measures the "newness" of products. This is an indication that the measure is about best practice rather than Lean practice.

After examining the LPI Assessment Matrix, the categories 'business and product development strategy', 'risk assessment and mitigation in the area of programme management', 'capability acquisition and deployment', 'use of phase/stage-gate reviews' and 'risk management in the area of multifunctional programme management' have been identified as "additional" to the Lean thinking.

More evidence that Lean is not sufficient for NPI good/leading practice can be found in examining concurrent engineering [CE] and set based concurrent engineering [SBCE]. CE is a major enabler for Lean practice (Haque and James-Moore, 2004a) and for good/leading practice in NPI. CE and Lean are complementary approaches. Lean acts at a high-level and CE provides necessary details for the implementation. The focus of CE is the integration of the development functions by employing various formal tools (Haque and James-Moore, 2004a). It is noteworthy that Toyota use SBCE for NPI and that this is presented as separate from the TPS. As a result, it can be said that Lean is not sufficient by itself for good/leading practice in NPI.

As an additional comment, Business Process Re-engineering [BPR] is often put forward when discussing lean, and is seen as an enabling process to achieve leading/good practice. The authors believe that BPR is a complementary business process that could either be coordinated by Lean or [less likely] contributes to an alternative way to leanness.

Bearing in mind all the evidence presented above, it should be possible to establish the hypothesis that Lean thinking is not sufficient for achieving leading/good practice in NPI. The examination of the UK LAI material showed clearly that Lean is not sufficient for leading practice as what has been presented does not link directly back to the original approaches presented in the lean literature. The approach of the UK LAI was to find first what is the leading practice and then to try to explore the relation too, or any enhancement that could be made with, the application of Lean Thinking. There has been some confusion in the work between what is labelled as ‘Lean Practice’ and what is recognised as ‘Good Practice’. It has been shown that lean is complimentary to the NPI process, but a number of non-lean tools, processes and techniques are an integral part of current leading practice in NPI in UK aerospace companies.

Conclusions

The objective of all research done in the field of New Product Introduction (NPI) is to create knowledge that is necessary for improving NPI. Improvement in NPI simply means that better products can be developed faster and with fewer resources. There is evidence in the literature and example case studies of applications in industry that show the Lean principles can help in this direction. However, this study has demonstrated that Lean is not sufficient for achieving leading/good practice. The examination of the case study material from the eight years of the Lean NPI research programme of the UK LAI has revealed that many practices for achieving leading/good practice do not derive from the Lean principles. This doesn’t mean that people who are working on the implementation of Lean thinking in NPI should stop. Lean thinking is necessary. The study has discussed the importance of Lean: its role is to coordinate –at a high level– the existing change initiatives and make them more effective.

This leads to the hypothesis that the application of Lean principles to NPI is necessary but not sufficient for leading/good practice.

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Figure 1. UK LAI NPI Process Model