Decision Support System Based on Effective Knowledge Management Framework To Process Customer Order Enquiry

Dr. Chike. F. Oduoza,
Reader in Process Engineering and Management,
School of Engineering and Built Environment,
University of Wolverhampton
WV1 1LY
United Kingdom

1. Introduction

The customer enquiry stage in a business management environment is very challenging as it strongly influences future workload of production management activity. At this stage, customers generally make enquiries requesting product delivery in terms of quantity, delivery date and sales price. Firms usually need to respond to these enquiries before customers can confirm the corresponding quotes and finally the enquiries may be translated into customer orders. A firm's potential profitability depends crucially on selecting a proper subset of enquiries to fulfill, delay or turn away. Such a decision is the responsibility of the sales and marketing department. However, it is the customer who makes the final decision as to whether to order or not and how many to order, based largely on the satisfaction derived from the enquiry. At present, there are very few, efficient, and effective, simple and easy to implement methodologies, to help businesses manage existing in house knowledge in order to respond to ordering enquiries at the customer enquiry stage.
Literature review (Harris, 2009) shows that:

- Existing management systems do not support all key activities within the enterprise product development process.
- Only a few systems provide the necessary decision support throughout product development and in most cases are more geared to specific tasks with stand alone functionality.
- Few decision support management systems provide the means for the exploitation of manufacturing constraints and product knowledge
- Available knowledge management systems do not provide the means to identify, capture, formalise, present and utilise tacit knowledge
- The lack of exploitation of information and knowledge has a major impact on overall product development process
- Knowledge and experiences gained from existing projects are sometimes poorly documented and therefore are not available for reuse in other related projects

Source: Decision Support Systems, Book edited by: Chiang S. Jao,
ISBN 978-953-7619-64-0, pp. 406, January 2010, INTECH, Croatia, downloaded from SCIYO.COM

- Transfer of knowledge from previous projects will no doubt affect the quality, efficiency, cost and time to market of developing new products and processes.

The aim of this chapter is to propose the application of a comprehensive decision support system for knowledge and information management during customer order enquiry with a view to minimise cost, achieve quality assurance and enhance time to market especially in new product development. This report will be illustrated by case studies demonstrating how effective and robust knowledge management would support decision making especially at the order enquiry stage during product development. It will also present a DSS that highlights the influence of negotiation on customer due dates in order to achieve forward or backward planning with a resultant profit maximization outcome if the strategy is carefully implemented. A mathematical model will be developed that links profit maximization with screening customer / order enquiries and thereby decide whether or not to proceed with an inquiry by balancing capacity against demands placed on it. In the long term it is expected that the decision support system will be capable of assessing future customer orders / enquiries based on previous experience.

2. The significance of knowledge management in decision making (processing order enquiries)

Experimental data is classed as raw or discerned elements and when these elements are patterned in a certain way, data becomes transformed into information. When rules or heuristics are applied to information, knowledge is then created as actionable information for producing some value added benefit. The knowledge that is created and shared amongst organisational members can be categorised into two typical forms of knowledge - Tacit and Explicit (Polanyi 1996).

Tacit knowledge is highly personal, context-specific, and therefore hard to formalise and communicate, this type of knowledge is stored in the human brain, such as in personal belief, expertise, perspective and values formed as a result of experience. On the other hand, **explicit knowledge** is defined as public knowledge and covers those aspects of knowledge that can be articulated in formal language and can be easily transmitted among individuals using information technology. There are two basic strategies for managing knowledge (Hansen 1999; Swan *et al*., 1999) as follows;

- ***Codification strategy*** is based on codifying the knowledge and storing it in artefacts and databases where it can be accessed.
- ***Personalisation strategy*** is where the knowledge is tied up to the persons who develop the knowledge and therefore the sharing of that knowledge is achieved only by personal interactions.

Vast amounts of work have been carried out on how knowledge is utilized in each organizational activity; especially in marketing, costing, design, manufacture etc, however there is limited research available on how knowledge from all the activities within product development can be pulled together and utilized to provide decision support throughout the product life cycle. Knowledge in product development environment is considered to consist of four different activities.(Harris, 2009)

1. Identification; the identification of knowledge required to develop new products, including product specifications, process, tooling, and material capabilities
2. Capture; how the knowledge is captured stored and retrieved.

3. Formalize and Present; how knowledge can be formalized and presented to ensure its use in existing and future projects.
4. Utilization; how the knowledge identified, captured and formalized can be integrated into products and decisions, and applied in other projects.

Western and Japanese cultures both view knowledge differently; while the Japanese view knowledge as being primarily tacit (not easily seen or expressible), the West focuses on explicit knowledge expressed in words and numbers and therefore more easily communicated than tacit knowledge. Perceptions of knowledge seem to be rooted in culture. Nonaka, and Takeuchi (1995), adopt a traditional definition of knowledge as" justified personal belief" and closely tied to an individual's or group's values and beliefs. On the other hand, Miller and Morris (1999) suggest that knowledge is gained when theory, information, and experience are integrated. Enterprise knowledge is thought to be a dynamic mix of individual, group, organisational and inter organisational experiences, values, information and expert insights. This concept originates in the minds of the individual knowledge workers, and then emerges as knowledge workers interact with each other and the environment, and finally knowledge is leveraged for efficient customer management and competitive advantage.

Knowledge management is thought to be a discipline whose major objective is to develop methods and tools for detecting, leveraging, distributing and improving the knowledge assets of organisations (Cortes et al (2001). Knowledge management background is thought to comprise organisational theory, information systems, knowledge representation, and human and machine learning. It is thought to be the systematic, goal oriented application of measures to steer and control the tangible and intangible knowledge assets of organisations, with the aim of using existing knowledge inside and outside of these organisations to enable the creation of new knowledge and generate value, innovation and improvement out of it. (Jaime et al 2006).

Global business enterprises are aware that access to essential operations information will enable them maintain competitive advantage and thereby stay one step ahead of other businesses. They therefore need to develop an effective knowledge management strategy both for the benefit of their employees and customers in order to support decision making process and thereby remain sustainable. Knowledge management concept has increasingly become fashionable however, many organisations are still unable to develop and leverage knowledge to enhance business performance. In most cases organisational knowledge are fragmented, sometimes difficult to locate and therefore to leverage, share and reuse. Tacit knowledge exists in the minds of employees and therefore may not be available to process customer queries and enquiries. There is a need therefore to develop robust decision support systems to capture, store, share and leverage data, information and knowledge. Decision support systems will enable the transformation of tacit to implicit knowledge to be shared and leveraged for improved decision making. They will also enable the conversion of explicit to implicit knowledge a process of internalisation.

There are various perspectives of knowledge management; strategic knowledge management – deals with pinpointing opportunities to find, distribute and transfer knowledge related to long term goals of an organisation; tactical knowledge management finds, distributes and transfers knowledge for the medium term organisational goals; operational knowledge management is associated with daily or short term operations (Young, et al, 2007). They developed a knowledge management framework demonstrating how design information and knowledge, manufacturing information and knowledge, operations information and knowledge and disposal information and knowledge all add up to shape the total product information for the product life cycle. Mustafa and Robert (2003), have also developed a knowledge-based decision support system (KBDSS) suitable for short term scheduling in flexible manufacturing systems and strongly influenced by the tool management concept to provide a significant operational control tool for a wide range of machining cells, where a high level of flexibility is demanded. The benefits are more efficient cell utilisation, greater tool flow control and a dependable way of rapidly adjusting short term production requirements. **Development of a robust knowledge-based system to support the decision making process is made necessary by the inability of decision makers to promptly address all the questions posed by potential customers at the enquiry stage and also to diagnose efficiently many of the malfunctions that arise at machine, cell, and entire system levels during manufacturing.**

Knowledge management models and frameworks are categorised based on their purpose; They could be predictive (predicting what a system's behaviour will be), explanatory / descriptive (enables past observations to be understood as part of an overall process) or prescriptive - provides a picture of the real world if certain rules are applied (Small & Sage, 2006)

Decision support systems would play a major role in information requirements determination in the system life cycle ranging from design through to manufacture, operations and final disposal. Unfortunately existing support methodologies especially in product design and manufacture focus on how to specify requirements once they are determined but however don't enable optimal determination of those requirements. There is therefore a need for a decision support system equipped with a structured knowledge base to help information analysts in the critical decision task of determining requirements especially in system design / manufacture. A typical application of the proposed decision system is in the determination of requirements for product design / manufacture to promptly respond to customer order enquiries in a business environment. Lui and Young (2007) have discussed key information models and their relationships in manufacturing decision support in three different scenarios. They confirmed that global manufacturing businesses are benefiting from the information and knowledge support provided by modern IT tools such as Product Life Cycle Management (PLM), Enterprise Resource Planning (ERP), and Customer Relations Management (CRM). For instance two types of decision making in a global manufacturing scenario can be distinguished; decisions associated with product configuration and decisions associated with project coordination

Figure 1 shows the concept of knowledge derived from theory, information and experience and extended to include wisdom – which is tacit in nature and could be described as successfully applied knowledge. For instance when an enterprise faces an order enquiry from customer, it should be able to respond to the enquiry based on available information, theory and experience. When there is a repeat enquiry in the future the enterprise should now be able to respond promptly based on what it has previously learned and also from a previous successfully applied knowledge.

Figure 2 demonstrates information / knowledge management framework for a product life cycle showing all the sources and phases at which information about the product can be derived. Each of the phases has data and knowledge that describe the characteristics of that stage in the product life cycle. Such information are useful to both the design and manufacture engineers and also to the customer who would need a full understanding of product attributes to enable optimal design, manufacture and guaranteed product

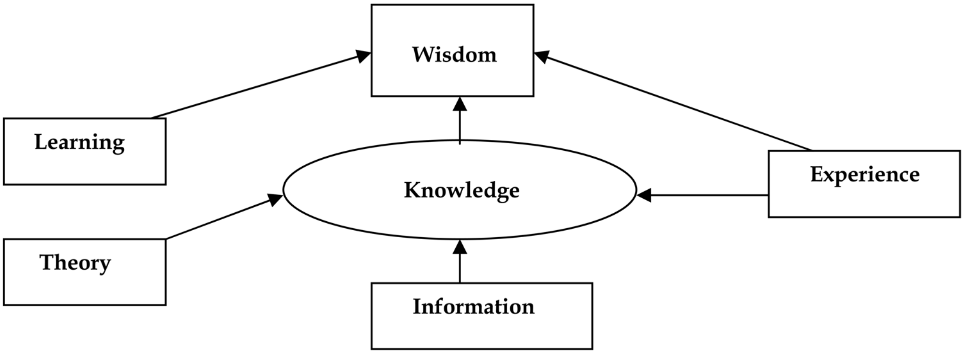


Fig. 1. Knowledge derived from Theory, Information and Experience

performance. At the order enquiry stage a potential customer would be made aware of all relevant information including data on product functionality, durability, efficiency, energy requirement, etc, while the sales representative will negotiate on product specification and requirements, mode of operation, value added, cost price, delivery due date, maintenance requirements, etc. The sales department working in collaboration with the design / production department will also establish that they can deliver what has been promised to the customer within the due date. This will involve material requirement planning, supplier management, production scheduling and planning, outsourcing requirement, quality assurance etc. An order is confirmed only when there is an agreement / contract established between

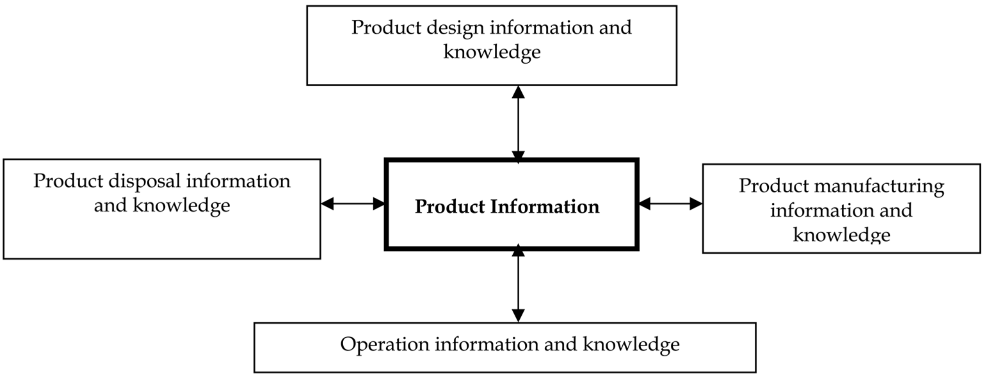


Fig. 2. Information and Knowledge Framework Derived Based on Product Life Cycle

3. Methodologies to respond to customer ordering enquiries – a literature review

Customer Relationship Management (CRM) has attracted the attention of both academics and practitioners. CRM focuses on managing the relationship between a company and its current and prospective customers and is key to success for many organisations (Gebert et al 2003). In CRM, one of the important concerns is how to offer improved levels of customer service and support by means of a variety of ideas, approaches, and tools (Sheikh, 2003). It provides a tool that will enable prompt decision making about an enquiry in a make to order environment to the mutual satisfaction of both the customer and the enterprise. Parente, Pegels and Nallan (2002) surveyed production and sales managers and their findings indicate that the internal relationship between sales and production is important to the customer, especially in Engineer-To-Order production situation. In today's highly customer-centric competitive market, improving customer service level would be crucial for firms to increase their competitiveness. While it is a challenging task it is worth the effort according to Xu et al (2002).

Currently, research into customer order enquiry is scanty yet initial customer enquiries constitute the gateway for building a sustainable customer relationship with an organization. The focus of a previous study by Kingsman *et al.* (1996) was on the management of manufacturing lead time and job release at the cutomer enquiry stage. They argued that dealing properly with enquiries is a major problem that make-to-order companies face, and a lack of co-ordination between sales and production at the customer enquiry stage often leads to confirmed orders being delivered later than promised and a possible production at a loss. Hendry and Kingsman (1993), indicated that a hierarchical production planning system specifically designed for the make-to-order sector of industry is necessary for customer enquiry management. The aim of the hierarchical system was to control the delivery and manufacturing lead times of all orders processed by a firm. However, details of how to respond to customer enquiries, especially for a large set of enquiries, were not elaborated on in their study. They only highlighted the problem and tried to work out a feasible solution.

Kingsman et al (1993) researched on the integration of marketing and production planning in make to order companies and concluded that a major problem confronting firms is the gap between sales/marketing and production functions. This lack of coordination often led to confirmed orders being delivered later than the due date by the sales team. Sometimes orders are produced at a loss, or could lead to a delay of other orders with a consequence of additional costs.. In another study, Hendry (1992) developed a methodology in which two decision levels, the customer enquiry and job release stages were addressed and linked. A decision support system (DSS) was finally developed to assist in planning the capacity at the customer enquiry stage in make-to-order companies. In order to make the response realistic, satisfying and competitive, the literature emphasizes that it is imperative to integrate marketing and production planning. Ulusoy and Yazgac (1995) argued that cooperation between production and marketing departments appear to have a large impact on the well being of a firm. They have therefore, developed a multi-period, multi-product model with the objective of profit maximization reflecting the characteristics of both departments. The advertising efficiency and price of the products are determinable within their model. Similarly, Kingsman *et al.* (1993) discussed possible approaches that depended on estimating routinely the probability of winning an enquiry order, dependent on many factors including price and lead-time etc. Olumolade and Norrie (1996) have developed a decision support system for scheduling in a customer-oriented manufacturing environment. The aim of their research was to assess schedulability prior to assigning parts for scheduling. Their system comprised four basic modules – the demand, material management, tool management and system status modules. Halsall and Price (1999) have also presented a DSS approach to support production planning and control in smaller companies and argued that SME companies would benefit from a manufacturing DSS in which the links between customer orders and manufacturing operations were maintained throughout the duration of the production planning process.

Xiong *et al.*(2003) recently proposed a DSS framework suitable for the management of customer enquiries for SMEs. Their studies indicate that the DSS approach plays a very important role in assisting SMEs to respond to enquiries at the customer enquiry stage. Enterprise Resource Planning System (ERP) can help firms automate their order entry, process customer order and keep track of order status. They are also used to plan capacity and create daily production schedule for manufacturing plants (Yen et al 2002). However, such software may be expensive and inappropriate for SMEs to use for only processing enquiries at the customer enquiry stage. Implementation of such software is complex, and elaborate, and requires huge initial investment and continuing maintenance expenditure (Halsall et al 1999 and Xiong et al 2006). Most recently, Oduoza and Xiong (2007) developed a decision support system framework to process customer order enquiries in SMEs.

3.1 Order processing at the customer enquiry stage, a challenge for businesses

The customer enquiry stage has a strong impact on the production workload and well being of businesses. At this stage, customer enquiries need to be transferred to customer orders and planned for in the next production run. If a firm fails to achieve enough customer orders, its production capacity would be underutilized and waste occurs. A key objective for businesses and SMEs in particular is to maximise profits and minimize waste while processing customer requirements. Generally, such a decision is based on the acceptance or rejection of an enquiry or could even involve negotiation with customers in order to protect the interest of both parties. This process needs to be carefully handled to maintain a firm's market credibility. Customer enquiry management therefore plays a very major role in the business operations of enterprises and for SMEs it is often difficult to properly manage this essential part of their business.

When orders become confirmed, firms generally schedule them against receipts of materials/components and the standard manufacturing lead-time. This forms the basis for Material Requirement Planning (MRP) or Manufacturing Resource Planning (MRPII). Stadtler and Kilger (2000), however, argued that such a method often led to unrealistic production plans because it assumed infinite supply of materials and capacity beyond the standard lead-time and creating supply recommendations based on order backlog. Additionally, such a method did not aim at processing enquiries at the customer enquiry stage, but at planning confirmed orders for the next production procedure. More importantly, customer enquiry is only a prelude to ordering and cannot be simply considered as an actual order. A lot of enquiries might sometimes only request a delivery date, a delivery quantity or sales price for a product without any commitment to ordering. A customer often makes a similar enquiry to several companies at the same time in today's e-business market environment and to a large extent, the decision as to whether an enquiry can be transformed to an order depends primarily on the satisfaction of the customer to the preliminary enquiries / responses from companies. The more responsive firms are in terms of speed, and quality of delivery, the more feasible it may be able to secure the current order and subsequently future orders. However, it seems almost impossible for businesses to provide a proper response without the help of practical and useful tools and techniques. Although there are commercially available software that can assist firms in dealing with orders including automating order entry, processing such orders and keeping track of order status, these systems often require information and function integration, and may therefore have a complicated system structure. Their implementation therefore, is complex, and requires huge initial investment and continuing maintenance expenditure (Halsall and

Price, 1999).. However, an SME company generally only has limited budget, and may not afford to implement such a system for dealing only with customer enquiries. In addition, the lack of professional expertise and technical support in SMEs more especially makes it difficult to make decisions if and when they finally prepare to implement such a system. Consequently, a relatively simple and practical tool would be very useful to guide SMEs in the rapid processing of customer enquiries.

As far as the decision on how to respond to customer sales department of a firm is concerned, the lack of effective coordination between different functions such as production and marketing departments could affect the reliability of the response. For most business enterprises, the production department is often confronted with unrealistic delivery dates for incoming orders. This usually arises when the marketing department often quotes a price and delivery date to maximise their chance of winning the order, however, the production department would need to reconcile impending demand with available resources, capacity utilization, production routing, etc. Because of a deficiency in an integrated information management system, the coordination of different functions may become difficult to achieve.

3.2 Responsive customer enquiry management

Speed of delivery and quality of responses to enquiries seem to be the two major factors affecting customer enquiry management (Xiong et al, 2003 and Xiong et al, 2006). The efficiency of such responses determines how fast the enquiry can be followed through. At the crucial stage, the time spent in responding to an enquiry comprises the time between the receipt of the enquiry and the completion of the response. By and large, a firm would endeavour to decrease this time to enhance the responsiveness to process enquiries as customers would not appreciate a long waiting time for a response. In today's highly competitive market, a customer would quickly resort to another supplier if an early response from a previous vendor is not achieved. The quality of response to customer enquiry is a measure of effectiveness of the management system. A reliable and feasible response is determined by the probability of keeping the delivery promise after making a response. In many cases, achieving response efficiency in terms of speed and as well as delivering error free orders could be conflicting and may sometimes prove difficult. Therefore, to optimise response efficiency and order delivery to specification simultaneously should be major objectives for effective customer enquiry management. By adopting suitable appropriate techniques, method and tools, it becomes possible to achieve customers' main priorities, such as precise delivery time, exact quantity required and also affordable sales price. For example, a successful customer enquiry management might allow customers to enquire and order via the Internet using a build-in-order model and ensuring they get what they want while also enabling the company to cover its cost.

Typically, an enquiry comprises information about requested quantity, delivery date (DD) and price for a product. This gives rise to a three-dimensional response surface constructed with quantity, delivery date and sales price as the axes, thus providing a possible solution, or guideline, for quoting orders for customers and negotiating with customers. There are generally two levels for the dimensions of DD and sales price, fixed level and flexible level. If the customer has specified a DD and a price in its enquiry, the time frame and price is generally considered as fixed. The firm also should be able to check whether it can benefit from accepting the order and whether sufficient capacity is available to produce the new order in addition to existing jobs that have already been confirmed for that time period. Under this circumstance, the firm cannot change the requested DD and price without renegotiating with customers in advance. On the other hand, if an enquiry does not specify a fixed DD and price, a feasible DD and a proper price are defined and included in the response in terms of other objectives such as prioritization, sales expectation, accounting, and capacity, etc. Such information can be used for quoting, approving and negotiation. Typical examples for such an enquiry are those with an unusually huge quantity requested for a particular product or orders with a very short delivery time. Normally, the response to such an enquiry must be considered and approved by production management, e.g. the tender vetting committee, in the firm.

4. Development of a decision support system to manage order enquiry processing

The procedure for responding to an enquiry is basically a multi-stage decision process (Kingsman et al 1996). The initial decision is whether or not to prepare a bid, and if so, how much effort to put into the specification and estimation process. The Make To Order company has the choice to put in a lot of effort to prepare a competitive bid or produce a quick estimate with a high safety margin to allow for errors and unforeseen problems and for further negotiation. Consideration has to be given to the accuracy of the cost estimates produced, the feasibility of being able to produce the order within the current work load at specified delivery times and finally possible overrun costs. If the decision is to go ahead to produce an order, the next step is to provide a response based on the three basic elements of the enquiry – Due Date, Quantity required and Sales Price. In the light of this challenge, a suitable approach is to develop a DSS (Decision Support System) environment to assess different options provided by the system and then make a final well-informed choice. For example, the detailed impact a DD would have on the workload can be estimated graphically, and also the implications of sticking to the DD while adjusting manufacturing capacities could be assessed for decision-making. Also, the decision to further negotiate with customers on a bid could be made if enquiry is considered very important. This involves combining robust business rules with powerful computing capability for effective decision-making. While it does not present an optimal solution, it provides the flexibility for users to consider alternative courses of action before making a decision. By using a DSS approach, potential feasible solutions arising from customer enquiries are evaluated against predefined objectives on the basis of which decisions are made. The major objectives of such a DSS approach are to,

- bridge the gap between sales and marketing functions on the one hand, and manufacturing, product development, finance, human relations, etc on the other hand.
- provide a guideline for negotiation between company and customers
- enable decision making in cases of uncertainty.
- optimize production capacity and material availability

4.1 Prerequisites of proposed decision support system

The architecture of the proposed DSS approach is shown in Fig. 3. The entire system is based on databases which provide all necessary data of customer, production capacity and materials availability, accounting, product and customer, etc. The whole process dealing with enquiries is streamlined and controlled within the environment and a set of interfaces are provided to integrate tools that equip the system with the flexibility to access necessary real time information, assess different options, and undertake a sensitivity analysis. The DSS is broken down into the following modules to enable the right business decision-making.

- **Web Based Enquiries:** Verify incoming enquiries for suitability of delivery (based on available production capacity, process capability, time constraint, potential profit) by the firm. A request could be rejected at this initial stage of the pre-screening process.
- **Due Date Check:** This module checks that the requested due date is feasible based on available production capacity and materials availability. If it is not feasible, some capacity adjustments may have to be made such as overtime usage, operator reallocation or even production rescheduling. The following three scenarios may then become possible;
  - **Negotiate Due Date, while aiming at a fast order**
    DD may be already set by company although this is the most critical success factor to the potential customer
  - **Negotiate Due Date and keep as a slow order**
    DD may be already set by company but this is not a critical success factor to the potential customer
  - **Due Date is fixed**
    The due date is fixed by the potential customer and not negotiable.
- **Evaluation of Enquiries:** Given limited available production capacity, enquiries need to be evaluated in order to select a subset of enquiries, which will be fulfilled. Such evaluation can be based on objectives such as reducing the inventory cost and/or increasing the potential profitability of orders. The DSS should provide several objectives to facilitate the needs of a variety of users. Hence, mathematical models may be combined with judgmental rules to improve the accuracy of the evaluation process.

Typical examples of judgmental rules include,

- Profitability of fulfilling the order
- Importance of the customer
- Value of the order and effect on future business
- Possibility for a repeat order
- Balance of workload for work centers
- Entry into new market
- Process capability to handle order

- **Financial Outcome:** The price for ordering a product for delivery on a given due date is assessed in terms of overall profit maximization and available capacity.
- **Enquiry Audit and Approval:**. The objective of this module is to audit the enquiry process prior to approval by management for important and/or unusual enquiries. These enquiries would strongly influence production planning and scheduling, hence a high level approval is required to finalise an order before confirmation is sent to customers.
- **Capacity Planning:** It is essential to allocate available capacity to priority orders which suggests a policy for order screening and portfolio management. The purpose of this module is to provide management with the capability to assess alternative courses of action necessary to fulfill customer orders. Typical outputs for capacity adjustment are; choice of alternative materials, critical paths/items, recommended purchase orders for critical materials, and request to expedite/de-expedite purchased orders, as well as the plan to assign overtime and reallocate operators between different work centers.

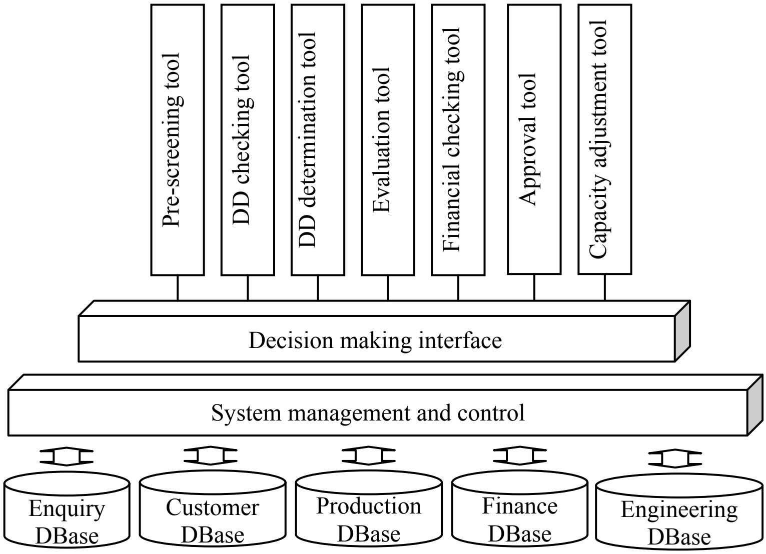


Fig. 3. Generic DSS architecture for customer enquiry management suitable for SMEs (Oduoza & Xiong, 2007)

The nature of the link between the proposed DSS approach and other production planning functions will depend on other systems that a company has in place. The proposed DSS can be envisaged as a front-end system to deal with enquiries in the first instance before they are translated into customer orders and then enter the production planning process. It also could be used at tender vetting committee meetings or in the preparation for such meetings. For enquiries that are considered not important enough to convene a committee meeting, the person responsible for providing a response to such enquiries would need to use it.

4.2 Framework constructs of the decision support system

Successful construction of the framework for the decision support system will depend on essential parameters such as available to promise (ATP) which is a function of material availability and available capacity necessary to manufacture the desired product. These parameters will now be discussed in greater detail.

4.2.1 Available To Promise (ATP) and its determination

The first concern for the proposed DSS is the definition of a criterion to measure the capability to meet customer requirements. Here, we propose to use a concept termed the available-to-promise (ATP) which is a bucketized quantity typically used on weekly basis. It is a standard quantity capable of being produced during a time period based on material availability of all components that assemble or manufacture the requested product. Therefore, product structure, described as bill-of-material (BOM), is essential in ATP computation. Typically the ATP computation complexity increases as the product BOM becomes more complex

Figure 4 shows a flow chart for decision support process based on customer flexibility in terms of due date for delivery. When due date is fixed b y the customer then it is defined by a backward planning to accommodate a new order subject to materials availability, potential profit and available capacity. However, a flexible due date can enable a forward planning. Overall, the final acceptability of an enquiry will be based on due date, available capacity, process capability, potential profit and materials availability.

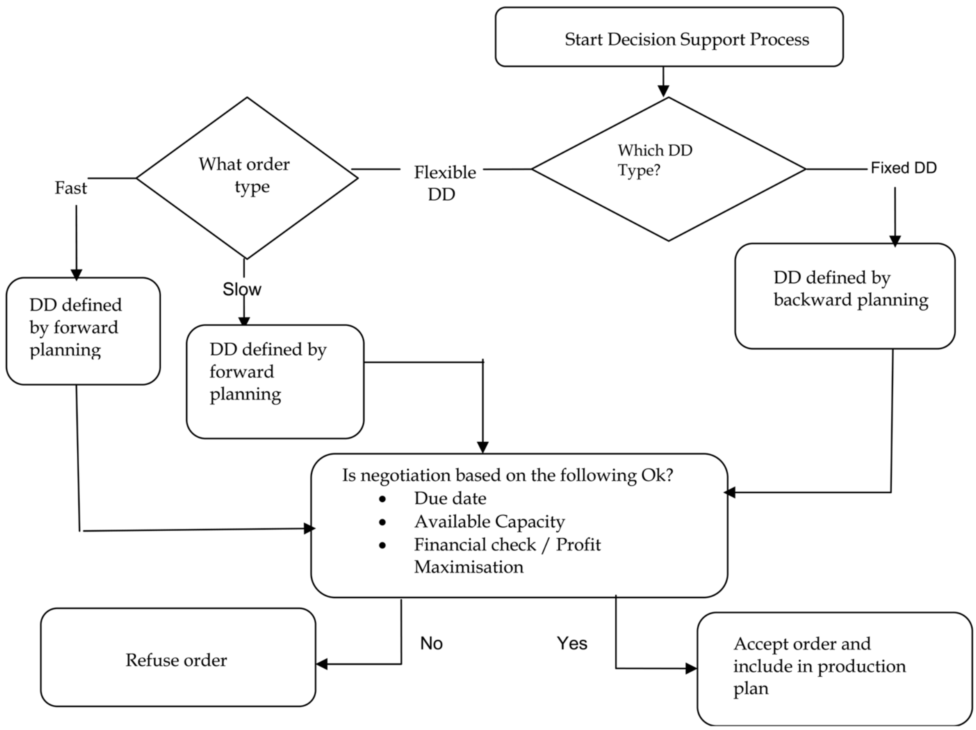


Fig. 4. Flow chart for decision support process based on negotiation with customer

Xiong *et al*. (2003), Oduoza and Xiong (2007) presented a dynamic BOM approach for handling the complex ATP computation for products with multi-level BOM. A dynamic BOM is a two-level BOM, which is generated dynamically in terms of the materials availability of different components during BOM explosion. Through an iterative process to generate a set of dynamic BOMs, the ATP can be accumulated through exploding BOM from top downwards by the associated computation approach. The process in which a set of dynamic BOMs is generated is shown in Fig 5. There are three dynamic BOMs generated sequentially in correspondence with the ordinary product BOM shown at the left side of Fig. 5. For the product BOM, Dynamic BOM 1 is first created due to materials shortage of component C_2 which is described as *Critical Item*. Corresponding to Dynamic BOM 1, ATP is initially determined by quantity per component and lead time of all components, C_1, C_2, …, C_I, required for the process.

4.2.2 Production capacity

The production capacity required for this manufacturing process is then checked against the available production capacity. If the available capacity is sufficient, material availability

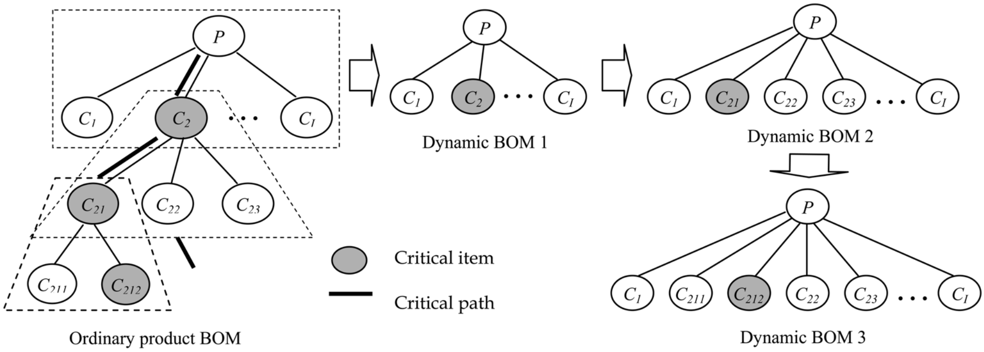


Fig. 5. The generation process of a set of dynamic BOMs during BOM explosion

restricts this production process; otherwise, the production capacity will be under constraint. If C_2 is identified as the Critical Item in Dynamic BOM 1, a new dynamic BOM (Dynamic BOM 2), is formed by replacing it with its direct child components, C_{21}, C_{22} and C_{23}, and similar ATP computation is carried out for Dynamic BOM 2. This process continues until a Critical Item is one bottom-level component in a dynamic BOM, such as C_{212} in Dynamic BOM 3. Details of the dynamic BOM based ATP computations have been previously described by Xiong *et al* (2003). In a recent short communication, Framinan and Leisten (2007) have recommended a reformulation of the model to redefine the inventory holding costs arguing that the model in its current form can lead to certain problems regarding the constraints and the objective function.

In the dynamic BOM based ATP computation presented above, both materials availability and production capacity are effectively reconciled and accounted for. ATP computed on this basis is thus more realistic and reliable too. Because it is easy to put into consideration the materials availability and related production capacity constraints in two-level BOM structure, such dynamic BOM based ATP computation is a suitable approach to determine the real time fulfillment capability with respect to customer enquiries.

4.2.3 Application of linear programming to enhance decision support

It is essential to extend traditional mathematical programming models incorporating intrinsic uncertainty to business decision making but without the assumption of model coefficients. Oliveira and Antunes (2007) have demonstrated the application of multiple objective linear programming models with interval coefficients for decision-making in uncertainty while Polacek et al (2007) applied variable neighbourhood search algorithm to schedule periodic customer visits in order to minimize travel time for salespersons. In a separate study Klashner and Sabet (2007) presented a new DSS design model for complex critical decision-making and partial empirical evaluation derived from a field study at a power utility control centre while most recently Power and Sharda (2007) reviewed model driven Decision Support Systems (DSS) built on the basis of decision analysis, optimization and simulation technologies. The authors presented issues that users need to be aware of in the operation of the decision support system and also emphasized on the user interface, as well as behavioural issues in decision support systems.

Zorzini, Corti and Pozzetti (2008) have also proposed an interpretative framework to identify the contextual factors impacting company choices during decision making at the customer enquiry stage. They presented a model that formalizes the decision process for setting due dates categorized as (a) negotiable due date, fast order (DD set by company but delivery time performance is the most relevant critical success factor), (b) negotiable due date, slow order (DD can be set by company and delivery time performance is not the main critical success factor) and (c) fixed DD (DD is fixed by customer).

Under limited Available To Promise quantities, it is imperative to evaluate a set of enquiries in order to select a subset to fill so that certain business objectives can be achieved. The objectives of this process vary from company to company, and are usually predefined based on company's policy and business philosophy. However, one of the very important business principles is to maximise company's revenue from processing customer enquiries. Assuming that all enquiries are requested for one product only and the DD of every enquiry is fixed, the model to evaluate customer enquiries is derived as follows.

Indices:

i - index of customer enquiries, $i \in I$, where I is the number of enquiries

t - index of time buckets, $t \in T$, where T is length of planning horizon

Parameters:

t_i - requested time bucket for enquiry i, $i \in I$

$E_i(t_i)$ - quantity required by enquiry i in time bucket t_i, $t_i \in T$ and $i \in I$

$p(t)$ - sales price per unit of product in time bucket t

$ATP(t)$ - ATP quantity used for filling customer demands in time bucket t

c_h - unit inventory holding cost per time bucket

c_p – unit manufacturing cost

c_l – unit lost sales cost

Decision variables:

α_i - binary variable stating whether to accept enquiry i

β_{ti} - fraction of $ATP(t)$ allocated to enquiry i

Objective function:

$$\underset{i \in I, t \in T}{Max}\ profit = f_{revenue} - f_{cost} \tag{1}$$

where, $f_{revenue}$ is the revenue from accepting customer enquiries, and f_{cost} is the cost incurred from accepting these enquiries.

$$f_{revenue} = \sum_{i=1}^{I} [\alpha_i * E_i(t_i) * p(t_i)] \tag{2}$$

$$f_{cost} = f_m + f_l + f_h \tag{3}$$

where, f_m, f_l, and f_h represent manufacturing cost, lost sales cost and inventory holding cost respectively, and they are defined as follows.

$$f_m = \sum_{i=1}^{I} [\alpha_i * E_i(t_i) * c_p] \quad \textbf{(manufacturing cost)} \tag{4}$$

$$f_l = \sum_{i=1}^{I} \sum_{t=1}^{T} [(1-\alpha_i) * E_i(t_i) * c_l] \quad \textbf{(lost sales cost)} \tag{5}$$

$$f_h = \sum_{t=1}^{T} \{c_h * [ATP(t) * (T - t)]\} - \sum_{i=1}^{I} [c_h * \alpha_i * E_i(t_i) * (T - t_i)] \quad \textbf{(holding cost)} \tag{6}$$

Constraints:

1. Customer requested quantity

$$\sum_{t=1}^{T} \beta_{ti} = \alpha_i \quad \forall i \in I \tag{7}$$

2. ATP quantity

$$\sum_{i=1}^{I} \beta_{ti} * E_i(t_i) \le ATP(t) \quad \forall t \in T\ ,\ t_i \ge t \tag{8}$$

3. Fraction of ATP in time bucket t allocated to enquiry i

$$0 \le \beta_{ti} \le 1 \quad \forall i \in I \quad \forall t \in T \tag{9}$$

4. Variable constraints

$$\alpha_i = 0 \text{ or } 1 \quad \forall i \in I \tag{10}$$

As described above, ATP is based on available working time of associated work centers as well as the materials availability of all related components. The objective of the model, in Equation (1), is to maximize the profit from accepting a subset of customer enquiries. Equation (2) defines the revenue objective while Equation (3) represents the cost incurred from accepting certain customer enquiries which includes manufacturing cost (Equation 4), lost sales cost (Equation 5) and inventory holding cost (Equation 6). Inventory holding cost f_h consists of two items; the first item represents the total inventory holding cost without accepting any customer enquiry; the second item is the decreasing inventory holding cost from accepting certain enquiries. Equation (7) defines the allocation fraction β_{ti}, generating a quantitative relationship between the sum of allocation fractions from ATP to a specific enquiry and decision variable α_i. Equation (8) ensures that the allocated ATP quantity for all orders within each time bucket must not exceed the ATP quantity in that time bucket.

The model proposed above is a mixed 0-1 linear programming model, and its global optimum can be obtained by using commercially available optimization solver such as LINGO. This mathematical model provides an adaptive combination of every cost as well as profit associated with acceptance of customer enquiries. It can thus help firms analyze real life management decisions.

4.2.4 Sensitivity analysis

In order to facilitate the assessment of every option to respond to customer enquiries, sensitivity analysis is imperative in other to run through customer enquiries effectively. For instance, in some cases, it may be necessary to take special actions by adjusting materials and production capacity in order to reduce the lead time. This is especially true in cases of large orders from customers or demand for a very short DD. Since the definition of capacity referred to in the proposed DSS includes materials availability and production capacity, the following information may be used in the DSS for adjusting materials availability.

- Alternative components
- Critical component and implications for related material shortage, and
- Delivery lead time and lot size for critical component

In the proposed DSS, the variables affecting material availability includes sourcing for alternative materials, issue of critical paths / items, purchase orders for critical materials, and expedite /de-expedite purchase orders.

At the planning stage, the production capacity is usually planned on a weekly basis by means of the forecast values of the total workload on the shop floor (Hendry, 1992). However, when a specific enquiry (for example an order for a large quantity) is received, the DSS should be able to adjust the production capacity to allow for the special needs for this particular order. The two most common methods for adjusting the production capacity – assigning overtime and reallocating operators between different work centers – can be easily incorporated into this proposed DSS. The overtime is usually assigned to some bottleneck work centers to increase their available working time. This is necessary to expedite such orders that may be delayed if no action were taken. The method of reallocating operators between different work centers will be appropriate if there is an imbalance of workload across the shop floor.

5. Knowledge management to support decision making during new product development – a case study

This section describes the case application of knowledge management to support decision making during new product development. Harris (2009) has developed a knowledge based framework to support new product development and describes logistical details of how knowledge acquired at the product / process design stage feeds into manufacture. The captured knowledge and lessons learnt from this initial cycle enhance/improve future product design in terms of tooling, manufacture and product attributes and requirements.

Figure 6 shows a knowledge based framework to support decision making during product development (Oduoza, Harris and Al-Ashaab, 2010). The system describes two major databases; product data archive, and a manufacturing knowledge base both linking to manufacture and product / process design activities. System end users, manufacturing staff and project engineers all have access to the two databases from their work stations and can extract relevant information when necessary. It clearly highlights how enterprise business strategy is linked to both product and process design and manufacture. The framework shows that details of the product and process design can be accessed from a product data archive comprising; product, manufacture, and tooling requirements and also the associated production history. The product archive feeds into the manufacture knowledge base which contains all the relevant information on machine specifications and capabilities, material requirements and planning, and quality assurance issues. The framework also describes details of how the product design department links and collaborates with manufacturing / production section in terms of procedure, technology and project management.

Product Data Archive

The product data archive comprises information, manufacture and tooling modules. It also highlights the product manufacturing history.

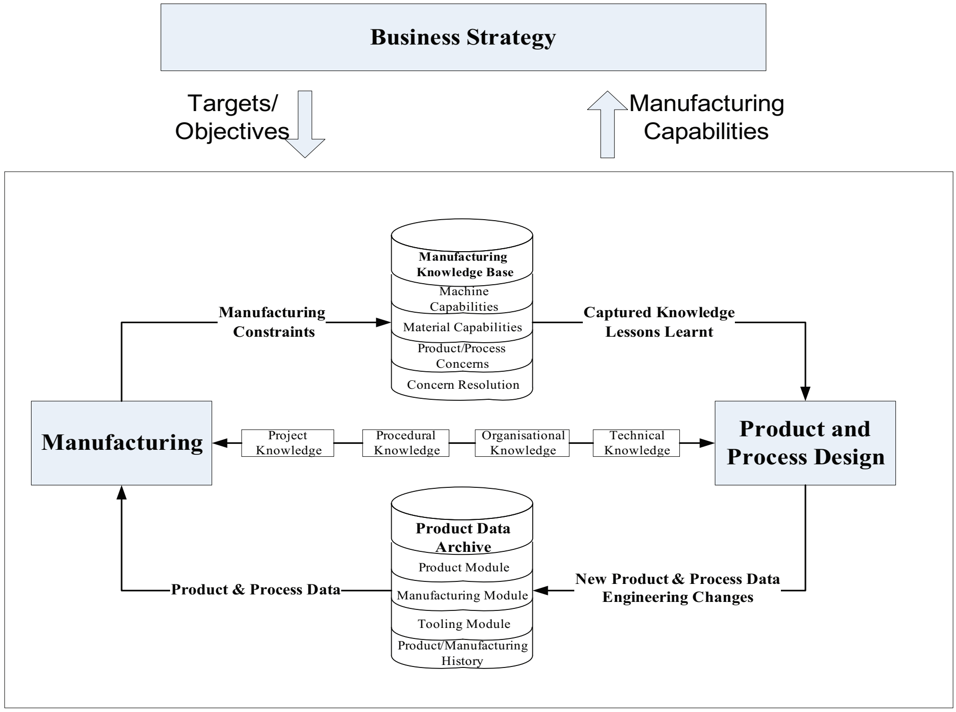


Fig. 6. Knowledge Based Framework to Support Product Development (Oduoza, Harris and Al-Ashaab, 2010)

Product module.

The product module details all the product specifications especially the drawing of the product, material specifications, quality assurance requirements, packaging, and delivery specifications. Each element of the product module highlights further details showing previous revisions, and issue dates.

Manufacture module.

Decision making during the product development process is quite often difficult as not all stakeholders have access to all the necessary information and knowledge related to the manufacturing process. This is made easier by assembling all the necessary information relating to the manufacturing process such as process capabilities, capacity, machine size and speed, standard operating procedures etc necessary to create a manufacturing module. The manufacturing module in the product data archive can be accessed in the form of charts, spreadsheets and system specifications. In summary, the Manufacturing Module contains the relevant knowledge necessary to identify the manufacturing methods and processes for new product development.

Tooling module

The tooling module consists of a variety of tool designs used in roll forming, cut off, piercing, setting sheets, programs for the production lines, and all the necessary information to produce and set tooling on the machines.

Product manufacturing history.

Product manufacturing history provides details of each product from the first enquiry, through to new product introduction and manufacture, and details all engineering changes relating to the product, manufacture and tooling modules.

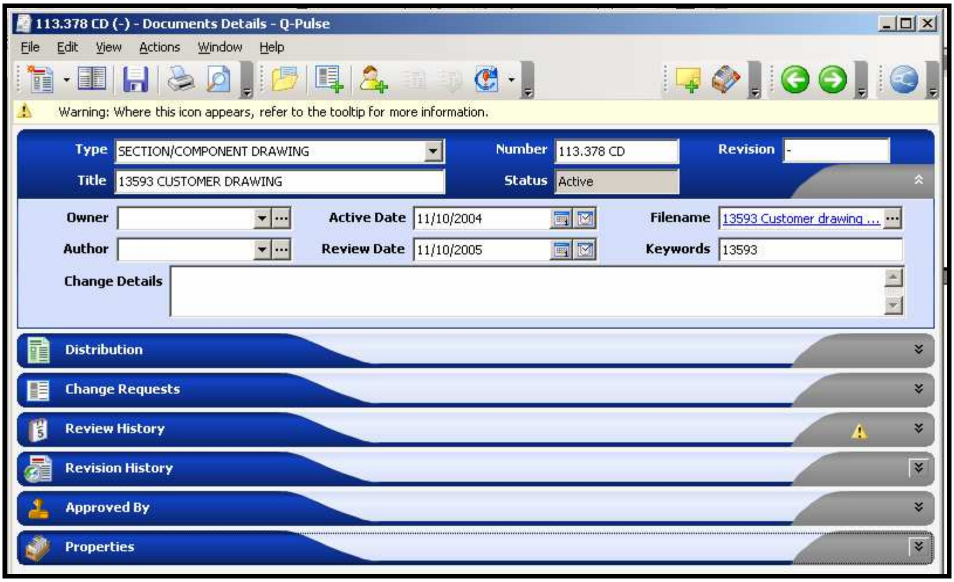


Fig. 7. Document details screen for part number 113.378 (Oduoza, Harris and Al-Ashaab, 2010)

Figure 7 shows a screen shot of the document details screen for a given part number in the product data archive

The data archive system is split into two major areas;

a. Document list screen, where documents can be searched by:

- Document Type.
- Part No.
- Document No.
- Revision level.
- Document owner.
- Customer.
- Product Market sector.
- Type of product.

b. Document details screen which provides information about the specific document and includes:

- Document type.
- Document number.
- Document status
- Document revision
- Document author
- Document owner
- Document active date; date of issue

- File name and hyperlink
- Distribution list
- Change requests
- Document review history
- Document revision history
- Document approval
- Document associated properties; product customer, product type, product market sector.

The document control side of the product data archive provides a central storage area for all documents related to the development and manufacture of products. It prevents the use of obsolete documents and only presents the most current revision to the user. Documents are securely managed to prevent uncontrolled modifications, drafts or copies. Records pertaining to document change, history, approval and distribution are securely held for each revision of a document and are readily available for review. Document registers are also automatically updated with approved changes, in other to eliminate the risk of human error while allowing for effective engineering change control.

Enquiry/engineering control.

A fundamental part of the product development system is the enquiry/engineering change request phase It is paramount that all information received from the customer and information / knowledge created internally are correctly documented and made available to all to avoid controversy.

Approximately 500 new enquiries and engineering change requests are received by the case company each year and these enquiries comprise insufficient details to quote and product tooling being quoted which is already available. The procedure starts with the enquiry being received from the customer/potential customer followed by data entry onto the system of the following; drawings, concepts and or specifications for the product etc. Enquiry will be declined or discontinued if customer fails to provide all the relevant information that will enable response. When all the relevant information become available, it is given a unique enquiry number, with drawings, product specifications and additional information such as customer and contact details are attached to the enquiry (embedded into the database). All departmental and sectional heads are alerted of a new enquiry on the system with hyperlink to open up the enquiry and make necessary input.

Figure 8 shows a screen shot of the enquiry page displaying general information relating to the enquiry; the enquiry number, date raised, status, ownership of enquiry, customer and customer contact, brief description of the enquiry/engineering change request, and the material specification of the product (provided by the customer). All drawings, specifications and communications relating to the enquiry sit as file attachments in the properties field shown at the bottom of the screen.

As soon as the enquiry has been entered into the system the sequence of steps to be taken is indicated in the drop down tabs in the bottom half of the screen:

- Tooling estimate; this field records tooling required, tooling costs and whether or not the part can be manufactured.
- Materials cost estimate; this field records estimated costs of material to produce the product and cannot be completed until the tooling stage is complete; the tooling stage confirms the material content of the component.
- Production estimate; this field records anticipated production speed, output/hour, utilization and manning levels.

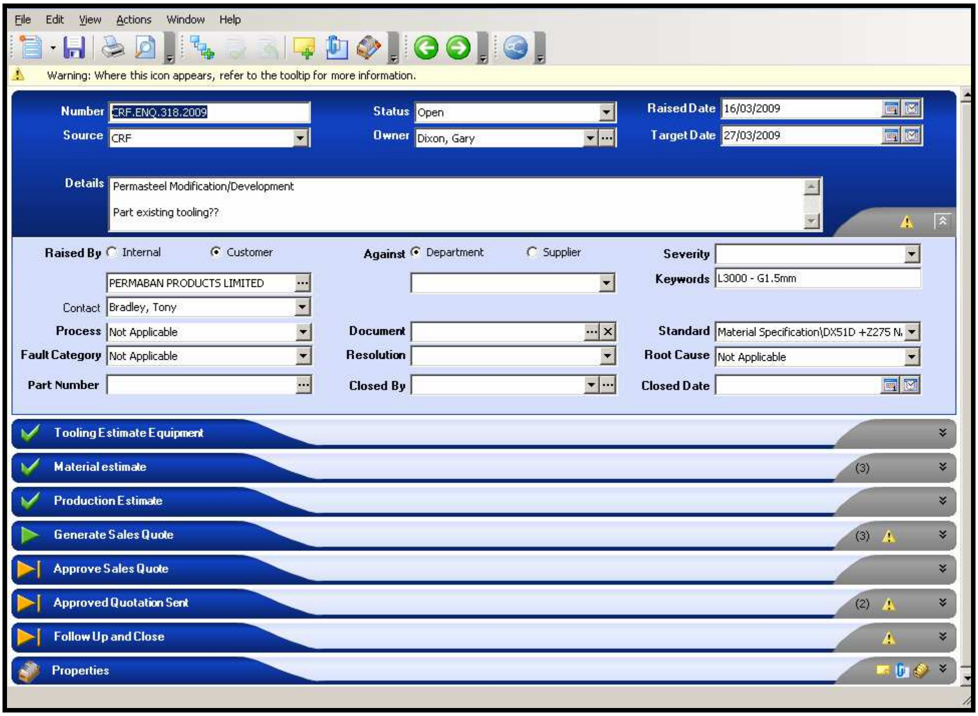


Fig. 8. Screen shot showing an open enquiry (Oduoza, Harris and Al-Ashaab, 2010)

- Sales quote; the system generates a sales quote only when it obtains detailed information on tooling, materials, and production estimates. The sales quote is then vetted and approved by the manufacturing director prior to release to the customer.
- Dispatch of approved sales quote; this field details when the sales quote is sent and prompts for a copy to be added in the properties field.
- Follow up and close order; If an order is received, details of the order are entered into this field, where the customer has declined the quotations, reasons are added and the enquiry is closed.

The enquiry process is sequential and the system will not allow further details to be entered until the previous stage is complete. All persons involved in the enquiry process are e-mailed when each stage is completed.

In the case organization, the enquiry system has been running for approximately 18 months, and has reduced the time taken to quote to an average of 5 days, and due to the robustness of the system it prevents quotations being raised without the necessary and appropriate information.

Manufacturing knowledge base.

The manufacturing knowledge base is a database with the information and knowledge required to support the product and process design activities. It aims to capture decisions taken and their context in order to support effective decision making in future product development activities. The database contains: machine capabilities, material capabilities, product/process concerns and problem resolution.

Machine capabilities

The manufacturing capabilities element of the manufacturing knowledge base is utilized to select suitable manufacturing equipment and production lines for the manufacture of a specific product. The selection of suitable manufacturing equipment is carried out in conjunction with the product module information.

Material capabilities

The material capabilities element of the manufacturing knowledge base is probably the most important aspect to be considered when developing a new product. Selection of the wrong material could have consequence on tooling specification / estimate.

6. Construction industry enquiry on material fabrication using cold roll forming process - a case study.

Cold roll forming is a manufacturing process to transform flat metal strips into various profile shapes achieved by means of forming rolls. This study describes a customer order enquiry received from a client in the construction industry, for the fabrication of lightweight lattice beams, joists and trusses to be utilized in a wide variety of buildings such as schools, hotels, sports halls, superstores and industrial buildings. The product specification was a very high strength to weight ratio, with the lattice beams required to be manufactured in depths ranging from 220mm - 3000mm, and able to span up to 38m depending on building type and application.

The customer proposed a product profile, which was analyzed in order to appreciate manufacturability in terms of physical size, shape, and suitability of the material to cold roll form. The product profiles were assessed by the relevant departments and quotation was put forward, however, tooling costs, were deemed too expensive for the project to be commercially viable. The tooling cost for the three profiles was assessed in excess of £90,000, however the customer requested that tooling costs should be no greater than £60,000. A review meeting held with the client to determine the critical profile requirements and what features if any could be modified came up with the following material recommendations:

- Yield strength of 420 N/mm^2 minimum
- Minimum structural properties and section modulus were specified.
- The overall width of the component was reviewed.
- Design to cost of tooling should not be higher than £60,000 achieved by designing the same set of tooling for identical profiles (spacers to lengthen or shorten the straight parts of the profile referred to as modular/platform tooling)

However, to fulfil this customer order requirement poses a conflict as follows;

- The tighter the specified radius of the product the more material that would be required to form the profile, thus increasing manufacturing product cost.
- There will be an increase/decrease in the sectional properties of the profile. (Dependent on shape and load direction)

Consequently, further analysis of profile structural characteristics was necessary to confirm that increasing the radius of the profile did not alter its structural properties beyond the specified limits. To standardize tooling profiles fully also required dimensional modifications, with two options considered, to either standardize the bottom forming or the top forming rolls. Standardizing the top forming rolls would result in additional set up time whereby all the rolls would have to be stripped off the rolling mill in order to change from one profile to the next.

Information highlighted in this case study can be stored as a part of a knowledge management system to serve as a point of reference for future order enquiries in other to minimise on cost, time and material resources. It will also enable the design of precise and accurate product dimensions.

7. Conclusion

It is essential to manage initial customer enquiries channeled to an organisation satisfactorily as this could facilitate order winning and could even be more rewarding if it became a lucrative project. Enquiry management could certainly be made easier if the sales / marketing agent is fully aware of the nature of the enquiry and whether or not this could be fulfilled. In other to provide a suitable response, the sales agent of a manufacturing enterprise, for instance, should be able to discuss the skills of the work force, and the capability of their business process to manage the fulfillment of that order. Sometimes the respondent to the enquiry is not fully aware of the implications of the enquiry and therefore cannot provide a satisfactory answer to the potential customer and consequently the order could be lost if not properly managed. It is therefore essential to put in place a decision support system to help the respondent to answer crucial questions at this critical stage of developing a potential lasting relationship with a customer.

This chapter has presented a decision support system driven by a robust knowledge management framework to aid the respondent (sales / marketing agent of the firm) at the enquiry stage to provide accurate and useful information which could confirm or transform an enquiry into an order. In a typical scenario (cited in this study) relevant to new product development, the framework comprises product data archive (product database consisting of product, manufacture and, tooling modules and the product manufacturing history) and the manufacturing knowledge base (describes machine and material capabilities, product / process concerns and any concerns resolution). When these two databases (from the knowledge management framework) are properly coordinated, they provide a vast amount of information about the firm which is beneficial for operations management and also useful to potential clients who would want to do business with the organization.

DSS approach proposed here will assist firms and other businesses involved in customer enquiry / order management to make proper and well-informed decisions for customer enquiries. By providing the desired flexibility to assess different responses and experiment with alternative courses of action, the speed and efficiency of making an informed response to customer enquiry can be significantly improved.

The major contributions from this study are:

1. the problems confronting businesses in managing order enquiries at the customer enquiry stage have been highlighted.
2. proposal of a DSS framework to enable effective and efficient management of order enquiries at the customer enquiry stage was initiated. This is significant especially for SMEs who lack the essential resource to respond to such enquiries as well as manage capacity scheduling, planning and materials availability.
3. mathematical model that links profit maximization with screening customer / order enquiries and thereby decide whether or not to proceed with an enquiry by balancing capacity against demands placed on it.

4. review of due date as an important DSS parameter and if negotiable could affect an enquiry outcome
5. construction of a flexible DSS structure suitable for web based customer enquiries, and a recommendation for its implementation.
6. decision support system driven by a robust knowledge management framework to aid the respondent (sales / marketing agent of the firm) at the enquiry stage in providing accurate and useful information which could help to confirm or transform an enquiry into an order

8. Acknowledgement

The author wishes to thank Alan Harris for providing relevant data on the knowledge management framework and also to Mohua. H. Xiong for a previous collaboration on decision support systems framework.

9. References

Cortes, U, Sanchez-Marre, M, Sanguesa, R, Comas, J, Roda, I.R, Poch, M and Riano, D (2001), *Knowledge Management in Environmental Decision Support Systems,* AI Communications, 14, 3-12.

Gebert, H., Geib, M., Kolbe, L., Brenner, W (2003)., *Knowledge-enabled customer relationship management: integrating customer relationship management and knowledge management concepts*, Journal of Knowledge Management, 7(5), 107-123.

Halsall, D.N., and Price, D.H.R(1999)., *A DSS approach to developing systems to support production planning control in small companies*. International Journal of Production Research; 37(7),1645-1660

Hansen, M.T.,(1999). *The search-transfer problem: the role of weak ties in sharing knowledge across organization subunits*. Administrative Science Quarterly 44, 82–111

Harris, A (2009), *A knowledge based framework to support lean product development,* MPhil Thesis, University of Wolverhampton, UK.

Hendry, L.C., and Kingsman, B.G (1993)., *Customer enquiry management: part of a hierarchical system to control lead times in make-to-order companies*. Journal of Operational Research; 44(1); 61-70.

Hendry, L.C (1992)., *COPP: a decision support system for managing customer enquiries*. International Journal of Operations and Production Management, 12(11); 53-64.

Jaime, A, Gordoni, M, Mosca, J and Vinck, D, (2006), *From Quality Management to Knowledge Management in Research Organisations,* International Journal of Innovation Management, Vol. 10, 197 – 215.

Kingsman, B.G., Hendry, L., Mercer, A. and De Souza A (1996)., *Responding to customer enquiries in make-to-order companies – problems and solutions*. International Journal of Production Economics. 46/47, 219-231

Kingsman, B.G., Lee, W., Hendry, L.C., Alan, M., Elaine, W (1993)., *Integrating marketing and production planning in make-to-order companies*. International Journal of Production Economics, 30/31 ;53-66.

Klashner, R and Sabet, S (2007), *A DSS design model for complex systems; lessons from mission critical infrastructure,* Decision Support Systems; Vol. 43; 990 - 1013

Liu, S and Young, R.I.M (2007), *An exploration of key information models and their relationships in global manufacturing decision support,* Proc. IMechE, Vol. 21, Journal of Engineering Manufacture, 711-724

Miller, W. L and Morris, L (1999) *Fourth Generation R&D: Managing Knowledge, Technology and Innovation*, Wiley, N.J

Mustafa, O and Robert, B (2003), *A Knowledge-Based Decision Support System for The Management of Parts and Tools in Flexible Manufacturing Systems*, Decision Support Systems, Vol. 35, 487-516),

Nonaka, I and Takeuchi, H (1995), *The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, New York.

Oduoza, C.F. and Xiong, M.H (2007), *A decision support system framework to process customer order enquiries in SMEs,* International Journal of Advanced Manufacturing Technology, Vol. 42, 398-407

Oduoza, C.F, Harris, A, and Al-Ashaab, A (2010), *Knowledge based framework used in decision support,* Manuscript in preparation for International Journal of Manufacturing Technology Management

Oliviera, C and Antunes, C.H (2007), *Multiple objective linear programming models with interval coefficients – an illustrated overview*, European Journal of Operational Research, Vol 181;1434-1463

Olumolade, M and Norrie, D (1996), *A decision – support system for scheduling in a customer – oriented manufacturing environment*, Integrated Manufacturing Systems; 7/3; 38-46

Parente, D.H., Pegels, C.C., Nallan S (2002)., *An exploratory study of the sales-production relationship and customer satisfaction*, International Journal of Operations & Production Management; 22(9); 997-1013

Polacek, M, Doerner, K.F, Harti, R.F., Kieche, G, and Reimann, M (2007), *Scheduling periodic customer visits for a traveling salesperson*, European Journal of Operational Research; Vol 179; 823-837

Polanyi, M (1966), *The tacit dimension*, London: Routledge and Kegan Paul

Power, D.J, Sharda, R, *Model –driven decision support systems: concepts and research directions 2007;* Decision Support Systems, Vol 43, 1044-1061

Sheikh, K., *Manufacturing Resource Planning (MRPII) with an introduction to ERP, SCM, and CRM*. McGraw- Hill; 2003.

Small, C.T, Sage, A.P, (2006), *Knowledge Management and Knowledge Sharing: A Review, Information* Knowledge Systems Management, 5, 153 – 169.

Swan J, Newell S, Scarbrough H, Hislop D (1999). *Knowledge management and innovation: networks and networking* Journal of Knowledge Management; 3(4).

Stadtler, H., Kilger, C.(2000), *Supply Chain Management and Advanced Planning – Concepts, Models, Software and Case Studies*, Springer Press.

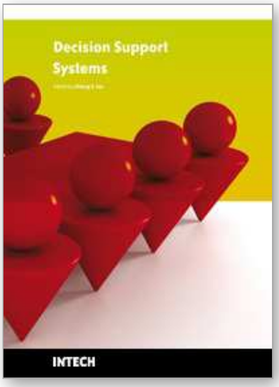
Xiong, M.H., Tor, S.B., Khoo, L.P., Bhatnagar, R., and Venkat, S.(2003a) *Framework to managing customer enquirers for SMEs*; Singapore-MIT Alliance Symposium, Singapore.

Xiong, M.H., Tor, S.B., Bhatnagar, R., Khoo, L.P. and Venkat, S (2006)., *A DSS approach to managing customer enquiries for SMEs at the customer enquiry stage*, International Journal of Production Economics; Vol. 103; 332-3461

Yen, D.C., Chou, D.C., and Chang, J (2002)., *A synergic analysis for Web-based enterprise resource planning systems*. Computer Standards and Interfaces; 24(4); 337-346.

Young, R.I.M, Gunendran, A.G, Cutting-Decelle, and Gruninger, M (2007), *Manufcaturing Knowledge Sharing in Product Life Cycle Management a Progression Towards the Use of Heavy Weight Ontologies*, Internatnional Journal of Production Research, Vol. 45, 1505-1519

Zorzini, M, Corti, D, and Pozzetti, *A, Due date (DD) quotation and capacity planning in make-to-order companies: Results from an empirical analysis*, International Journal of Production Economics, 2008, Vol. 112, 919-933



Decision Support Systems

Edited by Chiang S. Jao

ISBN 978-953-7619-64-0
Hard cover, 406 pages
Publisher InTech
Published online 01, January, 2010
Published in print edition January, 2010

Decision support systems (DSS) have evolved over the past four decades from theoretical concepts into real world computerized applications. DSS architecture contains three key components: knowledge base, computerized model, and user interface. DSS simulate cognitive decision-making functions of humans based on artificial intelligence methodologies (including expert systems, data mining, machine learning, connectionism, logistical reasoning, etc.) in order to perform decision support functions. The applications of DSS cover many domains, ranging from aviation monitoring, transportation safety, clinical diagnosis, weather forecast, business management to internet search strategy. By combining knowledge bases with inference rules, DSS are able to provide suggestions to end users to improve decisions and outcomes. This book is written as a textbook so that it can be used in formal courses examining decision support systems. It may be used by both undergraduate and graduate students from diverse computer-related fields. It will also be of value to established professionals as a text for self-study or for reference.

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821