A New Cost Management & Accounting Approach
For Lean Enterprises

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A NEW COST MANAGEMENT & ACCOUNTING APPROACH FOR LEAN ENTERPRISES[1]

Yvonne Ward[2] and Andrew Graves

ABSTRACT

The adoption of lean principles and practices has become widespread in many industries since the early 1990's. Companies are now beginning to realise that traditional costing and accounting methods may conflict with the lean initiatives they are implementing. Consequently, important research questions are being raised. Is a new cost management and accounting approach required for companies that adopt lean principles and practices? If so, what should this approach entail? This paper addresses these questions. The problems associated with continuing to use traditional costing and accounting methods in a lean environment are discussed and existing research in the area of costing, accounting and measurement for lean enterprises is analysed. The paper then outlines the findings of a joint academic-industrial research programme undertaken as part of the UK Lean Aerospace Initiative (UK LAI) and the resulting lean cost management and accounting proposals for the aerospace industry. The paper concludes by highlighting the academic and practical implications of this research.

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INTRODUCTION

Lean manufacturing has its roots in the automotive industry (Womack et al, 1990). A global study of the performance of automotive assembly plants during the 1980's resulted in the widespread adoption of lean practices in a variety of industries (Womack and Jones, 1996; Liker, 1998; Henderson and Larco, 1999). The application of lean ideas to a range of industrial sectors enabled Womack and Jones (1996) to derive five generic, over-arching lean principles. These principles are:

1. Customer Value - A key principle of lean manufacturing is that value is defined by the ultimate customer. Value is viewed "*in terms of specific products with specific capabilities offered at specific prices through a dialogue with specific customers*" (Womack and Jones, 1996: 19).

2. Value Stream – the Value Stream is defined as "*the set of all specific actions required to bring a specific product through the three critical management tasks of any business: the problem-solving task running from concept through detailed design and engineering to production launch, the information management task running from order-taking through detailed scheduling to delivery, and the physical transformation task proceeding from raw materials to a finished product in the hands of the customer"* (Womack and Jones, 1996:19). The aim is to expose wasteful activities (*muda*) that currently exist in the process of delivering a product to the customer and take action to eliminate these wastes.

3. Flow - Once any obviously wasteful steps are eliminated, the remaining value-creating steps need to be organised in such a way that they flow. This involves a move away from the traditional functional or departmental organisation towards an holistic, customer-focused organisation, laid out along value stream lines. Cellular manufacturing is usually adopted by lean manufacturers, where each cell contains all the resources required to produce a specific product or where a series of cells is organised to produce a specific product. In order to enable products to flow smoothly through the factory to the customer, batch production is rejected in favour of single-piece or continuous flow. The emphasis moves away from the *efficiency* of individual machines and people to the *effectiveness* of the whole value stream.

4. Pull - When the value-creating steps are organised to flow, the customer can then pull value though the system. Traditional production methods tend to push products through the system in the hope that a customer will buy them once produced. In a pull environment, no work is completed until required by the next downstream process.

5. Perfection - As companies widely adopt lean practices, it becomes clear that improvement is an on-going process. Initiatives to reduce effort, time, space and cost can be conducted continuously. As a result, lean manufacturers adopt a continuous improvement philosophy.

There are many associated tools and techniques which can be used to embed these principles within a company, including Value Stream Mapping, 5S, visual management, cellular manufacturing, Just-in-Time, *kanban* (pull) systems, preventative maintenance and *kaizen* (continuous improvement) activities (Bicheno, 1998; Rother and Shook, 1998).

Adopting a lean approach promises significant improvements in productivity, quality and delivery, resulting ultimately in substantial cost savings. However, although many companies across a range of industrial sectors have introduced lean working practices, lean initiatives are often not underpinned by appropriate and rigorous cost management and accounting methods. Furthermore, companies are now beginning to realise that traditional costing and management accounting methods may conflict with the lean initiatives they are implementing (Ahlstrom and

Karlsson, 1996; deFilippo, 1996 Womack and Jones, 1996). Consequently, important research questions are being raised. Is a new cost management and accounting approach required for companies that adopt lean principles and practices? If so, what should this approach entail?

This paper seeks to address these questions. Firstly, the problems associated with continuing to use traditional costing and accounting methods in a lean environment are discussed and existing research in the area of costing, accounting and measurement for lean enterprises is analysed. The paper then outlines the findings of a joint academic-industrial research programme undertaken as part of the UK Lean Aerospace Initiative (UK LAI) and the resulting lean cost management and accounting proposals for the aerospace industry. The paper concludes by highlighting the academic and practical implications of this research.

RESEARCH METHODOLOGY

This research programme was derived from a specific challenge facing aerospace companies participating in the UK Lean Aerospace Initiative (UK LAI) – what kind of costing and accounting approach is required to support the implementation of lean principles and practices in aerospace companies?

In order to address this issue, it was necessary initially to establish *if* a new costing and accounting approach was required by companies implementing lean principles and practices. This involved an extensive literature survey to: (1) identify the problems created by the continued use of traditional costing and accounting methods in companies adopting lean principles and practices; (2) examine existing research that aligns costing and accounting with lean manufacturing; and (3) identify costing and accounting tools and techniques that are suitable for application in a lean environment.

If it is accepted that a new approach to costing and accounting is indeed required for companies adopting lean principles and practices, then it is necessary to determine what such an approach should entail. The literature review provided a valuable insight into the cost management and accounting requirements for lean enterprises. The UK LAI research programme built on these theoretical foundations by examining the case of the aerospace industry and the specific cost management and accounting requirements of aerospace companies adopting lean manufacturing. A joint academic-industrial Working Group was established within the UK LAI to address the specific challenge identified by the member companies, to engage a wide range of stakeholders and to ensure relevance to the aerospace industry. Representatives of fifteen aerospace companies have been involved with the Working Group over a three year period from July 2001 to June 2004. This pragmatic, problem-focused approach is accepted as a valid methodology for management research (Aram and Salipante, 2003).

COST MANAGEMENT & ACCOUNTING FOR LEAN ENTERPRISES

Womack and Jones (1996: 262) raise the question: "*what kind of management accounting system would cause our [employees] to do the right (lean) thing?"* However, little guidance is provided to enable companies to determine which costing and accounting tools are appropriate for lean manufacturers. This section discusses the problems associated with traditional management accounting approaches (Kaplan, 1988; Cooper, 1995) and examines the limited existing research that aligns costing, accounting and measurement systems with lean thinking (Jenson et al, 1996; Maskell, 1996; Maskell and Baggaley, 2002).

Problems with Traditional Costing and Accounting Methods

Many writers have identified the limitations of traditional costing and accounting systems. Kaplan (1988) argues that cost systems have been designed primarily to satisfy the financial accounting requirements for inventory valuation and, as a result, are not appropriate for performance measurement, operational control or product costing purposes.

Kaplan (1988) states that a good product cost system should produce product cost estimates that incorporate expenses incurred in relation to that product across the organisation's entire value chain. He claims that standard product costs usually bear no relation to the total resources consumed by a product. This is due to the fact that overheads are allocated, often on the basis of direct labour hours, and as a result can cause distortions to product costs. As overheads need not be causally related to the demands of individual products to satisfy financial accounting requirements, many companies continue to use direct labour as the basis for allocating overheads even though it may account for less than 10% of total manufacturing costs. Cooper (1995) and Maskell (1996) also argue that the distortion of product costs, as a result of the inappropriate allocation of overheads, can lead managers to choose a losing competitive strategy by de-emphasising and over-pricing products that are highly profitable and by expanding commitments to complex, unprofitable lines.

In addition to product costing, standard costing has also traditionally been used for operational control purposes. However, measures such as labour productivity (the difference between standard and labour hours) and machine utilisation, in conjunction with variance analysis, can encourage behaviours that conflict with lean manufacturing principles. These non-lean behaviours include the manufacture of large batch sizes, the holding of high inventory levels, acceptance of poor quality and a lack of motivation for continuous improvement. Kaplan (1988) supports this view and also suggests that cost accounting calculations such as the allocation of overheads or variance analysis should not form part of the company's operational control system because they obscure the information that cost centre managers need to operate effectively.

As a result, traditional costing and accounting approaches are believed to be a major impediment to lean manufacturing (Maskell, 1996, 2000; Ahlstrom and Karlsson, 1996). However, accounting is an integral part of the planning and control system of any manufacturing operation and must remain so. Consequently, there are calls for a new costing and accounting approach to support lean manufacturing (Maskell and Baggaley, 2002; deFilippo, 1996; Womack and Jones, 1996). There is, however, no clear consensus as to what constitutes appropriate costing and accounting methods for lean manufacturers.

Aligning Cost Management and Accounting Methods with Lean Thinking

Pioneering contributions have been made in this field by Maskell (1996, 2000) and Jenson et al (1996).

A management accounting profile that supports manufacturing excellence

Case study research across a number of industrial sectors has enabled researchers to develop a profile of companies that successfully align accounting systems with lean principles (Jenson et al, 1996). Jenson et al (1996) found that companies that adapt their management accounting systems to support manufacturing excellence demonstrate the following characteristics:

1. Integrate the business and manufacturing cultures
2. Recognise lean manufacturing and its effect on management accounting measurements
3. Emphasise continuous accounting improvement

4. Strive to eliminate accounting waste
5. Encourage a pro-active management accounting culture.

This research provides a valuable insight into the type of management accounting changes that may be required in order to support a lean enterprise. As the findings are based on a series of case studies across a number of industries, it is evident that some companies are implementing these ideas in practice and that they are relevant to those companies adopting lean ideas. The primary limitation of this research is that many of the proposals for change are expressed in quite general terms. A more detailed consideration of appropriate costing concepts for different types of decision-making to support lean manufacturing is required.

Lean accounting model

The work of Maskell (1996, 2000) compliments Jenson et al's findings by providing generic, theoretical frameworks to examine how companies adopting lean manufacturing can move away from the use of traditional costing and accounting methods. Maskell's development of a 4-Step Lean Accounting Maturity Model represents one of his most valuable contributions (1996). This model proposes the changes that should be made to accounting systems in parallel with lean changes that are being implemented in other areas of the organisation. Table 1 provides a summary version of this model.

The model is valuable for identifying what accounting changes should be made and at what stage they should be introduced with respect to the maturity of lean implementation. However, there are some limitations associated with Maskell's work. There is no guidance as to what specific accounting changes should be made to support each type of decision and it is assumed that companies will move through the four steps in a linear fashion. In addition, as Maskell's ideas have evolved, he has referred to various different accounting tools and techniques that should be used to support world-class and lean practices. However, it is often unclear how these tools and techniques are to be used and in what context they should be used. It also appears to be assumed that all these approaches are compatible both with lean ideas and also with each other.

Table 1 - Maskell's 4-Step Lean Accounting Maturity Model

Maturity Steps	***Description***
1. Low-hanging fruit	Maintains current accounting and control methods but eliminates obvious waste within the processes (e.g. reducing detailed labour reporting and variance reporting, reducing the number of cost centres, simplifying accounting processes)
2. Removing transactions	Eliminates much of the detailed shop-floor tracking as lead times reduce and WIP becomes immaterial; eliminates unnecessary cost and financial reporting
3. Eliminating waste	Company operations no longer need to be in step with accounting periods; month ends are irrelevant to the sale of products, manufacture or distribution
4. Lean accounting	Move to minimal transactions – production completion or product shipment transactions are used to backflush all the relevant information through the control systems

THE EXPERIENCE OF THE AEROSPACE INDUSTRY

The History of Lean in Aerospace

In the early 1990's, the foundations of the global aerospace industry were shaken by two major factors.

1. The end of the Cold War prompted drastic reductions in defence procurement budgets resulting in reduced military markets. The defence industry could no longer justify the cost-

plus mentality that characterised the Cold War era and faced the challenge of seeking new markets (AW&ST, 1992; Interavia, 1999).

2. Passenger demand fell suddenly following the first Gulf War, forcing airlines to cancel or postpone civil aircraft orders. This followed a period where demand for civil aircraft had been running at unprecedented high levels. The inability of the industry to respond to unexpected changes in demand was reflected by long lead times (AW&ST, 1999).

These events signalled radical changes for the global aerospace industry. There was now over-capacity in the market and profits were declining (Cosentino, 1999). Global competition was on the increase as the major players were forced to seek business outside their traditional markets.

The US response to the new aerospace business environment was to transfer lean ideas from the automotive sector to the aerospace industry. The US Lean Aerospace Initiative (US LAI), a partnership between the US Air Force (USAF), Massachusetts Institute of Technology (MIT), major aerospace defence companies and the labour unions, was established in 1993. It was "*born out of practicality and necessity as declining defence procurement budgets collided with military industrial over-capacity prompting a demand for 'cheaper, faster, and better' products*" (http://lean.mit.edu). By the mid-1990's, a huge amount of rationalisation had taken place in the US aerospace industry. Surviving companies enjoyed healthy profit margins despite falling production rates and the US aerospace industry had been transformed into one of the most competitive aerospace industries in the world. It is believed that this transformation was in part due to the adoption of lean manufacturing techniques (Interavia, 1995).

In Europe, this revolutionary culture change was much slower (Interavia, 1994; 1995) despite the European Aerospace Association's acknowledgement of increased competition and call for continued cost reduction and increased efficiencies (AECMA, 1996). The European Commission also emphasised the need for "*sustaining growth and competitiveness against increasingly intense world competition*" and the importance of the "*integration of technologies for new-generation aircraft in order to reduce design, production and operating costs*" (European Commission, 1997, 1999).

The UK Lean Aerospace Initiative (UK LAI)

In contrast to the rest of Europe, the UK adopted lean ideas at a much faster rate. Following the example of the US Lean Aerospace Initiative, the Society of British Aerospace Companies (SBAC) launched the UK Lean Aerospace Initiative (UK LAI) in 1998 as part of its Competitiveness Challenge agenda. This initiative aims to improve the competitiveness of the UK aerospace industry in the global aerospace market through the widespread adoption of lean principles and practices. The UK Lean Aerospace Initiative comprises a research consortium (Universities of Bath, Cranfield, Nottingham and Warwick) and a continuous improvement implementation programme, known as Masterclass. The ultimate expectation is that total product costs will be reduced, throughout the supply chain and across product life-cycles, as a result of the adoption of lean thinking.

Cost Management and Accounting Requirements for Lean Aerospace Enterprises

Despite the introduction of lean initiatives throughout the aerospace sector and increasing cost reduction pressures within the industry, there have been difficulties in identifying how cost management and accounting practices can support the lean enterprise. The UK LAI member companies have begun to recognise that there may be a conflict between lean initiatives being undertaken at operational level and the costing, measurement and accounting systems that are used within their businesses. As a result, a joint academic-industrial research programme was undertaken in order to identify the appropriate cost management and accounting methods to support lean aerospace enterprises (Ward et al, 2003). This involved the establishment of a Working Group with representation from fifteen aerospace companies to enable the capture of industry needs and stimulate fast dissemination and implementation of research findings on an on-going basis.

The contributions of Jenson et al (1996) and Maskell (1996, 2000, 2002), as previously outlined, in conjunction with the wider literature review, have provided a good foundation for determining the cost management and accounting requirements for lean aerospace enterprises. However, both Jenson et al and Maskell place a heavy emphasis on costing and accounting at the manufacturing stage and on the elimination of waste within the accounting function itself. While this is a valuable starting point, this research indicated that a broader perspective is required for the aerospace industry. Within the aerospace sector, huge levels of investment are required during the new product introduction phase, lead times are long and products often have life-cycles of over 30 years. Murman et al (2002: 116) state that "*Lean principles must be understood and implemented in the context of aerospace products for which the link between design, manufacturing and sustainment has far-reaching implications in terms of life-cycle affordability and delivery of best value to customers and other stakeholders*". It is clear, therefore, that cost management and accounting methods that support lean principles in aerospace must also take a life-cycle approach into consideration. Furthermore, as over 70% of materials are bought-out at the prime contractor level (Cook and Graser, 2001; Murman et al, 2002), cost management in the extended value stream is a vital element in the reduction of total value stream costs.

Consequently, this research has examined the cost management and accounting issues in an holistic manner. The literature review has identified existing costing and management accounting approaches, tools and techniques developed in recent decades and considered how appropriate they are for aerospace companies adopting lean principles. The research took into account that different tools and techniques may be appropriate at different stage of the product life-cycle, through the extended value stream and for a variety of decision purposes. Figure 1 illustrates the research framework that has been adopted. The research addresses the cost management and accounting needs to support lean thinking in three separate dimensions:

1. New Product Introduction
2. Manufacturing
3. Extended Value Stream.

In order to attempt some distinction between the costing and accounting needs for different types of decision at the Manufacturing stage, the differential needs of product costing, operational control and costing for continuous improvement are considered.

This paper presents the findings of this research and examines the costing and accounting requirements for (1) Lean New Product Introduction, (2) Lean Manufacturing and (3) Extended Value Streams.

Figure 1: Research Framework

New Product Introduction	**Manufacturing**	**Extended Value Stream**
• Life-cycle costing • Target costing	***Product costing and overhead allocation*** • Activity-based costing (ABC) • Product costing in cellular environments • Time-based costing • Value stream costing ***Operational control*** • Non-financial performance measures • Value stream box scores • Throughput accounting • Backflushing ***Costing for continuous improvement*** • Kaizen costing • ABC and cost reduction • Cost of waste and waste indices • Cost of quality • Inventory reduction	• Activity-based costing for internal supply chains • Supply chain target costing • Supply chain kaizen costing • Total cost of ownership
LEAN ACCOUNTING APPLICABLE TO EACH PHASE AND DECISION TYPE		

COST MANAGEMENT FOR LEAN NEW PRODUCT INTRODUCTION

The aerospace industry is characterised by long development cycles and produces products and systems that can often be in service for more than 30 years. It is widely recognised that there are significant opportunities to reduce total product costs during the New Product Introduction phase, as up to 80% of costs may be committed by the end of the detailed design stage (Yoshikawa et al, 2003; Fabrycky, 1991; Murman et al, 2000, 2002).

Two valuable techniques that can be applied with the aim of enhancing value and reducing product costs throughout the life-cycle are target costing and life-cycle costing.

Target Costing

Target Costing is believed to be the most important development to support the commitment to low cost production (Sakurai and Scarborough, 1997). Target Costing is a multi-disciplinary tool for reducing total costs and is seen as being particularly applicable for multi-product, small-production-run firms (Monden and Hamada, 1991), therefore, implying that it is applicable to aerospace companies. It is applied at the planning and design stages of new products with the involvement of R&D, Engineering, Production, Marketing and Finance, with Engineering being viewed as the key discipline. The aim is to design cost out and design value in at the earliest possible stage.

Target costing is undertaken by working backwards from the market-driven target price for a new product in order to determine the target price, as illustrated in Figure 2 (Yoshikawa et al, 2003; Cooper and Slagmulder, 1997).

Figure 2 – Calculating the Target Cost

Market-driven Target Price *less* Desired Profit Margin = Target Cost

The target cost is the cost required for market success, regardless of whether or not that cost is supported by current manufacturing practices.

Target costing is intrinsically linked to Value Engineering (Cooper and Slagmulder, 1997). Value Engineering is a series of procedures that can be used to help design products so that the target costs can be realised. Value Engineering aims to increase value and provide additional functionality while reducing costs. Product and process innovation is encouraged through rigorous Value Engineering activities. The key concept in Value Engineering is to recognise that the final output is not the product, per se, but the services that the product delivers to the customer. These services will be reflected in the different attributes of the product, e.g. maximum cruising speed, manoeuvrability, range, payload. The focus of Value Engineering within a target costing approach is certainly to drive down cost at the design stage in order to meet the overall target cost, but it must do so without significantly affecting the desired attributes of the product. There is, therefore, a need to analyse costs by attribute (or product function). So, what has come to be called Functional Costing is needed to support Target Costing and Value Engineering.

Target Costing has the potential to yield widespread benefits and is highly compatible with lean principles. It is clearly aimed at enhancing customer value, using the target market price to set target costs. There is an explicit focus on continuous improvement, cost reduction and waste elimination. Risk is reduced as profit margins are protected. Competitive advantage may be gained due to the combination of cost reduction and additional product functionality and value.

In addition, collaborative ways of working are promoted, clear and common goals are made visible to all employees and an holistic approach is advocated.

Life-cycle Costing

Within the aerospace industry, it is recognised that it is no longer appropriate to purchase equipment based solely on procurement cost. There is an increased emphasis on total acquisition costs and life-cycle costing is a method that supports this thinking. Life-cycle costing is an active management tool used during the New Product Introduction phase which attempts to capture all the costs associated with a major capital asset, such as an aircraft, over its life-cycle, including research and development; production; operation, maintenance and support; and phase-out and disposal. It assigns expected costs to each separate phase of the life-cycle to arrive at total life-cycle costs for a new product or system. Life-cycle Costing, therefore, provides an understanding of the cost and revenue implications of equipment both before and after entry into service. It can be used to inform engineering decision-making and cost monitoring over the life of the product. Future cost estimates require judgements concerning costs that may or may not be based on past experience. They can be derived from expert opinion, cost estimating relationships or known cost factors and data. Cost data can be sourced from existing databases, product planning data, supplier documentation and data, engineering test and field data, and financial and accounting data.

In the aerospace environment, where through-life support is being strongly emphasised, life-cycle costing is becoming an increasingly important tool for satisfying customer needs and making realistic investment decisions for the business. It enables the evaluation of alternatives, both inter-system comparisons (comparison between products from different suppliers) and intrasystem comparisons (comparison between different design configurations of the same product). It also highlights the economic impact of design decisions and provides additional information for capital investment decisions. One of the key advantages of using Life-cycle Costing to support the lean enterprise is that it identifies high cost contributors across the product life-cycle and, therefore, highlights opportunities for cost reduction.

However, life-cycle cost analyses present major challenges with regard to data collection and consistency. Hence, they are inherently inaccurate. Information may need to be drawn from different sources and, therefore, contain inconsistencies or be in different formats. There may also be difficulties accessing data sources. In addition, it is extremely difficult to predict the costs and revenues associated with the later stages of the life-cycle. Furthermore, reliance on historic cost data from existing products may not provide a valid basis for predicting the cost behaviour of future products. Cost data may need to be adjusted to reflect improvements due to learning and continuous improvement activities (Cook and Graser, 2001).

Combining Target Costing and Life-cycle Costing

The ideal approach for aerospace would be a combination of the two methods – an extension of Target Costing to all life-cycle phases. This would enable the aerospace industry proactively to protect and enhance profitability throughout the value stream and across the life-cycle.

In practice, however, there are challenges in establishing target costs for all life-cycle phases, particularly in the aerospace sector where life-cycles are extremely long. The forecasting and prediction of costs, the changing nature of customer requirements over time and the impact of technological advances will remain significant issues for the use of such techniques as Life-cycle Costing and Target Costing within the aerospace industry. These problems may be lessened, however, by using Target Costing and Life-cycle Costing initially for just the first generation of a projected generic series of aircraft, with allowance made in the manufacture of the aircraft for flexibility for future development. Target Costing and Life-cycle Costing, with associated Value Engineering, could be undertaken each time that a significant model change is to be made. The aerospace companies involved in the Working Group strongly believe that the move to total care packages, prime contracting and "*power-by-the-hour*"- type contracts increases the need for Target Costing and Life-cycle Costing approaches.

COSTING AND ACCOUNTING FOR LEAN MANUFACTURING

Kaplan (1988) states that management accounting serves three purposes: (1) Inventory valuation for financial reporting, (2) Product costing, and (3) Operational control. For the purposes of this research, a slightly different approach has been taken. Product costing and operational control methods for lean manufacturing have been emphasised. However, as external financial reporting is regulated and represents non-value-added, but necessary, activity in lean terms, this has not been examined in detail. However, when dealing with operational control, the possible changes in internal financial accounting practices, in so far as profit and loss accounts are used to measure performance within the company, are considered. In addition, lean manufacturers emphasise continuous improvement and waste elimination in order to reduce costs. As a result, one of the primary uses of costing and accounting information in companies that adopt lean manufacturing is to support such improvement activities. Therefore, the Manufacturing dimension of the research framework presented in Table 2 below classifies various costing and accounting methods in relation to the three purposes of (1) Product Costing, (2) Operational Control, and (3) Continuous Improvement. This approach was then used to determine the most appropriate costing and accounting tools and techniques, for each of these purposes, within aerospace companies adopting lean manufacturing.

Table 2 – Costing and Accounting for Lean Manufacturing

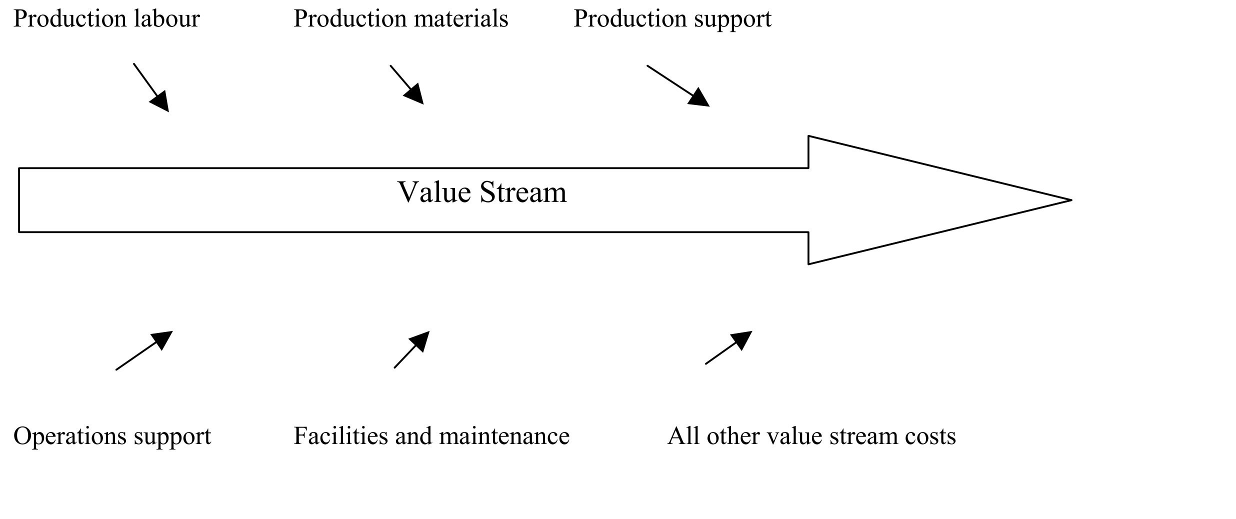
Product Costing	**Operational Control**	**Continuous Improvement**
• Activity-based costing (ABC) • Cellular costing • Time-based costing • Value stream costing	• Non-financial performance measures • Value stream box scores • Throughput accounting • Backflushing	• Benchmarking • Kaizen costing • ABC for cost reduction • Cost of quality • Cost of waste

Note: Refer to Figure 1 for the complete research framework.

Product Costing and Overhead Allocation for Lean Manufacturing

The majority of aerospace companies involved in the Working Group continue to use standard costing systems and allocate overhead on the basis of direct labour despite the implementation of lean manufacturing. However, these companies are keen to introduce more appropriate product costing methods. This research recommends the adoption of Value Stream Costing as the ideal.

Figure 3 – Value Stream Costing



Source: Maskell and Baggaley (www.maskell.com)

Womack and Jones (1996: 262) advocate "*value stream/ product-based costing…so that all participants in a value stream can see clearly whether their collective efforts are adding more costs than value or the reverse*". Maskell and Baggaley (2002) expand the concept of Value Stream Costing. Value Stream Costing allows the tracking of the actual costs of a value stream and aligns cost reporting with lean goals. All costs incurred by the value stream are charged into a cost pool for that value stream, including labour, materials, support services and facilities. As a result, up to 90% of costs can be directly assigned to individual products/or product groups and only a small fraction requires allocation from general overhead. The product cost is then the average cost of the items manufactured by the value stream during any particular time period. Figure 3 illustrates the concept of Value Stream Costing.

At the level of the final assembler or prime contractor, where most parts are bought in for the assembly of a large aircraft, there will not be a severe product costing problem in terms of allocating costs that are indirect to that major project. However, some assemblers themselves also produce thousands of components. It is likely, therefore, that at the component production level such firms will have an overhead allocation problem.

For major systems providers, if the production of some systems is interlinked with others with the use of common production resources or common overhead services, there will be a product costing problem. But, while the factors that should determine the costing basis used are the same as for prime contractors, more firms involved in the production of systems for aircraft will have related processes for different systems and will, therefore, need to give greater thought to product costing and overhead cost allocation. In addition, some firms in this category still depend heavily, in their product costing systems, on direct labour hours as the basis for overhead allocation. Such firms should consider whether a move to a more sophisticated system of cost drivers should be used.

At the component and materials supplier level, full separation of products and product groups may be difficult in some firms. This is especially true for companies that produce a high variety of components; many aerospace companies manufacture thousands of different components, although not necessarily in large volumes. Where production processes are related and there is a high degree of shared resources, e.g. chemical treatments, coatings, paint, there will be an overhead allocation problem. For component manufacturers with a restricted product range, value stream organisation and the avoidance of complex overhead allocation systems should be achievable.

In the situation where the ideal of value stream organisation cannot be fully achieved, other costing methods such as Activity-based Costing, Cellular Costing and Time-based Costing may prove valuable.

Activity-based Costing (ABC) was developed as a direct response to the problems that can arise as a result of the allocation of overhead on the basis of direct labour. Its main objective is to provide improved product cost information, using appropriate cost drivers as the basis for overhead allocation (Cooper and Kaplan, 1988). However, some advocates of lean manufacturing do not accept that ABC provides the solution to the problems caused by standard costing, believing that "*in reality it's just another method of allocating overhead*" (Womack and Jones, 1996: 136). The aerospace companies involved in the Working Group do not envisage introducing a full-blown ABC system. This mirrors existing research that found that companies involved in world-class improvement activities had not implemented ABC in a serious way and do not intend to do so (Jazayeri and Hopper, 1999).However, the companies did accept that *ad hoc* analyses of cost drivers could provide the information required for product pricing and product mix decisions.

Dhavale (1996) has described how ABC can be simplified in a cellular manufacturing environment. The accounts will indicate the cells to which resources are attached, thereby eliminating the need for resource drivers to allocate resources to cells. Each cell is treated as an activity centre and each resource traced to a cell forms a cost pool. This simplifies product costing and enables companies to move towards the goal of Value Stream Costing.

Another valuable costing method, also proposed by Dhavale (1996), is the use of Time-based Costing methods, where "time spent in a cell" is used as the overall cost driver. These methods are easy to use and encourage reduced cycle times. They may be beneficial for aerospace companies where shared services are necessary, e.g. chemical treatments, coatings, paint, which are located outside cells for practical or safety reasons.

Operational Monitoring and Control for Lean Manufacturing

Within a lean factory, it is important that the operational control system encourages low inventories, focuses on on-time delivery to customer and supports the concepts of flow and pull production. It has been shown that traditional control mechanisms often work against these objectives.

Traditionally, financial measures have been viewed as the primary measures of success. However, the use of both financial and non-financial measures is now widely promoted (Kaplan and Norton, 1998; Brown, 1996). Advocates of lean manufacturing promote the use of non-financial, customer-focused measures to measure operational performance. The UK Lean Aerospace Initiative has been instrumental in promoting a lean approach to performance measurement (Ward and Graves, 2001). A key set of measures for use in the aerospace industry, known as Aerospace Metrics, has been developed and includes quality, cost and delivery measures (Jones et al, 2001). These measures can be used as part of a more comprehensive performance measurement and operational control system and also used to promote continuous improvement. It is important that the measurement system captures operational and financial improvements at cellular, value stream level and enterprise level. The use of non-financial measures can be incorporated into Value Stream Box Scores, as advocated by Womack and Jones (2003).The Aerospace Metrics have been widely adopted throughout the UK aerospace sector, both by individual companies and through supply chains. They also form the basis for an annual benchmarking activity conducted by the UK LAI.

Two key lean principles are Flow and Pull, where the flow of value through the value stream is only initiated when pulled by the next step in the process. Internal financial accounting processes can be introduced in order to support pull and flow production. A costing method that aligns closely with the concept of flow production is Throughput Accounting, which was derived from the Theory of Constraints (Goldratt and Cox, 1993). Throughput is defined as Sales less Direct Materials Costs, with all other costs considered fixed. Throughput Accounting encourages inventory reduction and time compression, therefore, making it compatible with lean ideas. However, the aerospace Working Group believed that these objectives could be achieved by other means, i.e. the use of non-financial measures, and, as a result, the implementation of Backflush Accounting was seen as more of a priority than the use of Throughput Accounting.

Backflush Accounting (or cost recovery delayed until the point of sale) is consistent with pull production. The aerospace industry is in an excellent position to exploit pull production, as in both the commercial and military arenas, aircraft are built-to-order. However, traditionally the demand signals have been amplified down through the supply chain resulting in high levels of inventory along individual product value streams. Therefore, the aerospace industry, in a similar manner to the automotive industry, has widely adopted a Just-in-Time (JIT) approach over the past ten years or so, with *kanban* systems often used to trigger inventory movements and ordering of materials and components. The lean objective of reducing production cycle times means that, at a certain point, it no longer serves any useful purpose to maintain detailed transaction records on the movement of Work–in-Progress. As a practical matter, the product would be finished and dispatched before Work-in-Progress reports reflected its movement or status (Jenson et al, 1996). Therefore, the extra effort required to record and process these additional transactions is no longer justified. Maskell (1996) states the simple logic behind backflushing:

- If a product has been produced, certain components must have been used
- If the components have been used, they must have been received from suppliers

- If the components have been received, they must have been ordered from the supplier
- If the components have been ordered, the supplier needs to be paid.

This research recommends that within the aerospace industry, systems providers, component manufacturers and materials suppliers should apply backflushing to all of their normal production output. Granting no credit for inventory until production is in a saleable form, or even sold, can even play a significant part in inventory control and create incentives for inventory reduction. At the aircraft assembly or prime contractor level, backflushing may not be appropriate as project management techniques are usually in place to support pull production.

Costing for Continuous Improvement

A key element of lean manufacturing is the drive for continuous improvement. Although operational control methods, such as the use of non-financial measures, can provide significant incentives for continuous improvement, supplementary techniques may be required to manage cost reduction and support waste elimination activities. There are several costing methods that explicitly focus on waste elimination and cost reduction and can be used to support lean initiatives. A brief description of the proposed approaches is outlined in Table 3 below.

The participants in the Working Group believed that all the tools and techniques proposed would be valuable in aerospace companies. There was no preference for one approach over another, with the use of specific tools and techniques depending on specific circumstances.

Table 3 – Costing Methods for Continuous Improvement

Tool/ Technique	Brief description
Kaizen Costing	Forms part of a target costing approach but applied during the Manufacturing phase. Includes cost reduction activities that focus on manufacturing process change for existing products and involves both cost reduction activities for each product and for each cost (Monden and Hamada, 1991).
Activity-based Costing for Cost Reduction	A valuable tool for prioritising cost reduction activities based on cost drivers (Jenson et al, 1996).
Cost of Quality	An approach to the measurement, management and control of defects in the production process (Kumar and Brittain, 1995).
Cost of Waste	An extension of the Cost of Quality concept to quantify the costs associated with Ohno's Seven Wastes and support Value Stream Mapping activities (Ward et al, 2003).

COST MANAGEMENT IN THE EXTENDED ENTERPRISE

As lean ideas are adopted by individual companies, it becomes increasingly apparent that internal changes alone are not sufficient to maintain competitive advantage. Lean enterprises typically outsource a high proportion of the value-added of their products and, therefore, rely on highly efficient supply chains. The aerospace industry is characterised by a highly complex supplier base that is global in nature and cuts across numerous industries. Up to 70% of materials are bought-out at the prime level (Cook and Graser, 2001; Murman et al, 2002). Therefore, prime contractors are limited in the amount of cost they can influence through internally-focused lean initiatives. In recognition of this, many aerospace companies have begun to develop lean supply chain practices, including:

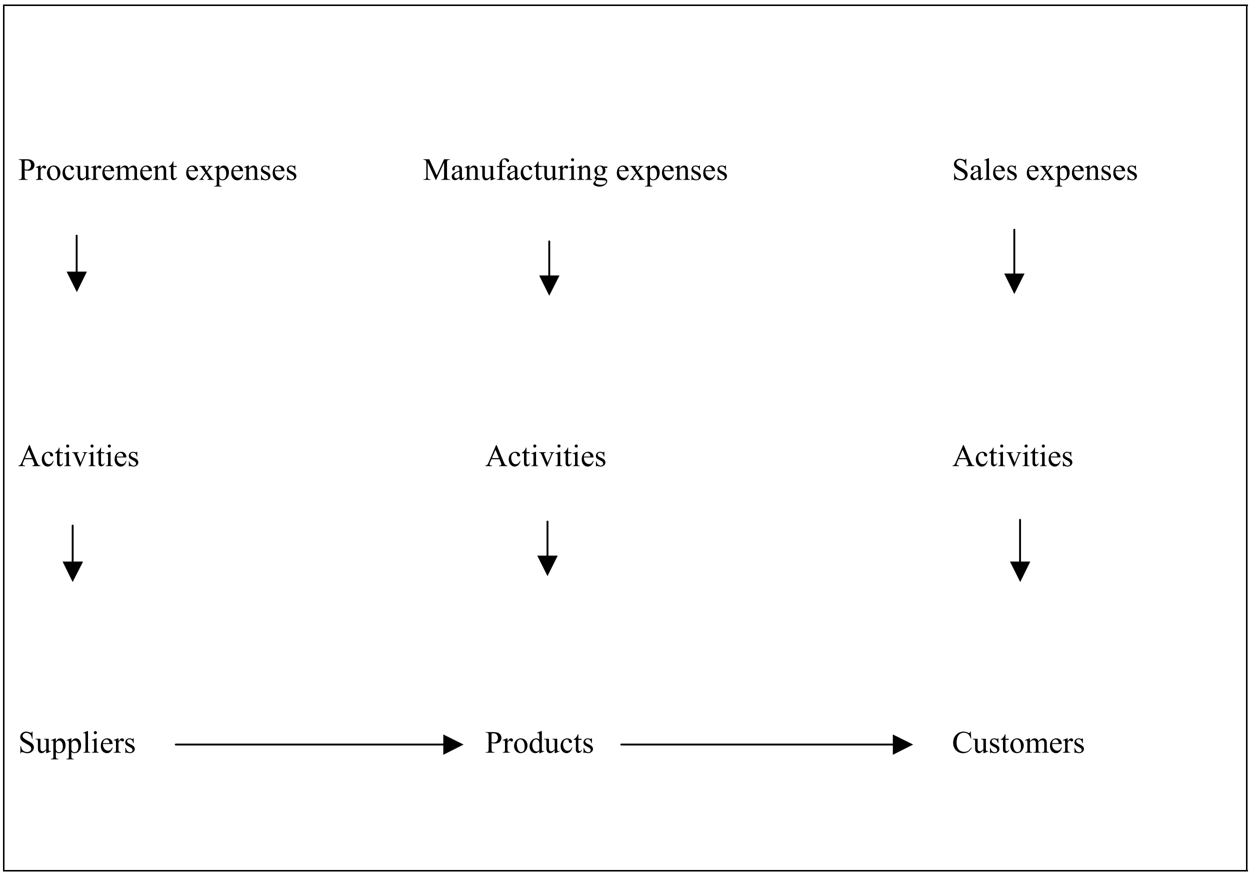
- Supplier certification/ preferred supplier programmes/ key supplier management
- Supplier development programmes
- Early involvement of suppliers in design
- Just-in-time supply
- Total care packages.

These practices are designed to improve quality and delivery performance, increase levels of partnership, co-operation and trust between customers and key suppliers and reduce total costs. Cost management outside the traditional boundaries of a firm, therefore, becomes increasingly important as lean practices are promoted throughout the supply chain (Cooper and Slagmulder, 1999). This involves managing costs across the product life-cycle and creating cost reduction pressure throughout the entire supply chain. There is a need to control costs within the supply chain to achieve reductions in total cost while simultaneously protecting the economic viability of supply chain companies.

Identifying Supply Chain Costs

Seuring (2002) defines Supply Chain Costing as a cost management technique that allows the analysis and control of all costs in a supply chain. Activity-based Costing can be used as a starting point for recognising supply chain costs within a firm and identifying some cost reduction opportunities (Slagmulder, 2002). This involves assigning costs to customers and suppliers as well as to products, as demonstrated below.

Figure 4 - The Activity-based Costs of Suppliers and Customers



Source: Slagmulder, 2002

The assignment of purchasing costs to suppliers motivates purchasing managers to select suppliers on the basis of total cost rather than initial purchase price. This means that the costs of poor quality, reliability and delivery performance are captured and efforts can be made to improve supplier performance. Once identified, supplier costs can be assigned to products. Products containing large numbers of unique components that rely on speciality suppliers will be viewed as more expensive than products that contain standard components. This has the advantage of encouraging designers to investigate options for parts standardisation and pursue a Design for Manufacture approach.

A similar approach can be used to assign sales costs to customers to enable individual customer profitability to be determined. An enhanced knowledge of customer profitability can be used attract and retain high-profitability customers.

The use of supplier and customer-focused Activity-based Costing encourages companies to eliminate waste and reduce transactional costs. However, although it can be used to support the cost reduction activities of specific value streams, it does not explicitly require joint action by buyers and suppliers to reduce costs and internal improvements may push costs down the supply chain rather than removing them completely. Greater improvement opportunities exist where customers and suppliers work together to achieve reduced costs.

Working in Partnership to Achieve Total Cost Reduction

Cooper and Slagmulder's (1999) work on Inter-organisational Cost Management provides a valuable contribution to cost management through the supply chain. They suggest three ways companies can reduce supply chain costs:

1. During the New Product Introduction stage
2. During the Manufacturing stage
3. Improving customer-supplier interfaces to further reduce transactional costs.

1. Supply Chain Cost Management during New Product Introduction

The most widely advocated technique for cost management throughout the supply chain during the New Product Introduction phase is Supply Chain Target Costing (an extension of Target Costing as previously described). This approach is particularly useful where high-value items are outsourced, where complex production processes are required across many companies and where lean supply relationships are being promoted. Supply Chain Target Costing is a mechanism by which competitive pressures can be transmitted through a supply chain. The output of the customer's target costing system becomes the input to the supplier's target costing system, i.e. the component-level cost within the customer organisation establishes the selling price for the next firm in the supply chain. This can be used as a basis for contracting with suppliers and aerospace customers have begun to employ this approach. It is important to emphasise that Target Costing in the supply chain needs to be used as a means of building long-term supplier relationships and involving key suppliers early in the design process, in order that all firms within the supply chain maintain an adequate level of profitability. Within the supply chain, investigations can be undertaken in order to identify specific cost reduction opportunities. The early involvement of key suppliers can highlight opportunities for re-design of the product and/ or components leading to substantial reductions in total product cost. This is particularly important in the aerospace industry, where design changes identified during the manufacturing stage often cannot be incorporated due to prohibitive re-certification and testing requirements. This method of working requires high levels of trust, co-operation and partnering.

2. Supply Chain Cost Management during Manufacturing

In a similar manner to the extension of Target Costing through the supply chain, Kaizen Costing can be extended to the supply chain at the manufacturing stage. It is important to realise that at the manufacturing stage, the functionality of the product cannot be changed and, therefore, the emphasis is on cost reduction of the existing design and manufacturing process improvements.

Again, customers can work with their suppliers to reduce costs by a specified amount over a specific time period or to reduce the costs of a specific product. This can be achieved by including customers and/ or suppliers in kaizen events or by customers assisting suppliers to achieve the required cost reductions. Within the UK aerospace industry, a number of prime contractors are making significant efforts to co-ordinate cost reduction activities within their supply chains.

3. Improving Customer-Supplier Interfaces

The efficiency and effectiveness of all the activities and processes associated with the transfer of goods and/ or services between companies in the supply chain can be improved to yield reduced transactions processing costs, uncertainty and inventory levels. Customers can improve relationships by sharing demand and forecast information, providing adequate order lead times and paying suppliers on receipt of goods. Suppliers can respond by improving quality and delivery, allowing increased access to order status information and taking more responsibility for customer inventory management. Joint initiatives such as improving the order-delivery process and adopting electronic commerce solutions can also bring about significant benefits.

Inter-organisational cost management heavily emphasises firms working together to reduce costs, in addition to cost reduction exercises within both the buyer and supplier firms. However, although this is a good starting point, this concept is still somewhat limited in that the emphasis is on interactions between the buying *firm* and the supplier *firm*. This means that it may only be used in parts of the supply chain, e.g. a prime contractor with its first tier suppliers, and may not lead to a fully integrated approach across the wider value stream.

There is also a danger that the use of the *firm* as the unit of analysis within supply chains will make cost management more difficult and require complex overhead allocation methods. The next section, therefore, will examine the concept of cost management in the *Extended Value Stream* as a possible alternative (i.e. the unit of analysis is the value stream not the firm).

Emphasising Extended Value Streams

It is believed that the value stream is a more useful unit of analysis than supply chain or supply network (Hines et al *in* Seuring, 2002:53). Although the term "*value stream*", as defined by Womack and Jones (1996), incorporates all the activities require to transform raw materials into a finished product delivered to the customer, it is often used to mean the internal value stream(s) within a particular firm. Therefore, the term "*extended value stream*" is used to convey the meaning more clearly. Extended value streams track interactions between firms relating to the delivery of specific products whereas the terms "*supply chain*" and "*supply network*" analyse the interactions between firms but not necessarily in relation to the delivery of specific products. Figure 5 illustrates how the "*value stream*" concept differs to the "*supply chain*" concept.

Figure 5: Extended Value Stream

Company A		
Value Stream (VS) 1	***Value Stream (VS) 2***	***Value Stream (VS) 3***
Key Suppliers to VS1	Key Suppliers to VS2	Key Suppliers to VS3
Tier 1 Suppliers to VS1	Tier 1 Suppliers to VS2	Tier 1 Suppliers to VS3
↑	↑	↑
Raw Materials Suppliers to VS1	Raw Materials Suppliers to VS2	Raw Materials Suppliers to VS3

The concept of extended value streams is very useful as a means of analysing the aerospace industry particularly as:

- the industry is structured around aircraft programmes, which effectively represent core value streams (Murman et al, 2002); and
- firms within the industry can occupy different positions in the supply chain depending on their level of involvement with different programmes.

If "*supply chain*" or "*supply network*" thinking is adopted, and the unit of analysis is taken to be at the level of the firm, then the aerospace supply chain or supplier network would appear hugely complex and any meaningful analysis would prove difficult. If, however, the extended value stream concept is used, analysis becomes simpler and also more meaningful.

Many lean supply initiatives are focused on Tier 1 suppliers, strategically important suppliers or under-performing suppliers but often fail to incorporate lower tier suppliers even though these suppliers may be vital to the success or otherwise of the final product (Johns et al, 2002). Inter-organisational Cost Management ideas could be adopted in these types of initiative and result in benefits to the companies involved. However, the hypothesis proposed here is that an extended value stream approach to cost management will have the most significant impact on total cost. The adoption of Inter-organisational Cost Management ideas *in an integrated manner throughout extended value streams* has the potential to produce significant benefits. It also represents a huge challenge, requiring many companies to work together on joint cost reduction activities and the transmission of cost reduction requirements from one firm to another all along the extended value stream.

Total Cost of Ownership

The aerospace industry has begun to adopt cost management practices that reflect value stream logic. The need for integrated cost management is becoming increasingly important not only for the production of aerospace products but in design for through-life affordability. It is recognised that it is no longer appropriate to procure equipment on the basis of purchase price alone and total care packages are becoming more the norm along with an emphasis on Total Cost of Ownership. For example, aero-engine sales are often based on "*power-by-the-hour*" contracts. This approach also represents a huge challenge, requiring many companies to work together on joint cost reduction activities and the transmission of cost reduction requirements from one firm to another all along the extended value stream. It is probable that small to medium-sized enterprises (SMEs) will no longer have the opportunity to deal directly with the final customers. Their involvement is more likely to be through the prime contractors as part of an extended value stream and, therefore, sustained participation in lean initiatives and supplier development activities organised by the primes is of significant importance to SMEs.

A Total Cost of Ownership approach will require an expansion of the use of innovative contracts and partnering arrangements. Incentives and gainsharing opportunities will also be critical to the success of extended value stream initiatives. The failure of customers to recognise both the financial and non-financial benefits of improvement activities may hinder moves to adopt partnering arrangements and innovative solutions which require close co-operation and high levels of trust. Sophisticated costing methods will be required to support the Total Cost of Ownership approach, including the use of Target Costing and Life-cycle Costing.

CONCLUSIONS

This research is of both academic and practical importance and has widespread implications. The research concludes that traditional costing and accounting methods have the potential to conflict with the implementation of lean manufacturing. Consequently, a new approach to costing and accounting is required to reflect the changes introduced by lean manufacturing. Due to the lack of consensus as to what type of costing and accounting systems are appropriate in a lean environment, the framework presented in this paper provides a valuable mechanism for identifying costing and accounting tools and techniques that may be of benefit to lean enterprises for distinct purposes. Although the tools and techniques that have been evaluated are not new in themselves, the importance of the research undertaken relates to the integration of the management accounting and lean literature in order to recommend an appropriate approach for one industrial sector, namely aerospace.

An important feature of this research is the collaborative approach taken, with researchers and industrial representatives working together to develop new knowledge combined in a specific area. The learning process was accelerated for all stakeholders, rapid knowledge transfer was enabled and practical application of some of the research ideas could be tested in parallel with the research effort. Consequently, the aerospace companies participating in the Working Group are driving change in costing and accounting methods to support lean enterprises.

Further research will be required in order to clarify the costing and management accounting requirements of lean enterprises and empirical studies will be required in order to evaluate the changes being made to costing and management accounting systems as a result of the adoption of lean thinking.

From the practical perspective, there are significant managerial, operational and financial implications for aerospace companies with regard to the integration of appropriate costing and accounting methods with lean initiatives. The UK LAI research findings may be more widely applicable throughout the manufacturing sector. However, the framework proposed for aerospace may require modification for other industries. There are also implications regarding the provision of training and education relating to management accounting and lean manufacturing. It also seems clear that finance personnel will be expected to adopt a pro-active culture, where they act as business consultants within their organisations, understand the core business in-depth and add value by supporting continuous improvement efforts.

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REFERENCES

AECMA (1996), *Towards a European Aerospace Policy – Perspectives and Strategies for the Aerospace Industry. Part 1 – Goals, Actions and Policies*, European Aerospace Industry Association, November 1996.

Ahlstrom, P. and Karlsson, C. (1996), "Change Processes towards Lean Production: the role of the management accounting system", *International Journal of Operations and Production Management*, Vol. 16, No. 11, pp42-56.

Aram, J. and Salipante, P. (2003), "Bridging Scholarship in Management: Epistemological Reflections", *British Journal of Management*, Vol. 14, pp189-205.

Aviation Week and Space Technology (1992), "Industry Must Bear its Share", 24 February 1992, p15.

Aviation Week and Space Technology (1999), "The Lean Imperative", 9 August 1999, ppS1-S19.

Bicheno, J. (1998), *The Lean Toolbox,* Picsie Books, Buckingham.

Brown, M. (1996), *Keeping Score – using the right metrics to drive world-class performance*, Quality Resources, New York.

Cook, C. and Graser, R. (2001), *Military Airframe Acquisition Costs – the Effects of Lean Manufacturing*, RAND Corporation.

Cooper, R. and Kaplan, R. (1988), "Measure Costs Right: Make the Right Decisions", *Harvard Business Review*, 66, pp96-103.

Cooper, R. (1995), *When Lean Enterprises Collide: Competing Through Confrontation*, Harvard Business School Press, Boston.

Cooper, R. and Slagmulder, R. (1997), *Target Costing and Value Engineering*, Productivity Press, Portland, Oregon.

Cooper, R. and Slagmulder, R.(1999), *Supply Chain Development for the Lean Enterprise – Inter-organisational Cost Management*, Productivity Press, Portland, Oregon.

Cosentino, C. (1999), "Widening the Scope of Aerospace Collaboration: Consolidation and Co-operation", in Lawrence P. and Braddon, D. (1999), *Strategic Issues in European Aerospace*, Publication of papers from *Aerospace 2000 Conference*, Bristol, 1997.

DeFilippo, J. (1996), "Management Accounting Learns to Adapt to Pratt & Whitney's Manufacturing Cells", *The Learning Organisation*, Vol. 3, No. 2, pp4-10.

Dhavale, D. (1996), *Management Accounting Issues in Cellular Manufacturing and Focused-Factory Systems*, Institute of Management Accountants, Foundation for Applied Research, New Jersey.

European Commission (1997), *The European Aerospace Industry – Meeting the Global Challenge*, 24 September 1997 [COM (97) 466 fin].

European Commission (1999), *Adopting the Fifth RTD Framework Programme (1998-2002),* Decision No 182/1999/EC, Official Journal of the European Commission.

Fabrycky, W. (1991), *Life-cycle Costs and Economics,* Prentice Hall, NJ.

Flight International (1993), "*The Lean Machine*", 2 June 1993, p12.

Goldratt, E. and Cox, J. (1993), *The Goal: a process of on-going improvement, 2nd edition,* Gower, Aldershot.

Henderson, B. and Larco, J. (1999), *Lean Transformation***.** Oaklea Press, Virginia.

Hines, P., Silvi, R., Bartolini, M. and Raschi, A. (2002), "A Framework for Extending Lean Accounting into a Supply Chain", *in* Seuring, S. and Goldbach, M. (2002), *Cost Management in Supply Chains*, Physica-Verlag, Heidelberg, Germany.

Interavia (1994), "*Lean Manufacturing: US Fighter Firms Set Pace*", January 1994, pp17-19.

Interavia (1995), "*Is Europe Competitive in Manufacturing?*", June 1995, pp32-34.

Interavia (1999), "*The Race is On in Lean Production*", September 1999, pp15-17.

Jazayeri, M. and Hopper, T., (1999), "Management Accounting within World Class Manufacturing: a case study", *Management Accounting Research*, No. 10, pp263-301.

Jenson, R., Brackner, J. and Skousen, C. (1996), *Management Accounting in Support of Manufacturing Excellence*, Institute of Management Accountants, Montvale, New Jersey.

Johns, R., Crute, V. and Graves, A. (2002), *Lean Supply: Cost Reduction of Waste Reduction?,* UK Lean Aerospace Initiative (University of Bath), Society of British Aerospace Companies, October 2002.

Jones, M, Ward, Y. and Graves, A. (2001), "A Common Set of Metrics for Improved Competitiveness in Aerospace", *International Journal of Aerospace Management*, Vol. 1, No. 2, June 2001, pp131-137.

Kaplan, R. (1988), "One Cost System isn't Enough", *Harvard Business Review*, January-February, pp61-66.

Kaplan, R. and Norton, D. (1998), *The Balanced Scorecard – Measures that Drive Performance*, Harvard Business Review on Measuring Corporate Performance, HBS Press, Boston, MA.

Kumar, K. and Brittain, J. (1995), "Cost of Quality: evaluating the health of British manufacturing industry", *The TQM Magazine*, Vol. 7, No. 5, pp50-57.

Liker, J. (1998), *Becoming Lean,* Productivity Press, Oregon.

Maskell, B. (1996), *Making the Numbers Count*, Productivity Press, Oregon.

Maskell, B. (2000), "Lean Accounting for Lean Manufacturers", *Manufacturing Engineering*, Vol. 125, No. 12, December 2000.

Maskell, B. and Baggaley, B. (2002), "Lean Management Accounting", [www.maskell.com/ LeanArticle.htm. Latest access 08/04/04]

Monden, Y. and Hamada, K. (1991), "Target costing and kaizen costing in Japanese automobile companies", *Journal of Management Accounting Research*, Fall 1991, Vol. 3, pp16-35.

Murman, E., Walton, M. and Rebentisch, E. (2000), "Challenges in the Better, Faster, Cheaper Era of Aeronautical Design, Engineering and Manufacturing", *The Aeronautical Journal*, Vol. 104, No. 1040, October 2000, pp481-489.

Murman, E., Allen, T., Bozdogan, K., Cutcher-Gershenfeld, J., McManus, H., Nightingale, D., Rebentisch, E., Shields, T., Stahl, F., Walton, M., Warmkessel, J., Weiss, S. and Widnall, S. (2002), *Lean Enterprise Value*, Palgrave, New York.

Rother, M. and Shook, J. (1998), *Learning to See, Version 1.1*, Lean Enterprise Institute, Massachusetts.

Sakurai, M. and Scarborough, D.P., (1997), *Japanese Cost Management*, Crisp Publications, California.

Seuring, S. (2002), "Supply Chain Target Costing – an Apparel Industry Case Study", *in* Seuring, S. and Goldbach, M. (2002), *Cost Management in Supply Chains*, Physica-Verlag, Heidelberg, Germany.

Slagmulder, R. (2002), "Managing Costs Across the Supply Chain", *in* Seuring, S. and Goldbach, M. (2002), *Cost Management in Supply Chains*, Physica-Verlag, Heidelberg, Germany.

Ward, Y., Crute, V., Tomkins, C. and Graves, A. (2003), *Cost Management and Accounting Methods to Support Lean Aerospace Enterprises*, A UK Lean Aerospace Initiative Report, University of Bath, October 2003.

Ward, Y. and Graves, A. (2001), "Lean Performance Measurement for Aerospace", *International Journal of Aerospace Management*, Vol. 1, No. 1, February 2001, pp85-96.

Womack, J. and Jones, D. (1996), *Lean Thinking*, Simon and Schuster, UK.

Womack, J. and Jones, D. (2003), *Lean Thinking*, *Revised and updated*, Simon and Schuster, UK.

Yoshikawa, T., Innes, J., Mitchell, F. and Tanaka, M., (1993), *Contemporary Cost Management,* Chapman Hall, London.

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