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Sharing-ETO-Knowledge: Managing the NPD process in Engineer-to-Order Manufacturing Organisations

SHARING ETO KNOWLEDGE: MANAGING THE NPD PROCESS IN ENGINER-TO-ORDER MANUFACTURING ORGANISATIONS

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Abstract
Sharing Knowledge is considered an important part of managing new product development (NPD) research on the process of NPD and Knowledge Management methods have influenced industry in various ways (Hicks, 2002). For example the management of the NPD process, the use of tools, techniques and the organisation of teams, and the integration of the marketing and manufacturing have resulted in considerable progress within NPD process. Prior studies on the NPD problems have delivered various models of the NPD process and a variety of supporting methods, tools and techniques in a generic context. A more realistic scenario however, is to consider the needs of firms that develop products on Engineer-to-Order (ETO) basis. One of the main problems associated with ETO is how ETO manufacturers learn from what are essentially “one-off” projects. This paper presents a framework that supports knowledge sharing across the ETO projects. The framework focuses on assessing the critical phases of the new product development (NPD) process, as well as providing a knowledge base for embedding, managing and disseminating the aspects of the learning curve in order to support future projects. The paper highlights the importance of sharing knowledge and the on-going uncertainties of NPD-ETO and is supported by a complex industrial case study within multinational ETO manufacturing enterprise.

Keywords: Knowledge Sharing, Engineer-to-Order, New Product Development, Project Management.

Introduction
The ability of ETO firms to produce to cost, schedule and with full functionality depends on their ability to efficiently allocate resources and to coordinate their specialised knowledge and technologies to solve design problems and prevent costly redesign feedback loops. Since the extent of any redesign work impacts negatively on the productivity of the project, the economic emphasis is on ‘uncertainty management’. Muntslag (1994) identified three uncertainty factors namely (a) Product mix and volume uncertainty, (b) Product specification uncertainty and (c) Process specification uncertainty. ETO companies mainly produce customise products, for the purpose of this paper includes (transport, power generation, process equipment and materials handling) and can be identified as of the following:

1. High value, low volume (often one-offs);
2. High levels of uncertainty (product, process product mix & volume);
3. At least customised, and often unique to the customers need;
4. Both produced by and sold to, large industrial users (hence the better name industry to industry)

Therefore, the process of ETO warrants a separate product development approach compared to Make-to-Stock (MTS) companies (Rahem 2003). The supply in the ETO capital goods sector is characterised by the high levels of uncertainty in terms of specification, demand, process durations and lead times (P.A Konijnendijk 1994). High complexity arises from: deep and complex product structures; the combination of different types of production systems; and uncertainties due to incomplete or missing information and engineering revisions caused by overlapping of manufacturing and design activities. The nature of the NPD-ETO process changes through the life cycle of an ETO manufacturing project. The main products have a deep and complex product structures, which gives rise to many levels of processes. Certain items are highly customised, whilst others are standardised and need to be coordinated and controlled. Each customer order is at least partly unique, this means that ETO companies are in a very specific product development process. As stated at the start of a project the specification may be vague. The structure and information content of the specification. From the understanding of business processes in which the relationships with other processes can be improved, therefore a key question therefore is; by what means are these ‘uncertainties’ managed and by what processes can new knowledge be captured, managed, embedded and disseminated to support future projects? In parallel to this research, efforts have been made to develop a framework for ETO product development. Rahem (2003) highlighted New Product Development (NPD) frameworks centred round MTS manufactures, furthermore the work focused developing a NPD-ETO framework. This paper is concerned with the application of a framework to support knowledge sharing of within engineer-to-order (ETO) product development projects.

The organisation of this paper is as follows: this Section 2 reviews the literature available on NPD-ETO considering three major determinates a) NPD, b) ETO, c) Knowledge Management. The details of the research methodology incorporating the research objectives, questions and data collection methods and the profiles of the companies participating in the study are presented in Section 3 Section 4 presents the outline of the case study, Section 5 presents the SETOK framework. Details of the empirical results and analysis are presented in section 6. Finally, a summary of the finding and conclusions are given in section 7.

The characteristics of NPD-ETO

A distinctive feature of the development of products in engineering companies is the need to manage various types of development project. These include contract projects where the product is developed to a customer's particular requirements, and product development projects to develop a new or improved product either for sale as a standard item or customising to customers' individual requirements. Despite the importance of this sectors contribution to the UK economy, it has been neglected to some extent by academic research. These manufacturing enterprises of MTO and ETO suppliers of capital goods are an important sector of the world economy. In 1995, overall production in the mechanical and capital goods industries in the EU was ECU425bn (Maffin and Thwaites, 1998). The characteristics in such low-volume MTO/ETO manufacturing enterprises (i.e. organisation, products, markets, and so forth), their competitive environments and their range of strategic and operational choices, are both complex and diverse.

Success Factors for NPD-ETO

The success of NPD-ETO depends on a wide variety of NPD activities, uncertainties or vulnerabilities that have affected the performance on the NPD-ETO activities or processes. Therefore a framework is desirable to organise, identify the 'vulnerabilities' or 'Hotspots' within the NPD-ETO process. Hicks (2002) recognised that Knowledge Management has a promising set of methods and tools that could help knowledge workers in performing their job better and that will probably be used in many different occupations in the future. It seems that the last years' focus on knowledge management has made a business climate for learning, and even learning "on the job". The field of knowledge management is also a truly interdisciplinary arena, where many communities including artificial intelligence, organisational development, software engineering, pedagogy and psychology meet. Hicks (2000) identified. First, the effective sharing of knowledge and information requires the use of common systems that support tendering, design, procurement, and project management. This requires records of previous designs, standard components and subsystems together with costing, planning, vendor performance and sourcing information. This knowledge is a key source of competitive advantage for ETO companies.

It is also clear that ETO manufacturing organisations do not utilise the knowledge that has been created in previous projects (Hicks 2002) Therefore there is an urgent need to test the applicability of new tools and techniques for developing the concepts of knowledge sharing with such ETO manufacturing environments.

Research Methodology

There is a limit amount of research data that exists about the NPD-ETO from both a practical and theoretical sense. Therefore this paper is concerned with the links between the role of knowledge sharing and engineer-to-order manufacturing organisations. Four interview case studies and two longitudinal case studies provided an empirical method of inquiry which enabled the researcher to investigate sharing knowledge within a real life context using multiple resources of evidence. This paper presents the findings one particular ETO manufacturer of which was a large multinational organisation.

Within the case study company 10 projects were 'live' or on-going which allowed the researcher to focus on different aspects on the NPD-ETO process e.g. quotation, order entry, engineering, manufacturing, testing, despatch & other (project management). Between 50 and 60 interviews were conducted for data gathering and process mapping purposes. In addition project related documentation was made available to the researcher. The investigation was designed to identify the loop holes within the NPD process. Particular attention was given to the critical decision making points and mechanisms of transferring the business processes.

Case Study

The company is UK based and it is the principle plant for the groups' core pump systems product range. The company is a market leader, has an excellent reputation, and can be considered to be successful when compared to its sister companies and competitors. One of the companies strengths is its readiness to review its' operations and receive external inputs, hence its' involvement with this research. The pump systems have evolved over the last 20 years, although excellent from an engineering perspective they are not yet fully optimised for competitiveness. These factors have increased the need to review NPD-ETO to maximise competitiveness, and improve the organisation's sustainability within the marketplace.

The NPD-ETO Process

The model starts by a customer requesting a response from a contractor to a project specification (varying in detail from a detailed design through to a functional or cardinal point specification). In accordance with the customer requirements, the sales & tendering department produces a quotation defining the time, costs and specification for the product or service delivered. (REF) Should implementation problems occur the engineering function is asked to change the product specification, in many cases, this triggers repetitive processes which significantly effects the logistics, planning, and which has direct impact on the firm's ability to satisfy the commercial requirements laid down by the customer. This happens because the necessary inter-functional coordination between the individual functions is lacking and therefore the product development process is carried out sequentially, thus causing both project lead-times and costs to increase.

Knowledge Sharing Assessment Model

The success of NPD-ETO depends on a wide robustness of the methods, control, influences factors, uncertainties, fuzziness that have different effects on the NPD-ETO activities. Therefore a framework is desirable to organise, identify and measure the effect of the uncertainties and resources in the process. This requirement highlights the need for a tool that is, universally applicable to all activities identified under the NPD process, which can model the whole process and yet provide the opportunity to focus on specific detailed activity and its' elements when required. It has been well documented that the IDEF modeling is one such approach was used to represent the NPD process and represents both the activities of the NPD-ETO process and the required support tools. Figure 1 and 2 show the IDEF0 model and assessment matrix.

As shown in Figure 1 above, in a single IDEF activity box, the transformation of input to output is carried out by the attribute(s), which are also referred to as resources, following certain instructions or operating within certain conditions and monitors referred to as "Controls". The Assessment Matrix (Figure 2) is presented in Figure 2. The calculation is based on the Failure Mode and Effects Analysis (FMEA) (Teng and Shin-Yann, 1996) which is a methodology for analysing potential reliability problems early in the product development cycle. The quality of each output is derived from the following criteria:

1. Explicit Knowledge – Relates to the completeness of the data and information received in order to fulfill the output requirements for the individual activity. These are typically based on data and supporting information available within and outside the company.
2. Tool Quality– Related to the quality and effectiveness of the tool/resources in order to cope with the turbulent activities defined with each individual activity.
3. Tacit Knowledge– Represents the skill of the human resource in supporting each individual activity. These are typically based on knowledge, experience, 'know-how', available within the process or function.
4. Output Quality Score – Is the result of the resource assessment (Explicit Knowledge, Tool Effectiveness and Tacit Knowledge of Individual or Team) with the combined resource characteristics (inputs, methods and controls) in each individual process activity).
5. Section F: Reliability Score – Is the result of the resource assessment of the combined Knowledge, Tool Effectiveness and Tacit Knowledge across the resource characteristics (inputs, methods and controls) in each individual activity).

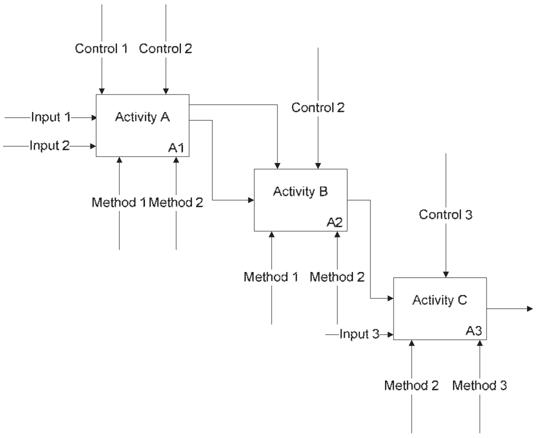

Figure 1 IDEF "Point of Commitment" Assessment

		Assessment Criteria			
	A2	Explicit Knowledge	Tool Quality	Tacit Knowledge of Individual /Team	Reliability Score
Attributes	Method 1	6	7	10	420
	Method 2				
	Control 2	7	7	4	496
	Reliability	Total	Total	Total	Total

Figure 2 IDEF Assessment Matrix

The SETOK Framework

Three generic levels of analysis were developed. These were based on or contingent upon the analysis focus and the modelling approach used. Each level was then partitioned further to deal with the different perspectives or viewpoints. Note that as opposed to the traditional levels of the organisational analysis the new model adopts the "process hierarchy" into the framework as well. The analysis levels developed were:

- Level 3 – Company Strategic Level- Company Strategy for process improvement (company wide assessment)
- Level 2 – Functional and NPD-ETO Projects level– Middle management level, focusing on Department or Functional performance of the main phases, as well as learning across
- Level 1 –Detailed Process Level – Focusing on the operational activities at an operational level, and inter functional levels process activity level

This qualitative performance evaluation was complemented by qualitative data gathered during the interview process and recorded separately. The sections were summarised in figure 3 below to show knowledge sharing mechanisms within the process, as well as activities highest levels of reliability.

Case Study Findings

Should implementation problems occur the project management function is asked to change the product specification, in many cases, this triggers repetitive processes which significantly effects the logistics, planning, and which has direct impact on the firm's ability to satisfy the commercial requirements laid down by the customer. This happens because the necessary inter-functional coordination between the individual functions is lacking and therefore the NPD-MTO process is carried out sequentially, thus causing both project lead-times and costs to increase.

Analysis at Level 1 identified the broader issues in the organisation relation to NPD-ETO, which could be traced to managerial level such as key performance indicators, elements showed up as issues at Level 2 analysis. However is was found that Level 3 analysis was not always an accurate state of affairs, because Level 1 and Level 2 analysis revealed the most beneficial and interesting, and presented them in a way would enable managers to solve the real problem. The senior management team has since resolved the issues above. As an example the issue of high level project management hotspots are highlighted in figure 2 below. Furthermore, the researcher investigated a variety of tools for Knowledge Sharing and knowledge sharing at those 'Hotspots' under the following headings:

- Manuals & Procedures
- Post Project Reviews
- Storytelling
- Information System Tools

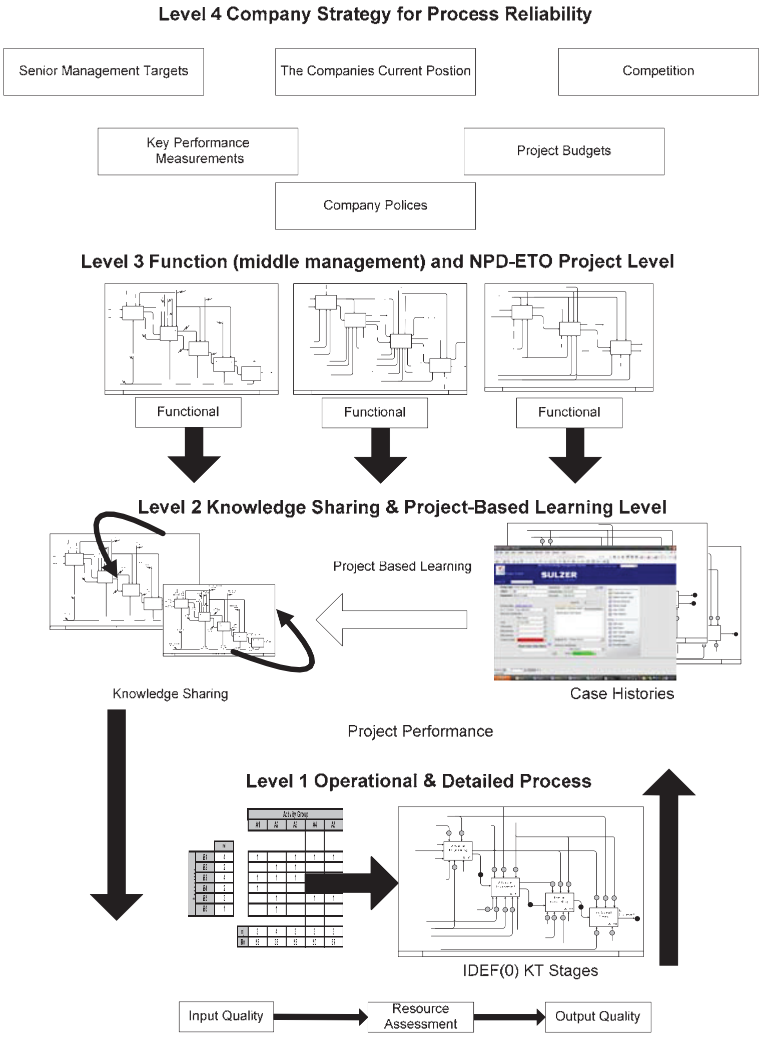

Figure 3; SETOK Framework

The interface between management and the project team is also very important based on these case histories. Management's responsibilities for new product development must be executed in a disciplined, consistent, and focused manner. These responsibilities include the alignment of projects with enterprise strategy, the selection of project team membership to get pertinent functional representation, and disciplined decisions (or Gate reviews). Problems in these areas tended to be more serious, and can be mitigated by a good NPD process design. Previously agreed gate milestones, another form of checklist, are of considerable benefit to improving the discipline and consistency of gate reviews (Reid and Cockerham, 2004). To avoid some of these problems, the integration of project management tools (work breakdown structure, overall master plan) and typical manufacturing management tools (master production schedule, material requirements planning and enterprise resource planning) have resulted in companies making new products better and faster (However, there is usually very little information available to managers to guide them through the decision making process, and assist them with uncertainties in the NPD-ETO. This is largely because of the difficulties associated with knowing what has been sold at the 'front-end' of the process.

Refinement of the Framework

There was an aspect to do with project-based learning. Here we analyse project's performance against previous case histories which is drawn up through the level one analysis which assesses the level of reliability whether due to poor 'information sharing' or low 'project-based learning'. The data gathered through a quantitative analysis of:

I. The contributions made by previous projects to a NPD-ETO phase (i.e. the outputs of the phase);
II. The level 1 process outcomes of each operational activity and process for the contributions.

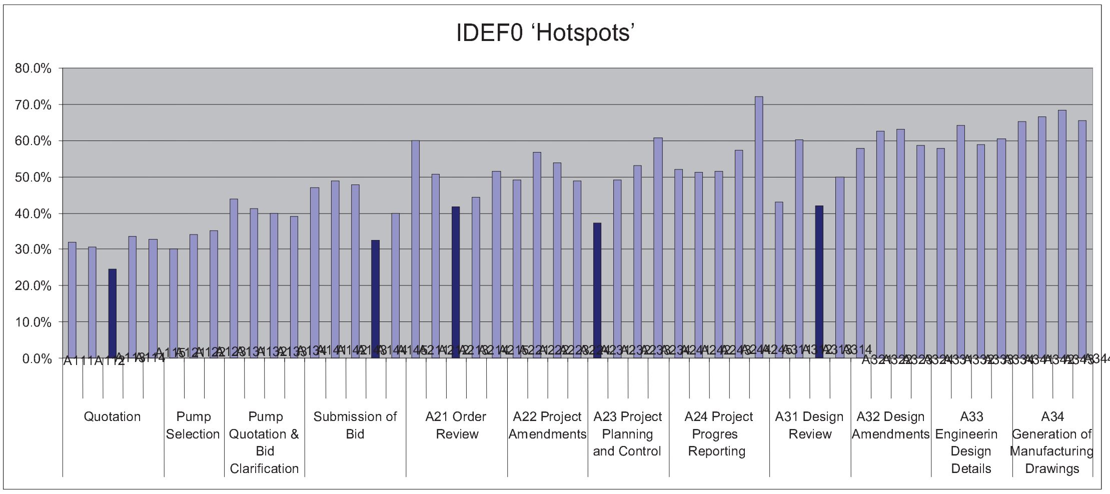

Figure 4; NPD-ETO Activity 'Hot Spots' (Sales-Tendering-Projects-Engineering Design)

Conclusions and Further Work

Due to the 'uncertainty factors' within the NPD-ETO process the proposed SETOK framework will assist both MTO and ETO organisations with repetition and project-based learning of customer orders through the monitoring, review and examination of past projects via the SETOK assessment. This paper has discussed the need and presented the requirements for a knowledge sharing framework. Our sample case study has highlighted the need for project-based learning and the general problem areas (each of which contains a number of 'Hotspots') as highlighted in figure 4.

Future work will attempt to develop a knowledge-base system that will support project managers that will include the features as mentioned above. The framework could be modified to suit weighting factors which include key performance indicators (KPIs) associated to the NPD including the assessment of the existing methods and controls e.g. project budget and quality of resources e.g. suitable NPD tools and techniques.

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EXPANDING INFORMATION VISIBILITY IN THE SUPPLY CHAIN: THE IMPLICATIONS OF AN UPSTREAM AND DOWNSTREAM APPROACH INVOLVING FINISHED VEHICLE LOGISTICS

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Abstract
In the academic literature there are numerous cases highlighting information sharing to achieve visibility in the supply chain. Researchers and practitioners have recognised that information visibility in the supply chain improves operating performance and decision making. Common methods used to measure the benefits of information visibility such as modelling and simulation have demonstrated the mitigation of demand amplification, reduction of excess inventory levels, as well as an improvement in the levels of synchronisation of deliveries taking place between tiers, all of these by employing an upstream supply chain approach. Information visibility in automotive supply chains that also comprise finished vehicle logistics rely on the use of modern Information and Communication Technology (ICT) solutions, but the use of mobile ICT solutions promises to provide enhanced levels of visibility in the supply chain, not to mention the opportunity to achieve better fleet management and operations efficiency. Dedicated Short Range Communication (DSRC) is a wireless network technology that can facilitate upstream and downstream supply chain visibility thus enabling better planning, forecasting, and overall supply chain performance whilst solving reliability and connectivity problems associated to the use of heterogeneous technologies, not to mention difficulties associated to limited range, scalability and security.

Keywords: information visibility, wireless vehicular networks, road haulage, finished vehicle logsitics

Introduction
In the academic literature there are numerous cases highlighting information sharing to achieve visibility in the supply chain. Researchers and practitioners have recognised that information visibility in the supply chain improves operating performance and decision making. Common methods used to measure the benefits of information visibility such as modelling and simulation have demonstrated the mitigation of demand amplification (bullwhip effect), reduction of excess inventory levels, as well as an improvement in the levels of synchronisation of deliveries taking place between tiers.

ICT has provided the links where information flow is used to control the flow of materials. According to Barrat and Oke (2007) industries such as in the retail sector have recognised the critical role of supply chain management and the need to effectively manage the flow of materials, money and information across the supply chain. Kulp et al. (2004) have highlighted the numerous studies focusing on achieving visibility to improve decision making and operational performance. Sahin and Robinson (2005) acknowledge that the creation of external linkages based on the sharing of information to gain increased visibility of customers and suppliers is a growing trend experienced by many organisations. Information visibility in the supply chain is a concept that has drawn lots of attention and has been top of the list in the agenda of researchers and practitioners (Mason-Jones et al., 2002). Academics have highlighted that it is in the hands of the recipient to determine whether the information initially shared is accurate, useful, timely, trusted and in a format ready for use (Whipple et al., 2002).

It is generally agreed that in recent years ICT has had a major impact on logistics and supply chain management, making possible to experience high levels of visibility, control and connectivity. Organisations have invested heavily in sophisticated Internet-enabled applications such as Enterprise Resource Planning (ERP) and modules such as Advanced Planning Scheduling/Optimisation (APS/APO). According to APICS (2006) these types of applications have resulted in benefits that cover: flexible systems that are responsive to changing needs; customer-oriented business models; greater focus on trading partner collaboration; reduction of barriers that add cost or cycle time; responsive manufacturing methods such as Build-to-Order; Internet-enabled communications for data