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Using information systems to drive process change: an aerospace industry example from the Knowledge Transfer Partnership scheme

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Abstract. This paper explores the growing role of shop floor systems in overall information systems strategy and how the Knowledge Transfer Partnership scheme was used to implement an integrated suite of shop floor systems in a major aerospace company. It also focuses on the significant process change that accompanied the introduction of new systems and the benefits this has brought to a company that has to meet large scale orders for aero engine components sometimes placed several years in advance. The paper also illustrates how shop floor engineering systems can be integrated with mainstream corporate systems.

Keywords: Shop floor systems, IS strategy, knowledge transfer, systems integration, product lifecycle management, process change

1. Introduction: information systems and process change

Probably the most debated area in which the introduction of new systems is associated with process change is in the context of Enterprise Resource Planning (ERP) systems implementation. These large scale software packages normally encompass the main transaction processing and information reporting requirements of a company, spanning sales order processing, financial management, human resource management, stock movement and inventory control. Benson et al's (1992) 'staple yourself to an order' example in the early 1990s illustrated well the potential for process improvement and introduced many practitioners to the concept of function vs. process. This was developed further in the 1990s by Michael Hammer and others (Hammer and Champy, 1993) who argued that process change was essential to business survival and acknowledged that this could be associated with new IS. Hammer argued that there was no scientific definition of processes, but that in his opinion there were three main business processes that could fit most company operations: 'Obtain a customer order', 'Fulfill the order' and 'New Product development'.

In the engineering field, the introduction of new systems and process thinking paralleled the development of the concept of full product life-cycle management for engineered products, from concept through design and engineering, to manufacturing, delivery and even product performance on client sites, spanning the new product development and order fulfilment processes identified by Hammer. This gave rise to Product Lifecycle Management (PLM) systems, which can be defined as a general plan of the product lifecycle in a particular business or product area. It is a compilation of business rules, methods, processes and guidelines as well as instructions on how to apply the rules in practice (Saaksvuori and Immonen, 2002).

The engineering industry already used a range of specialist (largely standalone) systems including Computer Aided Design (CAD), Computer Aided Manufacture (CAM), and Computer Aided Engineer (CAE) packages, and also often had an interface with companywide ERP, manufacturing requirements planning (MRP) and data warehouse/business intelligence systems. This paper examines how the introduction of a range of new systems in a major aerospace company through the KTP scheme has been a driver for significant process change.

2. Shop floor engineering systems

For many years, systems in this field were limited to programmable logical controllers (PLCs) and associated supervisory control and data acquisition (SCADA) packages and computer aided design (CAD) tools. Product Lifecycle Management (PLM) systems evolved from earlier Product Data Management (PDM) systems (Stark, 2005). PDM systems can be seen as a subset of a PLM system. In the 1980s, engineers had recognized the need to manage the increasing volumes of design data produced by, and contained in, a range of automated and semi automated systems, such as CAD files, specification and requirement documents, and CAM and CAE analytics. PDM allowed the user to store and control all product data, manage document issue levels, maintain Bill of Materials and immediately visualize the relationship between parts and assemblies.

However, being able to manage the data alone was not enough. There was the clear need to manage the entire product lifecycle, of which product development is just a part. According to Ameri and Dutta (2005), a product lifecycle can be divided into 5 stages: imagine, define, realize, use/support and retire. The first three stages are part of product development but engineers needed a more comprehensive system to support both product development and the full product lifecycle. PLM is a compilation of business rules, methods, processes and guidelines as well as instructions on how to apply the rules in practice (Saaksvuori and Immonen, 2002). The PLM concept encompasses several systems. Ameri and Dutta (2005) describe change management, document management, workflow management and project management as PLM systems that support concurrent engineering and streamlined product development processes. PLM seeks to extend the reach of PDM beyond design and manufacturing into other areas like marketing, sales and after sales service, and at the same time addresses all the stakeholders of the product throughout its lifecycle.

PLM extends PDM functionalities to include the creation of product definition information as well as the management and control of such information. Looking at this another way, PDM is focused on the management of data created by information authoring tools, whereas PLM also includes the authoring tools themselves. PLM seeks to fill the gap between enterprise business processes and product development processes.

3. Company profile and project background

ASP UK Ltd has a turnover of circa £17m and employs 250 staff in the south west region of the UK. It is part of the ASP group, which is considered the largest bearing manufacturer worldwide. ASP UK currently holds approximately 7% of the world market in aero engine bearings, the majority of which derives from major aircraft engine manufacturers. To retain existing market share and create opportunities for new business, the company needed to be more efficient in providing engineering data and more cost effective in its operations to be price competitive. A key tenet of this strategy was to effect a major upgrade of their shop floor engineering and associated technology infrastructure to allow them to compete more effectively.

The KTP project was central to the implementation of the systems upgrade strategy. ASP UK was the first ASP group company to implement this strategy, and thus the final product selection and its implementation on the shop were to be an important precedent for other group companies. The lessons learnt from this implementation are transferable as other companies in the group attempt similar shop floor process and infrastructure improvements. In addition, the KTP project made a major contribution to the cost competitiveness of the business by providing more efficient and effective engineering and data management capabilities.

4. Overview of the KTP project

“To plan, develop and implement an integrated engineering information system to support future business competitiveness based on improved customer responsiveness” was the project mission statement for the KTP project. The implementation of a new PLM system as well as new CAD/CAM packages, both linked with ERP and shop floor data systems, was seen as essential to support the company in delivering big contracts to its main customers. The main software products were NX (CAD/CAM) and Teamcenter (PLM). Within the company, the KTP programme was named the "Engineering Systems Integration" (ESI) project (Figure 1).

ID	Task Name	Start	Finish	Duration
1	Document business processes, system/data	03/04/2007	14/12/2007	184d
2	CAD project pilot and deployment	28/01/2008	30/10/2008	199d
3	Compare group and Stonehouse New Product Development process	01/08/2008	30/09/2008	43d
4	Integration of CAD/CAM with CNCs and CMMs	01/10/2008	23/03/2009	124d
5	Implement Teamcenter document management at the engineering department (pilot)	01/10/2008	23/03/2009	124d
6	Improve supply chain managerial reports	06/02/2009	23/03/2009	32d
7	Implement scheduling system for trial	06/02/2009	23/03/2009	32d
8	Verify suitability of Teamcenter and other software packages	14/11/2007	20/02/2009	333d

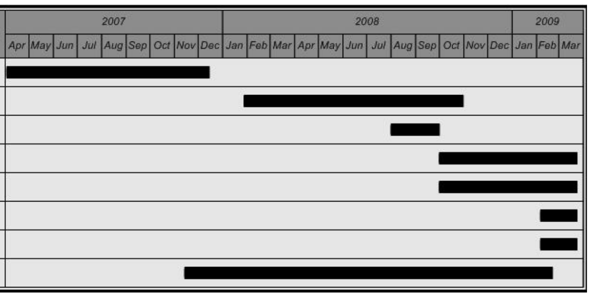

Fig. 1. Project timetable for ASP ESI project

The objectives of the ESI project were to:

- Create a business process map which encompasses the company's main business processes (Figure 2)
- Implement NX (CAD/CAM) and manage the NX project pilot
- Manage the basic Teamcenter (PLM) implementation
- Evaluate and cost justify the need for, and benefits of, other software packages
- Define and implement the integration of NX and Teamcenter with CMMs and CNCs
- Implement managerial reports using business intelligence tools (Cognos Pro-IV)
- Implement a shop floor planning system

Fig. 2. Main Business Processes at ASP UK Ltd

The project was divided into distinct stages (Figure 1) and project managed using selected elements of the PRINCE2 methodology (Wynn, Shen and Brandao, 2008). The initial stage focussed on industry knowledge gathering, and process mapping. The Associate held a series of workshops with management and shop floor staff to get agreement to the process maps and start to identify areas for process improvement. This established the Associate's credibility and role brief with the company's engineers and paved the way for stage 2 which saw the implementation of the Computer Aided Design (CAD) system on the shop floor, moving users to a three-dimensional CAD environment. This reinforced project momentum and broadened support for the KTP programme as a whole. As part of stage 3, the process maps (Figure 2) were revisited, and the project team spent some time examining the overall group processes for product development and production, and the implications of group software strategy (which favoured the NX/Team Centre PLM software combination).

Stage 4 refocused on software implementation and developed links between the CAD/CAM functions and the shop floor machines (CNCs and CMMs) where the major focus is on the product quality and precision after each operation of the product's development. The initial raw material goes through a sequence of operations that involves CNCs and/or manual machines shaping the component and CMMs verifying whether those machines achieved the tolerance required by each stage on the product line. To have a machine program downloaded to the CNC, a Direct Numerical Control (DNC) system can be used which provides program version control and the logging of program interruptions and necessary amendments. The implementation of the 3D CAD/CAM system fully integrated with the CNC and CMM machines was the first ASP aerospace business within the corporate group to achieve this (Brandao and Wynn, 2008).

Stage 5 delivered the implementation of the Teamcenter document management system in the engineering department, delivering significant time saving benefits for information retrieval. Until then, the company was still using print copies as their master copy for auditing and even for product changes. By making the digital copy secured and all the product information also being held in the PLM system, the management and maintenance of product development and change control became faster and more secure.

Stage 6 reflected a change of focus as business priorities and staff personnel changed. The Associate was now tasked with assessing possible information improvement across the broader supply chain, and his main achievement was the development of new management information, using the Cognos business intelligence tool running on the CHESS MRP system (Figure 3).

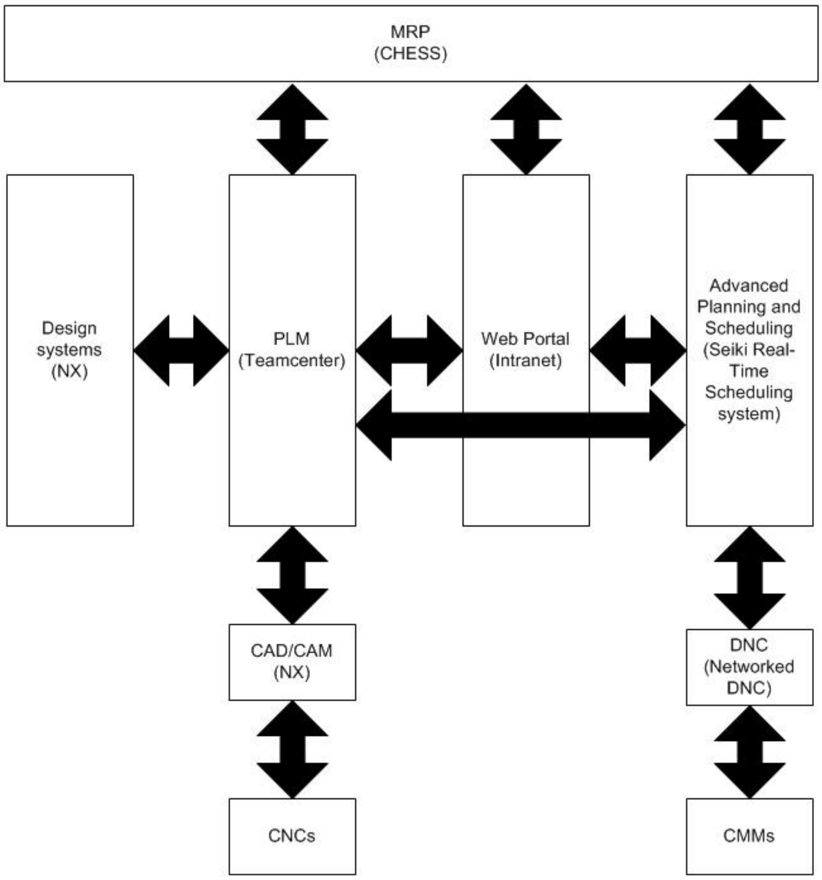

Fig. 3. Selected Software Solutions and Systems Architecture at ASP UK Ltd

Software packages implemented at ASP were CHESS (MRP), Teamcentre (PLM), NX (CAD/CAM) Seik (Advanced Scheduling) and Cognos Pro-IV (Business Intelligence/Reporting)

The concept of customer facing product channels was introduced to drive new efficiencies on the shop floor. This divides the product portfolio into categories, and machines are aligned in sequence on the shop floor creating product category lines. Before the introduction of this concept, the shop floor was laid out with the same type of machines being clustered together in cells. The process change team were charged with implementing this element of the overall project, but key information was needed to make the most of the concept. To establish what could be the 'bottleneck machines' in each channel before the channel was fully implemented was a key challenge, so that appropriate redesign of the channel machine configurations could be made. Various reports were required on a daily basis by the channel implementation team, and these were developed using a recognized business intelligence tool (Cognos Pro-IV).

In addition, the supply chain function was further developed in Stage 7 where the Associate undertook package evaluation for other supply chain processes, notably scheduling, leading to the selection and pilot implementation of a new scheduling software package. Prior to this, lead-time calculations were difficult to estimate due to the number of orders, the quantity of operations for product development and the limitations of the corporate MRP package in visualizing the impact of any changes on the shop floor. In addition, due to a long lead-time for aerospace product development, some customers forecast orders for the next 3 years and, to be able to secure these, the company had to prove it had available capacity over that period. The scheduling system implemented provides the ability to simulate those conditions and report an accurate picture of future capacity. This completed a major overhaul of the company's IS portfolio (Figure 3).

5. The implementation process

At the first meeting of the Project Board, it was recognised that for the project to be successful, there would need to be three parallel running and inter-related streams of work – Process, Technology and People/Training streams. Each of these streams was allocated a senior manager to act as overall owner and coordinator. The implementation of the new technologies started with an overview of the business and the core processes involved directly with business revenues. Some Six Sigma techniques (such as spaghetti diagram and lead time analysis) were applied in order to understand where priority focus was required. Other sites (and even competitors) were visited and analyzed, to ascertain what technologies were used to address each of the company's issue. After a careful analysis, the implementation of 3D CAD/CAM and a Product Life-cycle Management system were embarked upon.

The second priority was to improve key operational (and strategic) decision-making by providing accurate information to senior managers and the managing director. It became clear that a new approach was needed to provide quality management information from an evolving technical and systems environment and a Business Intelligence (end-user reporting) tool was installed (with appropriate training) to extract information from a number of key systems. While the development of the reports required complex tasks to be done, the usage of them is relatively easy and required minimal training or process adjustment.

Third, the issue of managing shop floor load and future production capacity needed to be addressed and the Seiki real time scheduling software package was chosen after a review of available package options. The implementation required integration with other systems but the major problem would come later with driving through the associated business change. By implementing these new technologies, it was clear that processes needed to change and improve to deliver the benefits of the new systems. It was accepted that process improvement initiatives often require change in staff attitudes, knowledge, practices and procedures, which in turn requires training and embedding of new concepts and awareness.

The change from 2D to 3D design and engineering brought major process change in this area. Initially, the development of a new product was taking longer due to the nature of the 3D system, but the increased accuracy of the design and machine programs generated by the new system made

this cost effective overall. In addition, the change design process was much quicker due to the new product development process which integrated each operation with the product design.
Significant training was necessary on a number of implementation fronts: design/development, programming, post-processing and new product development, and change management. From the outset, significant effort was dedicated to helping engineers to come to terms with, and embrace, the new processes and systems, which in the end produced the institutionalization and embedding of new ways of working.

In this aerospace business, there were some difficulties in implementing some of the new technologies, for example the CAD/CAM. Theses systems work very accurately in automotive businesses and are well matched to their business requirements. However, some difficult design shapes are needed in aerospace and knowledge from the company used on the 2D system was effectively converted to the 3D CAD/CAM. Another example was the PLM system and its data classification solution. The level of detail handled by the classification was limited in comparison with the levels of detail needed by an aerospace business. Therefore, the PLM developers had to encompass that requirement and introduced limited systems customisations to attend to this business need.

6. Concluding remarks: operational benefits for ASP

New knowledge has been generated and acquired in the process mapping, software package evaluation and implementation that can be carried forward and used in subsequent phases of the project. Indeed, the creation and validation of current process maps generated an understanding of the relationship between departments. This was used in a customer audit to demonstrate new development flows. The re-organisation of the design manuals in the design portal improved document management and provided a tool for document retrieval. The integration of the CAD/CAM system with the CNCs and CMMs machines was the first site of the aerospace group division to achieve this integration and provided technical knowledge of machine program implementation that can be used elsewhere in the group.

The company had very little in-house IS resource, but now has the capability to move forward with the implementation and further embedding of the new CAD and Teamcentre systems; and the comparative analysis of local business processes with group level business processes has allowed a move towards alignment of processes and software deployment across the group. The PLM solution implemented had document management, 3D visualization, process management and classification functions. Document management was used across the business while the 3D visualization was mainly used on the design/engineer department as well as on the shop floor. The time constraints did not allow the project to include all the processes to the process management system but with the channel implementation the project was able to classify the parts that go to each channel.

The implementation of this new systems portfolio was accompanied by a reorganization of the shop floor to halve product lead times for bearings from 90 days to 45 days, with a forward target of 30 days. This involved a radical change in shop floor structure from an organization that reflected management functions to one based around product-customer channels, in which 80% of operations required for product development and delivery are contained within each channel. Seven main channels were identified that crossed and utilized elements of the old functions (e.g. heat treatment, grinding, final view-assembly-packaging – Figure 4). This resulted in faster product flow and less work in progress, and eliminated product data on systems not linked to specific orders. This represents a core process improvement, which, allied to the new technologies and upgrade in people skills, will deliver major benefits and cost savings.

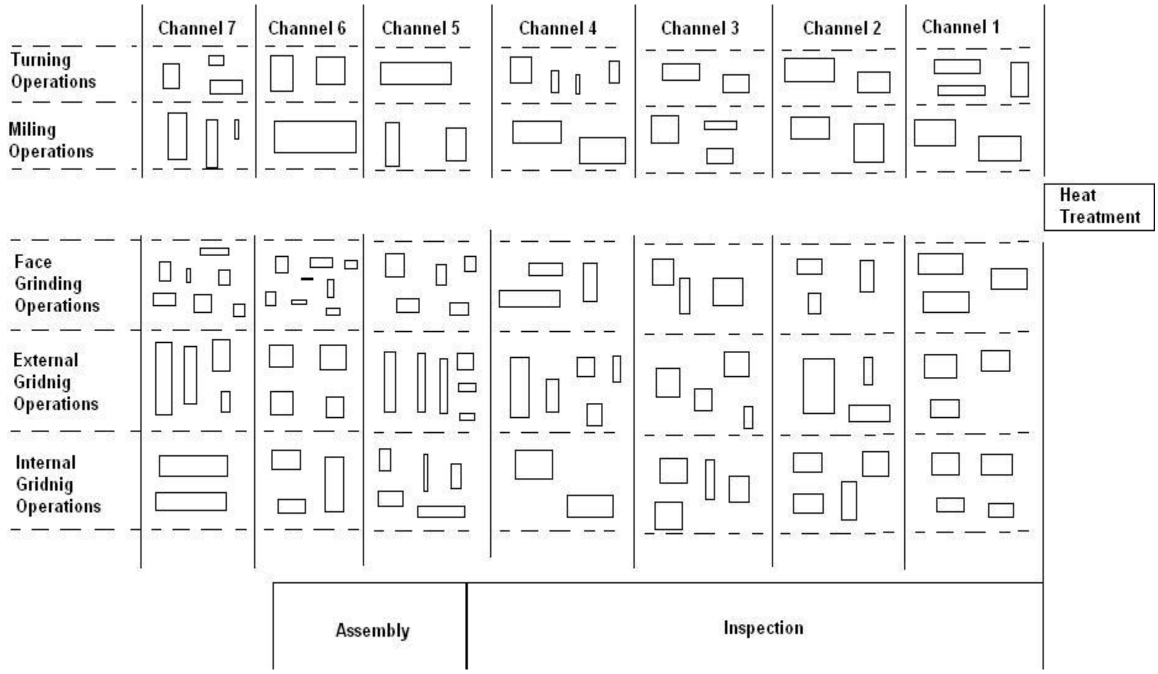

Fig. 4. Shop floor process alignment around channels at ASP UK

Savings achieved by implementing the CAD/CAM and PLM are predicted to payback the investment cost within three years and will exceed a £1m net benefit within 10 years. The Cognos (Business Intelligence) implementation was done on the basis of the ‘difficult to quantify’ benefits of more accurate management information and associated decision making. The implementation of the new scheduling and capacity planning system will allow ASP to take new contracts worth £1.5M per year in 2010, 2011 and 2012. The working relationship and availability of information on the company’s engineering database between departments has been substantially improved as a result of the KTP project. The company’s CAD system has been upgraded meeting customer demands and future expectations.

The achievement of the KTP scheme nationwide was recognized by Lord Sainsbury in 2007, when he recommended a doubling of KTPs nationwide and concluded that ‘by almost all measures, we have seen a dramatic increase in recent years in the amount of knowledge transfer from British Universities’ (Sainsbury, 2007). This article has attempted to illustrate one small part of this success story, in the development and implementation of a new IS strategy and process change in an aerospace company.

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