Preparation of Modular Bill of Materials (BOM) and interfacing with customized ERP software – A Case Study in OTOBI

by

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The thesis titled **"Preparation of Modular Bill of Materials (BOM) and interfacing with customized ERP software – A Case Study in OTOBI"** submitted by **Mohammed Mafuzul Islam Mazumder, Student No. 040408010F, Session- April 2004,** has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Master of Engineering in Industrial & Production Engineering on December 17, 2005.

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Declaration

It is hereby declare that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

Mohammed Mafuzul Islam Mazumder

This work is dedicated to my loving

Father

Md. Nurul Islam Mazumder

&

Mother

Monowara Islam

Contents

List of Figures

List of Tables

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Abstract

Enterprise Resource Planning (ERP) is a complete manufacturing planning and control system to make the process efficient and productive in the current competitive market. ERP system defines the way each product is to be built, realistic game plans and delivery promises and also provides useful management information for continual improvement. The capability of the system to adapt changing needs and technologies determines its acceptability and future success of the company. Manufacturing initiative, combined with today's ongoing and dramatic IT innovation, is driving the evolution of Enterprise Resource Planning (ERP) around the world. In the current business environment, the entrepreneurs in Bangladesh also have realized that they need to modernize their whole system. As a result, manufacturing industries in Bangladesh are also gradually incorporating ERP system into their respective organizations. Although the professional ERP software costs a huge investment, due to knowledge limitation about system, most manufacturers still fall short of getting the most return from their substantial ERP investment. Maximizing ERP system is a contingency-based guide to optimize the benefits of an ERP application. It outlines a contingency ERP systems approach that is flexible, understandable, and designed to work in a variety of industries and environments. A fully functional ERP system can achieve the following benefits like reduced inventories, reduced order cycle time, increased production capacities, lower total logistics cost, decreased procurement costs and reduced manufacturing waste.

Bill of Materials (BOM) is one of the most important factors in a production system for maximizing the benefits of ERP implementation. A manufacturing item reflects concurrent product and process design considerations in its bill of materials. BOM also provides a model of the product design for manufactured components A recent approach in preparing BOM is to implement modular product architecture, which offers many advantages to manufacturers and consumers. Modular architecture can reduce the number of parts in a product, reduce the time to manufacture and assemble the product, and streamline and simplify the conceptual design and embodiment design phases through the reuse of previous parts or ideas.

In this context, one case study has been conducted in one of the leading furniture manufacturing company name Otobi limited. Otobi limited is a world class Metal, Lamination board and Plastics furniture and accessories manufacturer. This organization is trying to implement and maximizing application of the ERP system in their organization. The study has been conducted in Metal department to prepare Modular BOM and to interface the database with ERP system in Otobi limited. This study will investigate the status of the bill of material of Metal Furniture department of Otobi Limited and customize the BOM to incorporate it into ERP system to achieve maximum benefit.

CHAPTER I

INTRODUCTION

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1.1 INTRODUCTION

The manufacturing environment today is dynamic and changes continuously. The dynamic behavior creates a demand for dynamic behavior of the planning environment as well. The whole organizational planning and scheduling is significant factor for a large manufacturing company's outcome. Today planning and scheduling are done in several different ways. Manual planning and scheduling, whether it is done with pen and paper or with tools like Microsoft Excel, Microsoft Access or Microsoft Project, is still common even in larger modern companies. Sometimes it works well but it tends to be time consuming and create its own bottlenecks. One or a few persons possess the knowledge of the facility and these persons absence can be devastating to the daily operation. The need for a fast and flexible manufacturing process in industry today has increased the need for a more accurate planning of the manufacturing resources. Now a day, the operational planning has been done with the help of Planning and scheduling tools are today available in most Enterprise Resource Planning (ERP) systems and give a helping hand to the production planners. That's why OTOBI limited has been implementing customized ERP software in their organization, which is one of the leading furniture manufacturing company in Bangladesh.

1.2 BACKGROUND

Enterprise Resource Planning (ERP) is a complete manufacturing planning and control system to make the process efficient and productive in the current competitive market. ERP system defines the way each product is to be built, realistic game plans and delivery promises and also provides useful management information for continual improvement [1]. The capability of the system to adapt changing needs and technologies determines its acceptability and future success of the company. Manufacturing initiative, combined with today's ongoing and dramatic IT innovation, is driving the evolution of Enterprise Resource Planning (ERP) around the world. In the current business environment, the entrepreneurs in Bangladesh also have realized that they need to modernize their whole system. As a result, manufacturing industries in Bangladesh are also gradually incorporating ERP system into their respective organizations. Although the professional ERP software costs a huge investment, due to knowledge limitation about system, most manufacturers still fall short of getting the most return from their substantial ERP investment. Maximizing ERP system is a contingency-based guide to optimize the benefits of an ERP application. It outlines a contingency ERP systems approach that is flexible, understandable, and designed to work in a variety of industries and environments [1]. A fully functional ERP system can achieve the following benefits like reduced inventories, reduced order cycle time, increased production capacities, lower total logistics cost, decreased procurement costs and reduced manufacturing waste [1,2].

Bill of Materials (BOM) is one of the most important factors in a production system for maximizing the benefits of ERP implementation. A manufacturing item reflects concurrent product and process design considerations in its bill of materials. BOM also provides a model of the product design for manufactured components [3]. A recent approach in preparing BOM is to implement modular product architecture, which offers many advantages to manufacturers and consumers. Modular architecture can reduce the number of parts in a product, reduce the time to manufacture and assemble the product, and streamline and simplify the conceptual design and embodiment design phases through the reuse of previous parts or ideas [4].

Table 1.1 Business Profile of OTOBI Ltd

Product Category	Types of Products	Category-wise Annual Sales in percentage
Metal products	a) Different types of Almira b) Different types of Filing Cabinet c) Chair, Sofa d) Heavy Duty Rack Etc.	35
Laminated products	a) Different types of Almira b) Different types of Cabinet c) Office workstation etc.	55
Others	Special projects	10

In this context, one case study has been conducted in one of the leading furniture manufacturing company name Otobi limited. It is a world class Metal, Lamination board and Plastics furniture and accessories manufacturer. Business profile and Department-wise Cost profile of the organization are shown in the table 1.1 and table 1.2 respectively. This organization is trying to implement and maximizing application of the ERP system in their organization. The study has been conducted in Metal department to prepare Modular BOM and to interface the database with ERP system in Otobi limited. This study will investigate the status of the bill of material of Metal Furniture department of Otobi Limited and customize the BOM to incorporate it into ERP system to achieve maximum benefit.

Table 1.2 Department-wise Cost Profile

Departments	Types of Raw Materials Used	Percentage of Total Cost
Metal Department	a) Mild Steel b) Stainless Steel c) Chemicals d) Paints etc	65
Lamination Department	a) Particle Board b) Melamine Board c) Formica etc	25
Others		10

1.3 JUSTIFICATION

As the business world moves ever closer to a completely collaborative model and competitors upgrade their capabilities, to remain competitive, organizations must improve their own business practices and procedures. Companies must also increasingly share with their suppliers, distributors, and customers the critical in-house information they once aggressively protected. And functions within the company must upgrade their capability to generate and communicate timely and accurate information. To accomplish these objectives, companies are increasingly turning to enterprise resource planning (ERP) systems.

The expected return on investment provides the cost justification and motivation for investing in ERP. There are quantifiable benefits as well as intangible benefits in the ERP investment decision. The quantifiable benefits have a bottom-line impact on profitability and asset turnover and a potential effect on stock turn. The quantifiable benefits in terms of several areas of improvement in justification of implement ERP. The most significant quantifiable benefits involve reductions in inventory and in material, labor, and overhead costs, as well as improvements in customers' service and sales. The intangible benefits of an integrated ERP system can be viewed from several perspectives. The major benefits focus on production and material management, product and process design, accounting, sales, and MIS functions [1,2].

In general, production planning includes activities such as material requirement planning (MRP), available-to-promise (ATP) and capable-to-promise (CTP) and so on. They can provide planners and managers with the production management and control information. Each of them has a sophisticated computation algorithm and requires huge amount of information on inventory, product structure, customer/supplier orders, order policy, and product priority, etc. Thus, there is a need for the company to formulate and automate this process so as to facilitate decision-making in a timely, accurate and efficient manner. Some commercially available Enterprise Resource Planning (ERP) systems can possibly help the company performing such decision-making. For example, major vendors of ERP systems, such as SAP, PeopleSoft. Baan, Oracle and J.D. Edwards, currently delivered several dominant ERP systems that are capable of undertaking production planning and management. However, they are fundamentally built on client/server architecture and are generally centralized decision-making and information systems. But each of those ERP systems requires huge amount of investment that a local company is hardly able to bear.

The intangible benefit of a customized integrated ERP system one major and critical facor is product design and production management Modular BOM is one of the very important factors of product design and production management for material planning and scheduling. Product design and production management of ERP systems helps establish realistic schedules for production and communicate consistent priorities so that the most important job to work on at all times. Visibility of future requirements helps production prepare for capacity problems, and also helps suppliers anticipate and meet needs. As Changes to demands or suppliers do occur, it helps identify the impact on production and purchasing Modular BOM offers many advantages to manufactures and consumers. Modular BOM can eliminates the number of parts in a product, reduce time to production and delivery lead time etc. It helps eliminate many crisis situations, so people have more time for planning and quality [1]. Moreover, from the overall company standpoint, ERP provides a framework for working effectively together and devising a consistent plan for action.

Keeping all these in mind, this study was conducted in a local furniture manufacturing company named OTOBI Limited, where they wants to implement the customize ERP software

1.4 OBJECTIVES

The main objectives of the present work are:

- To study the existing BOM and collect related data and information.
- To analyze the collected BOM, data and information.

- To prepare database for modular BOM that can be interfaced into ERP system.

1.5 ORGANIZATION OF THE THESIS

Second chapter of this thesis paper presents literature review of the thesis containing necessary relevant information and a review of few research work previously done on ERP system. Chapter three represents the methodology data collection and steps required to perform the study The fourth chapter presents the Findings and analysis of Modular BOM Chapter five contains the database design and interfacing the modular BOM database with customized ERP system. Chapter six presents the conclusions of the thesis and recommendations for the future work.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents the relevant information and explanation of the ERP system, Modular BOM, database design and interface related literature review from different reference books and journals.

2.2 WHY ERP

The business environment is dramatically changing. Companies today face the challenge of increasing competition, expanding markets, and rising customer expectations. This increases the pressure on companies to lower total costs in the entire supply chain, shorten throughput times, drastically reduce inventories, expand product choice, provide more reliable delivery dates and better customer service, improve quality, and efficiently coordinate global demand, supply, and production [5].

As the business world moves ever closer to a completely collaborative model and competitors upgrade their capabilities, to remain competitive, organizations must improve their own business practices and procedures. Companies must also increasingly share with their suppliers, distributors, and customers the critical in-house information they once aggressively protected. And functions within the company must upgrade their capability to generate and communicate timely and accurate information. To accomplish these objectives, companies are increasingly turning to enterprise resource planning (ERP) systems.

ERP provides two major benefits that do not exist in non-integrated departmental systems: (1) a unified enterprise view of the business that encompasses all functions and departments; and (2) an enterprise database where all business transactions are entered, recorded, processed, monitored, and reported. This unified view increases the requirement for, and the extent of, interdepartmental cooperation and coordination. But it enables companies to achieve their objectives of increased communication and responsiveness to all stakeholders.

2.3 EVOLUTION TOWARDS ERP

The focus of manufacturing systems in the 1960's was on inventory control. Companies could afford to keep lots of "just-in-case" inventory on hand to satisfy customer demand and still stay competitive. Consequently, techniques of the day focused on the most efficient way to manage large volumes of inventory. Most software packages (usually customized) were designed to handle inventory based on traditional inventory concepts [5,6].

In the 1970's, it became increasingly clear that companies could no longer afford the luxury of maintaining large quantities of inventory. This led to the introduction of material requirements planning (MRP) systems. MRP represented a huge step forward in the materials planning process. For the first time, using a master production schedule, supported by bill of material .les that identified the specific materials needed to produce each finished item, a computer could be used to calculate gross material requirements. Using accurate inventory record .les, the available quantity of on-hand or scheduled-to-arrive materials could then be used to determine net material requirements. This then prompted an activity such as placing an order, canceling an existing order, or modifying the timing of existing orders. For the first time in manufacturing, there was a formal mechanism for keeping priorities valid in a changing manufacturing environment. The ability of the planning system to systematically and efficiently schedule all parts was a tremendous step forward for productivity and quality [5,6,7].

Yet, in manufacturing, production priorities and materials planning are only part of the problem. Capacity planning represents an equal challenge. In response, techniques for capacity planning were added to the basic MRP system capabilities. Tools were developed to support the planning of aggregate sales and production levels (sales and operations planning), the development of the specific build schedule (master production scheduling), forecasting, sales planning and customer order promising (demand management), and high-level resource analysis (rough-cut capacity planning). Scheduling techniques for the factory floor and supplier scheduling were incorporated into the MRP systems. When this occurred, users began to consider their systems as company-wide systems. These developments resulted in the next evolutionary stage that became known as closed loop MRP [7].

In the 1980's, companies began to take advantage of the increased power and affordability of available technology and were able to couple the movement of inventory with the coincident financial activity. Manufacturing resources planning (MRP II) systems evolved to incorporate the financial accounting system and the financial management system along with the manufacturing and materials management systems. This allowed companies to have a more integrated business system that derived the material and capacity requirements associated with a desired operations plan, allowed input of detailed activities, translated all this to a financial statement, and suggested a course of action to address those items that were not in balance with the desired plan [6].

By the early 1990's, continuing improvements in technology allowed MRP II to be expanded to incorporate all resource planning for the entire enterprise. Areas such as product design, information warehousing, materials planning, capacity planning, communication systems, human resources, finance, and project management could now be included in the plan Hence, the term, ERP was coined. And ERP can be used not only in manufacturing companies, but in any company that wants to enhance competitiveness by most effectively using all its assets, including information [5,6].

2.4 THE PROMISE AND PITFALLS OF ERP

Enterprise systems appear to be a dream comes true. The commercially available software packages promise seamless integration of all information flows in the company financial and accounting information, human resource information, supply chain information, and customer information. For managers who have struggled, at great expense and with great frustration, with incompatible information systems and inconsistent operating practices, the promise of a quasi "of-the-shelf" solution to the problem of business integration is enticing.

It is no surprise that business organizations have been beating paths to the doors of enterprise system developers. A successful ERP project can cut the fat out of operating costs, generate more accurate demand forecasts, speed production cycles, and greatly enhance customer service—all of which can save a company millions of dollars over the long run. At Toro Co., ERP, coupled with new warehousing and distribution methods, resulted in annual savings of $10 million due to inventory reduction. Owens Corning claims ERP software helped it save $50 million in logistics, materials management, and sourcing. ERP also resulted in a reduction in inventory because material-management planners had access to more accurate data—such as how much inventory was already in the pipeline—and could do a better job forecasting future demand [8]. ERP systems reportedly also lead to improved cash management, reduction in personnel requirements, and a reduction in overall information technology costs by eliminating redundant information and computer systems [8].

In 1997, $10 billion was spent to purchase ERP systems [9]. That figure increases significantly when the associated consultant expenditures are included. A 1999 APICS survey indicated that one fourth of members considered or planned to purchase a new ERP system or upgrade their old ERP system in the year 2000. That number jumped to 34.5% among companies with annual revenues of $1 billion or more. Boston-based AMR Research predicted that the ERP market would grow at an annual rate of 32% through 2003. AMR concluded that the impetus for this skyrocketing demand would be manufacturers' desire to establish better control over their supply chains [10] Clearly, the economic slowdown experienced through 2001 dampened this projected demand. However, as the economy recovers, the demand for ERP systems should again dramatically increase.

Surprisingly, given the level of investment and length of time needed to implement ERP systems, many companies have proceeded to implement ERP without making any return on investment (ROI) calculations. But, most companies seem to have had good reasons for doing so—some wanted to integrate diverse business units, others wanted to consolidate redundant proprietary information systems, and many implemented ERP systems to solve their year 2000 problems. But the price of securing the benefits of ERP may be high. Not only do ERP systems take a lot of time and money to implement, they can disrupt a company's culture, create extensive training requirements, and even lead to prodnctivity dips and mishandled customer orders that, at least in the short term, can damage the bottom line [8]. Moreover, according to Standish Group research, 90% of ERP implementations end up late or over budget.

Although it has been estimated that the payback period for an ERP system typically ranges from one to three years [10], the evidence is mixed. Meta Group recently surveyed 63 companies— ranging in size from $12 million to $43 billion in corporate revenue—to quantify the payback firms realized from their ERP investments. The data indicated that the average implementation cost $10.6 million and took 23 months to complete. In addition, an average of $2.1 million was spent on maintenance over a two-year period. Ultimately, their research indicated that companies showed an average ROI loss of $1.5 million over a six-year period [8].

2.5 CRITICAL FACTORS FOR SUCCESSFUL ERP IMPLEMENTATION

Implementing an ERP system is not an inexpensive or risk-free venture. In fact, 65% of executives believe that ERP systems have at least a moderate chance of hurting their businesses because of the potential for implementation problems [11]. It is therefore worthwhile to examine the factors that, to a great extent, determine whether the implementation will be successful. Numerous authors have identified a variety of factors that can be considered to be critical to the success of an ERP implementation. The most prominent of these related to this study are described below.

2.5.1 Data accuracy

Data accuracy is absolutely required for an ERP system to function properly. Because of the integrated nature of ERP, if someone enters the wrong data, the mistake can have a negative domino effect throughout the entire enterprise. Therefore, educating users on the importance of data accuracy and correct data entry procedures should be a top priority in an ERP implementation [8].

ERP systems also require that everyone in the organization must work within the system, not around it. Employees must be convinced that the company is committed to using the new system, will totally changeover to the new system, and will not allow continued use of the old system. To reinforce this commitment, all old and informal systems must be eliminated. If the organization continues to run parallel systems, some employees will continue using the old systems.

2.5.2 Extensive education and training

Education/training is probably the most widely recognized critical success factor, because user understanding and buy-in is essential. ERP implementation requires a critical mass of knowledge to enable people to solve problems within the framework of the system. If the employees do not understand how a system works, they will invent their own processes using those parts of the system they are able to manipulate [6,12]

The full benefits of ERP cannot be realized until end users are using the new system properly. To make end user training successful, the training should start early, preferably well before the implementation begins. Executives often dramatically underestimate the level of education and training necessary to implement an ERP system as well as the associated costs. Top management must be fully committed to spend adequate money on education and end user training and incorporate it as part of the ERP budget. It has been suggested that reserving 10–15% of the total ERP implementation budget for training will give an organization an 80% chance of implementation success [13].

All too often, employees are expected to be able to effectively use the new system based only on education and training. Yet, much of the learning process comes from hands-on use under normal operating conditions. Thus, a designated individual (preferably the project leader) should maintain ongoing contact with all system users and monitor the use of, and problems with, the new system. There is also a need for post-implementation training. Periodic meetings of system users can help identify problems with the system and encourage the exchange of information gained through experience and increasing familiarity with the system [14].

2.5.3 Focused performance measures

Performance measures that assess the impact of the new system must be carefully constructed Of course, the measures should indicate how the system is performing. But the measures must also be designed so as to encourage the desired behaviors by all functions and individuals. Such measures might include on-time deliveries, gross profit margin, customer order-to-ship time, inventory turns, vendor performance, etc.

Project evaluation measures must be included from the beginning. If system implementation is not tied to compensation, it will not be successful. For example, if all managers will get their raises and bonuses next year even if the system is not implemented, successful implementation is less likely. Management, vendors, the implementation team, and the users must share a clear understanding of the goal. If someone is unable to achieve agreed-upon objectives, they should either receive the needed assistance or be replaced. When teams reach their assigned goals, rewards should be presented in a very visible way. The project must be closely monitored until the implementation is completed. The system must be forever monitored and measured [19].

Management and other employees often assume that performance will begin to improve as soon as the ERP system becomes operational. Instead, because the new system is complex and difficult to master, organizations must be prepared for the possibility of an initial decline in productivity. As familiarity with the new system increases, improvements will occur. Thus, realistic expectations about performance and time frames must be clearly communicated [7,15].

2.5.4 Multi-site issues

Multi-site implementations present special concerns. The manner in which these concerns are addressed may play a large role in the ultimate success of the ERP implementation. The desired degree of individual site autonomy may be a critical issue, which depends on two factors: (1) the degree of process and product consistency across the remote sites, and (2) the need or desire for centralized control over information, system setup, and usage. One of the objectives of an ERP implementation may be to increase the degree of central control through the implementation of standardized processes. Alternatively, the implementation may be undertaken in order to provide the remote sites with capabilities that allow them to fine tune their processes to their unique situations.

Another complexity in dealing with multi-site implementations is the degree to which the culture of the organization differs between sites. The fundamental issue here is one of corporate standardization versus local optimization. Corporate standardization brings with it simplified interfaces among diverse parts of the organization, ability to move people and products between sites with minimal disruption, and relative ease in consolidating data across the entire organization. On the other hand, local optimization may result in more effective and efficient operation and may reduce costs.

Perhaps the most difficult decision to be made in a multi-site implementation is the question of cutover strategy. The organization must choose between an approach where the implementation takes place simultaneously in all facilities or a phased approach by module, by product line, or by plant with a pilot implementation at one facility. With a large outlay of cash up front for software, hardware, and the project team, the company may want a simultaneous implementation in order to recoup its investment as quickly as possible.

In a multi-site implementation, a phased approach is generally considered to be preferable. This is partly because the success or failure experienced in the first attempt at implementation often decides the fate of the entire project. Thus, the management team can gain momentum by selecting a pilot site that has a high likelihood of success. And if ERP is installed in a phased approach— module-by-module, department-by-department, or plant-by-plant—the lessons learned at early sites can make the implementations at later sites go smoother [16].

2.6 ERP SYSTEM SELECTION

An estimated 50–75% of US firms experience some degree of failure in implementing advanced manufacturing technology [17] Since an ERP system, by its very nature, will impose its own logic on a company's strategy, organization, and culture, it is imperative that the ERP selection decision be conducted with great care. The greatest enterprise system implementation failures seem to occur when the new technology's capabilities and needs are mismatched with the organization's existing business processes and procedures.

Most enterprises can expect to change or significantly upgrade their computer information systems at least every five to seven years. With the rapid development of new technology, the expansion of features and capabilities, and the proliferation of software vendors, there are numerous options for ERP systems. While most ERP packages have similarities, they also have substantial differences. Most ERP software vendors make assumptions about management philosophy and business practices. Thus, buying an enterprise application/ ERP suite means much more than purchasing software–it means buying into the software vendor' view of best practices for many of the company's processes A company that implements ERP must, for the most part, accept the vendor's assumptions about the company and change existing processes and procedures to conform to them. Therefore, each organization should try to select and implement a system that underscores its unique competitive strengths, while helping to overcome competitive weaknesses [6,15,18]. The ultimate goal should be to improve the business, not to implement software.

When ERP systems are carefully examined, 80–90% of a particular system will be the same across different implementations, but 10–20% will be different and tailored to the specific needs of the enterprise [19]. Therefore, the company must identify its critical business needs and the desired features and characteristics of the selected system. Two distinct methods can be used for system selection. One method is to implement some overall business strategy by focusing on the information technology infrastructure. Some companies, especially large ones, may derive their greatest benefit through the centralization of data and increased control. The other method is to determine the particular features that are required to run a specific business. So some companies, especially small and medium ones, may opt for software that closely matches the specific functions and processes of their business to more easily manage the business, increase efficiency of operations, and reduce costs [6,14].

ERP packages are primarily proprietary systems as opposed to open system architectures. This can limit the flexibility of the enterprise that adopts a particular ERP package. Approaches to process design depend on the enterprise software selected. Standardized processes such as SAP R/3 and PeopleSoft require the adopting firm to adapt its processes to the requirements of the software. SQL and Oracle are more accommodating and allow firms to tailor the software to existing processes. In addition, companies with the necessary expertise can develop their own systems for integration. Developing in-house software can offer the freedom to find creative solutions to integration problems. For example, in 1996, Dell Computer Corporation initially planned to roll out SAP's full R/3 suite, but it balked because Dell executives did not believe that the package could keep up with Dell's extraordinary corporate growth. Instead the company designed a flexible architecture to allow the company to add or subtract applications quickly and selects software from a variety of vendors [20].

The importance of the actual software selection process must not be underestimated. The current literature includes some recommended steps and suggestions for the selection process [7,15,21]. Based on the available sources and experiences, the authors [22] recommend the following thirteen-step selection process: Create the vision, Create a feature/function list, Create a software candidate list, Narrow the field to four to six serious candidates, Create the request for proposal (RFP), Review the proposals. Consider strengths, Select two or three finalists, Have the finalists demonstrate their packages, Select the winner, Justify the investment, Negotiate the contract, Run a pre-implementation pilot and Validate the justification.

2.7 MODULAR BOM

The development of a framework to collect, classify and share information on products and their components, has been discussed by Pahng et al. [23]. In their work, they have delineated a framework for *Object-based Modeling and Evaluation (OME)* of product design problems. Otto and Wood [24] have proposed a 10-step reverse engineering and redesign methodology for improving design of existing products. Marshal et al. [25] have discussed the benefits of design modularization. Their emphasis is that variety can be offered efficiently through a standard set of modules, and the reuse of related modules. Ulrich [26] has defined product architecture as the mapping from function to form. Huang and Kusiak [27] have also discussed types of modularity. Two main categories of product architectures are identified, namely, integral and modular.

Meyer and Lehnerd [28] define a product platform as a set of parts, sub-systems, interfaces and manufacturing processes that are shared among a set of products, thus allowing the development of derivative products with cost and time savings. The development of product platforms with extensive information on the part sets, subsystems, interfaces, and the manufacturing process is assumed to benefit companies. The product platform approach is a major step towards meeting inexpensive product variants, mass customization, shrinking of design cycle, and a medium for information sharing by engineers and designers. Though product platforms offer many advantages, as products become more complex, product platforms become more complex. The design and embodiment information associated with the product platform becomes both large and complex. .

The development of product platforms is discussed by Otto et al. [29] Specific applications to interplanetary missions and consumer products are explored. Regardless of the application, extending tools for modular product design and product platform design remains a critical design need. Frameworks are needed that allow designers to reason about various modules, interfaces, interaction information and embodiment information.

Modularity is viewed by Ulrich and Tung [30] as, (i) similarity between the physical and the functional architecture, and (ii), minimization of incidental interactions between physical components. McAdams et al. [31] have described analytical methods to study percentage occurrence of function chains in products and their interactions. Sets of sub-functions that are grouped based on a logic pattern are called as modules. Stone et al. [32] have formulated a set of heuristics to group functions to form a module. These modules in effect are a collection of related sub-functions that perform one of the many tasks accomplished by the final product. We will use the heuristics here to identify modules from functional models

Kayyalethekkal [33] has performed experimental studies on part count reduction in products and developed a product architecture based conceptual design for assembly technique. In this work, the author recommends a heuristic that if the number of functional modules recognized by Stone's heuristics is less than the number of assembly module identified by disassembly, then part count reduction is possible by reducing the number of elements that take part in modular interaction.

Finally, we end this literature review with a discussion on some recent and pertinent work on modular products. Otto et al. [4], have formulated a framework for architecting a family of products that share inter-changeable modules. They define a modularity matrix for one family of products from a manufacturer. This matrix lists the sub-functions as rows and products as columns. The matrix allows commonalties to be easily identified. The interchangeability and reusability of modules for one of the products from one manufacturer has been investigated.

2.8 DATABASE AND INTERFACE DESIGN

Database is a very important factor in an ERP system. In market there are lots of database software are available such as Microsoft Access, Oracle, SQL server, Sybase, DB2, ODBC etc. [34].

Microsoft Access database provides the users with such benefits as easy to use and user friendly, individual report buildup, manual data entry and accuracy justification, provision of manual operation if system fails, easy to learn and trained, more data display provision on one screen i.e. a consistent, user-friendly design and availability [35]. From aforementioned points of view, studied organization advised to prepare the Modular BOM database in Microsoft Access or Microsoft Excel. In this context, Modular BOM database are prepared in Microsoft Access.

Database interfacing or connectivity is major issue of dynamic online ERP software. The database connector files contain the necessary information to connect to the appropriate data source. An interesting feature of Customized ERP software is its export/ import module. This allows users to interface the database by using various interfacing software (manually) or automatically database can import or export form any reliable database, and is especially beneficial for interface connectivity issues. The data from distributed databases is uploaded automatically using a dial up connection (every 3 to 4 hours) to an FTP site and downloaded at the head office. There are lots of interfacing software are available in market such as Microsoft Visual Basic, Microsoft SQL Server, Microsoft C+ +, Oracle etc [36].

Form design in Microsoft Visual Basic and user interface design in general are important components of all interactive database management systems. Microsoft visual developers have a nearly infinite combination of fonts, colors and layouts from which to choose. It is important to choose a combination of characteristics, which will provide a simple and pleasant interface to the data for the user. Here are a few recommendations for Microsoft Visual Basic developers who want to make user-friendly database interfaces [35, 36] such as *coding and debugging enhancements, IDE customization and help system, enhancements; building data-centric applications, easy interfacing technique and user friendly programming technique.* That is why, Microsoft Visual Basic 6.0 has been used to interface Modular BOM database.

Based on the literature review, this research work has been setup in Modular Bill of Materials items; it is one of the main entities of material requirement planning, which is very important sections of ERP system and one case study have been conducted. The construction of the research work and the methodology of data collection and analysis have been presented in the following chapter.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The case study research has been carried out in the selected Metal departments of OTOBI Limited situated in Dhaka, Bangladesh in 2005. From the thesis work, overall product architecture scenario of the studied organization's Metal department has been identified that are analysis and prepared Modular BOM database and interfacing with customized ERP software. This chapter presents the methodology of prepared database and interfacing steps required to perform the case study.

3.2 ENTERPRISE RESOURCE PLANNING

The term "ERP" stands for Enterprise Resource Planning. ERPs are popularly considered to be modern, integrative, technology-based solutions that permit organizations to replace [37]:

- Disparate, legacy applications and stove-piped data; and
- The Associated organizational inefficiencies that arise from the use of the disparate data and applications.

As legacy systems were not typically designed to easily share information with other systems. It leads to confusing situations where the organization doesn't know the answer to questions such as how many customers it has! Each disparate legacy application/data combination typically supports an individual functional-area such as finance, ordering, or logistics, etc Only recently have organizations become aware of that the magnitude of these disintegration costs – *ranging from 20-40% of organizational IT budgets.* When considering enterprise resource planning as a potential solution to specific organizational challenges, major considerations include [37]:

- Understanding ERP's complex MRP II origins;
- ERP capabilities;
- Five ERP implementation challenges as –

  (a) Inaccurate ERP expectations,

  (b) Customization challenges,

  (c) Long payback periods; and

  (d) Data quality costs;

  (e) "Hidden" implementation costs
- ERP metadata value in support for ERP implementation.

3.3 OVERVIEW OF AN ERP SYSTEM

The basic architecture of an ERP system consists of 12 business functions utilizing a common manufacturing database, as shown in Fig. 3.1 [1]. This top-down model shows how aggregate plans (the business, sales, and production plans) drive the detailed plans for coordinating supply chain activities. The accounting function tracks the financial implications of supply chain activities. The common database master files and the functions related to bill of material are described briefly here:

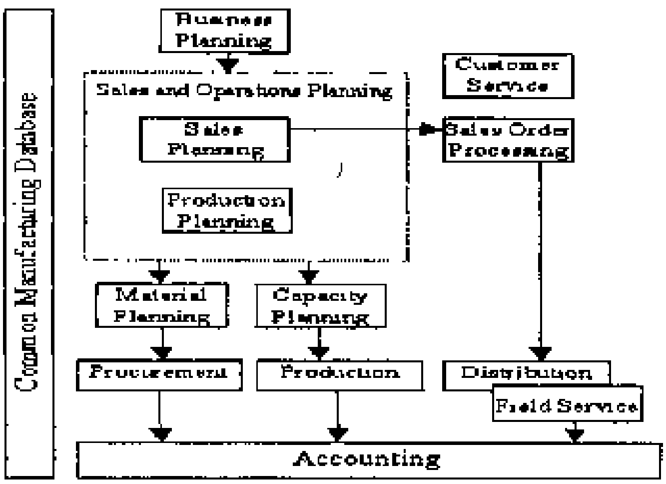

Fig. 3.1: Simplified Information Flows for ERP

3.3.1 Common Manufacturing Database:

Each business function builds on the foundations of common manufacturing database. The heart of the common database consists of several master files about customers, vendors, products, inventory, locations, and general ledger accounts, since it models many aspects of the manufacturing enterprise.

Product data about standard products consists pf master files about items, bills of material, resources, and routings. The item master identifies every standard product, and raw materials to saleable end items. Bills of Material reflect the product design. Bills information gets used for product costing, material planning, material usage reporting, lot tracking, and stages of manufacturing. Planning bills can be used for forecasting and production planning of standard product (Make to Stock) [1,2].

Product data about custom products consists of configurations and planning bills. A custom product configuration is normally defined in the context of a quotation or sales order. It defines a one-time bill of material and routing that gets used for costing and pricing and the other purpose cited above (such as material and capacity planning, scheduling, and so forth. Planning bills can be used for forecasting and production planning of custom products components, as well as option selection to create a configuration [3].

3.3.2 Production planning:

Production planning provides a game plan for each product that coordinates supply chain activities to meet demands The approach to formulated each game plan to contingent on the type of product and production strategy, and the nature of supply orders fro make-to-order prodncts. Production planning formulates realistic game plans based on analyzing constraints identified by capacity and material planning (from bills of Material.). Infinite capacity planning identifies potential overloaded periods requiring adjustments to capacity or loads Materials planning identifies potential shortages requiring expediting. Finite scheduling (accounting for capacity and material constraints) may be used to identify potentially late or impossible deliveries to meet demands. A production plan may be used to represent aggregate available capacity, such as a dedicated manufacturing cell producing all items within a product family [1,2,3].

3.3.3 Capacity planning

Capacity planning can be used to support sales and operations planning (to make plans realistic) and production scheduling. Infinite capacity planning uses proposed schedules (extended by routing information) to calculate loads and identify potential overloaded periods for each resource. In overloaded situation, the courses of action include increasing available capacity 9 by overtime, additional equipment and personnel, and other measures) or reducing loads (by rescheduling, alternate operations, and other measures). Finite capacity planning, also termed *finite scheduling*, treats the available capacity as given constraint to identify late and unscheduled orders

3.3.4 Material planning

Material Planning is based on the master schedule and final assembly schedules for each game plan. It calculates material requirements based on the bills of material, and suggests change to existing supply orders or new planned supply orders (reflecting item planning parameters). It communicates recommended actions to planners and buyers, and provides the basis for production and vendor (for kanbans), to synchronize supplies to meet demands [1,3].

3.3.5 Procurement

Procurement involves identifying and qualifying vendors, as well as negotiating agreements. Procurement may start with requests of quotes. Procurement also involves daily coordination of external suppliers, through purchase orders and vendor schedules, to align supplies with demand. Procurement activities involve different types of purchase, from normal and subcontracted standard products to outside operations and those related to custom product configurations. Receiving activities encompasses purchase orders receipts and other type of receipts. Receipt transactions provide the basis for measuring vendor performance (in items of delivery, quality, and price), and automatically building a buy-card history. Daily coordination can be accomplished through visible replenishment techniques such as Kanbans [1].

ERP incorporates a complete Procurement Management system. This module monitors the procurement of goods from Vendors, right from the requisition stage. The information flow is as follows [38]:

- Material Requisition
- Enquiry to Suppliers
- Quotations from Suppliers / Blanket Purchase Orders / Rate Contracts
- Purchase Orders
- Purchase Order Amendments

3.3.6 Production

Production and production activity control daily coordination of internal resources through a production schedule and manufacturing orders to align supplies with demands. Production activities involve different type of manufacturing orders, from normal orders (with indirect linkage) to custom product and final assembly orders (with direct linkage to sales order). These all the orders like production or work order etc. are processing through Manufacturing Resource Planning (MRPII). The work orders processing & manufacturing module is integrated with the Purchase, Inventory and Sales Management modules. This is a Bill of material based module, which caters to the manufacturing operation requirements of an organization. This module aids in creation of Bill of Materials, material requirements planning, Issues to production / work order on the basis of bill of materials [3, 38]

A manufacturing order defines the quantity and dates for producing an item. On a order, the order-dependent bill and routing may be modified to reflect material substitution or alternate operations. Material resources usage and labor and resource expenditures and reported against the manufacturing orders. Reporting actual material and resource consumption provides the basis fro measuring progress, efficiencies, and actual costs. Actual costs can be compared to standard costs for calculating variances for standard product or for calculating profitability on a custom product configuration. A production schedule (or dispatch list) coordinates operations performed at each resource, and identifies the parent item and order. A router or traveler (of detailed process instructions for each operation) can also serve as coordination tool, especially in custom product environments. Quality management considerations related to production are frequently expressed in factors for item yield, component scrap percentages, or operation yield percentages and may also mandate lot-trace and serial-trace requirements, as well as receiving inspection requirement.

3.4 STEPS REQUIRED TO PERFORM THE STUDY

BOM for different types of metal furniture will be prepared using Microsoft Access. This chart for BOM will then be interfaced with the customized ERP software using Microsoft Visual Basic. The generalized database about bill information will be used for prodnct costing, material planning, material usage reporting, lot tracking, analyzing variances and tracking progress through stages of manufacturing.

The steps to achieve the above objectives are:

Step –1: *Collecting data from both primary (documented) and secondary sources*
First of all a primary survey was conducted in metal department in order to have a clear conception about the product architecture as well as collecting existing products Bills of Materials from both primary sources (documented sources) and secondary sources (job floor shop, section in-charge.

Step –2: *Using modular product architecture concept to prepare BOM:* The primary and secondary sources data was formulated by Modular architecture concept. Before finalizing the modular BOM, necessary modification was made considering reducing the number of parts in a product, simplify the product design through reuse or same components are use in different products and also reduce to time to manufacture and assemble products.

Step – 3: *Analyzing data using hierarchical techniques:* At this stage, the data that have already been obtained by primary sources, secondary sources and observation were processed in the order of Modular /BOM level-wise, which are hierarchical techniques. For this hierarchical techniques, make a workstation or process code in different sections on the basis of component level or manufacturing level-wise. After completion of the data processing, the analysis was documented.

Step – 4: *Preparation of modular BOM using Microsoft Access:* In this stage, prepare Modular BOM table structure database was made on the basis of product architecture, materials and operation centric, level and process code etc in Microsoft Access. Then the diagnostic documented Modular BOM was gather in Microsoft Access database.

Step –5: *Interfacing with customized ERP software using Microsoft Visual Basic:* At this stage, the database of the modular BOM interfaced with customized ERP software using Microsoft Visual Basic. The generalized database about bill information will be used for raw materials purchase order, product costing, material planning, material usage reporting, lot tracking, analyzing variances and tracking progress through stages of manufacturing.

3.5 WORKING PRINCIPLE

3.5.1 Construction Of Bill Of Materials

The construction of bill pf material in complete form for a practical product is undoubtedly a tedious work [3]. The Bill of material file contains the complete product description, listing not-only the materials, parts, and components but also the sequence in which the product is created. The BOM file is one of the three main inputs to the material requirement-planning program. The BOM file is often called product structure file because it shows how a product is put together shown in fig 3.2 and Table 3.1. It contains the information to identify each item and the quantity used per unit of the item of which it is part.

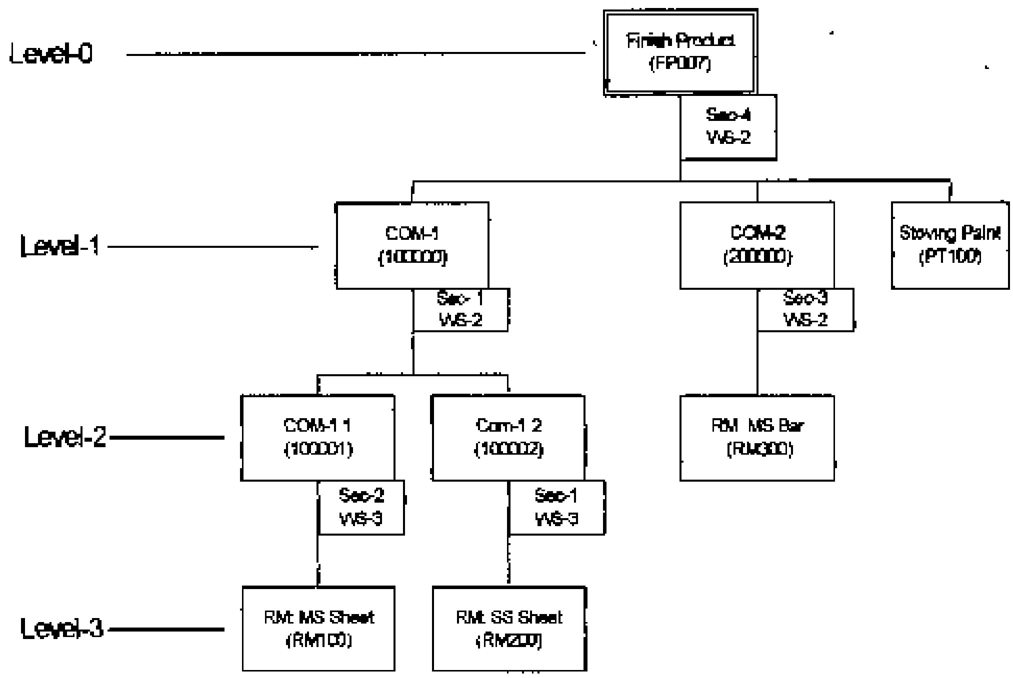

Fig. 3.2: Multi-level Bill of Material

Table 3.1: Multi-level Indented Bill of Material

Level	Item (code)	unit	Quantity
0	Finish Products (FP007)	Pcs	01
1	COM-1 (100000)	Pcs	02
1	COM-2 (200000)	Pcs	01
1	Stoving paint (PT100)	Sft	5
2	COM-1.1 (100001)	Pcs	1
2	COM-1.2 (100002)	Pcs	1
2	RM. MS Bar (RM300)	Rft	6
3	RM. MS Sheet (RM100)	Sft	2
3	RM. SS Sheet (RM300)	Sft	1

3.5.2 Construction Of Modular Bill Of Materials

A modular bill of materials is the tenn for a buildable item that can be produced and stocked as a subassembly [4]. When a product or process is 'modularized' the elements of its design split up and assigned to modules according to a formal product architecture or plan. From an engineering purposes, a modularization generally has three purposes: a).To make complexity manageable; b) To enable parallel works; and c) to accommodate future uncertainly [39]. In this case study, Modular Bill material is prepared by some components redesign, restructure, nature of same functionality, similar operation in similar workstations etc. are considered shown in Fig 3.3. In brief, the research followed three heuristic broad phases [40]:

- identification of modules in an identification of modules in sheet metal product and mapping of function to module for basic 42 products;
- examination of the identified modules for frequency of occurrence;
- cataloging of module-function-from design knowledge;

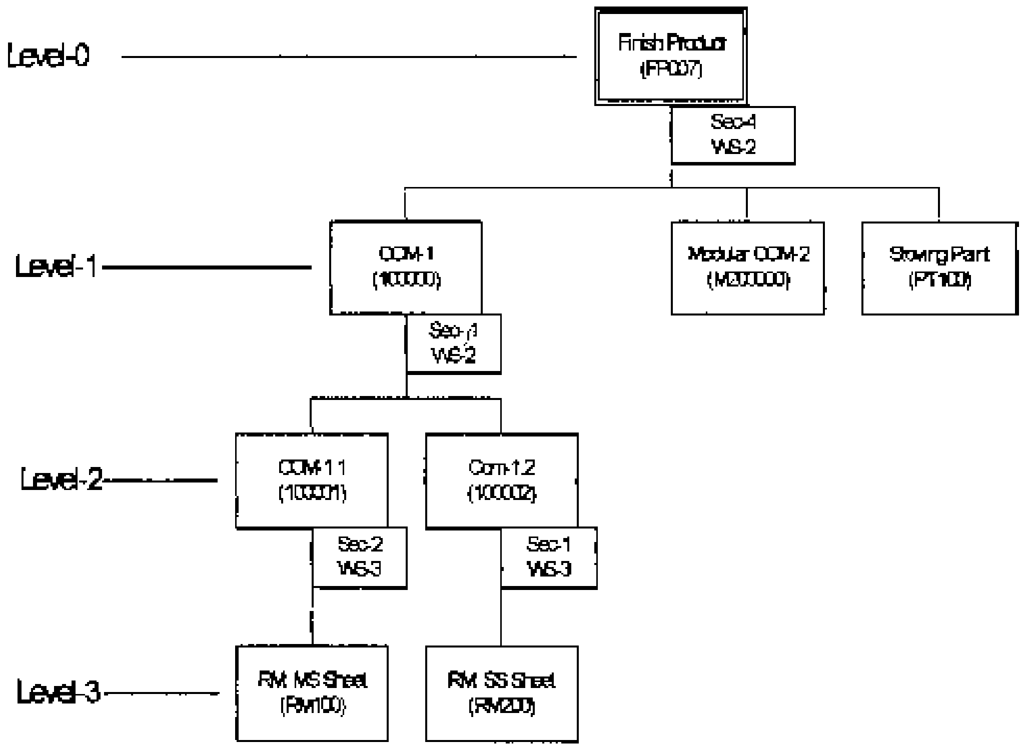

Fig. 3.3: Multilevel Operation-centric Modular Bill of Material

3.5.3 Database Design And Interfacing

The most important part of creating database-driven project is the design of database scheme after preparing the modular Bill of Materials. In brief, the research is using Microsoft Access to prepare the Modular Bill of Materials database. The database programming interfaces uses ADODC, a relatively recent Microsoft technology, with higher-level interface referred to as ActiveX Data Objects [35, 36], using Microsoft Visual Basic Version: 6.0.

As per the steps described in the previous section, case study on the selected organizations has been conducted. The Findings and analysis is presented in the next chapters.

CHAPTER 4

FINDINGS AND ANALYSIS

4.1 INTRODUCTION

This chapter presents the overall findings of the case study. The case study has been conducted in 'OTOBI' that uses the manual material planning. The case study deals with different aspects of the efficient and modern material panning in connection with multilevel heuristic Modular bill of Material technique. Analysis has been performed based on procedure discussed in chapter three. The findings and analysis are presented in the following sections.

4.2 OVERALL FINDINGS FROM THE CASE STUDY

The 'OTOBI Limited' unit-2 metal department, which used normal and conventional planning and scheduling system, faced lot of problems during manufacturing in this regard. The problems encountered in the metal department production area are described below-

4.2.1 Real bill of material is not available

No real bill of material for any sheet metal products like Almira, Filing Cabinet etc was found written in the studied organization. Only a few product-wise drawing files was come across in production office and different sections. Moreover, list of common components used in various products were documented in written form nowhere in the concern department but in the mind of one or two prime persons of the concerning job. This partial documentation was found to be a great problem for a new person to know how many components and quantity is required to manufacture a product or components. Besides, this made it problematic for the concerning production personnel to estimate the real cost of product fabricated. It is, therefore, necessary to formulate the bill of material of all products according to multi-level hierarchical model for the particular department of studied organization for maximization and proper implementations of ERP system.

4.2.2 No process and machine wise workstation

Since no process-wise or machine-wise workstations were defined clearly in the studied organization, it was not possible for the production personnel to prepare the proper scheduling. As a result, most of the time, machine became idle or overloaded. Ultimately, the sheet metal department was not able to meet the delivery lead-time of the customer. For this reason, the studied organization lost some good and big customer. However, though some sections were found in various departments, but it is not sufficient for implementation of customized ERP system. So it is needed to restructure the different sections and to define the workstation according to similarity in operations or process to enhance productivity of man and machine through proper scheduling and to achieve the customer satisfaction as well.

4.2.3 Product architecture modularity is absent

There was no product modularity in the studied organization. That why, number of components required to fabricate a particular product was found to be large in the assembly line. This caused complexity in the assembly line and resulted in long assembly time. It is, therefore, necessary for components/products to be grouped into modular architecture, a one-to-one correspondence between sub-function sets and the components, to reduce the number of components in product and assembly time, and to accelerate the conceptual and embodiment design stages.

4.2.4 Do not use any scheduling technique

In metal department, no technique of productions and operation management was followed for scheduling. As a result, several times, man and machine became idle or overloaded. This, eventually, affected the productivity and delivery lead-time.

4. 2.5 Inadequate and insufficient data and drawing is present

In job floor shop, drawings available were insufficient and inadequate. In this connection, some wrong or poor quality products or components were manufactured.

4.2.6 Job floor shop has not mentioned routing

There were no routing or operations sheets that determine movement of products or components from machine-to-machine, section-to-section and workstation-to-workstation as per the requirements of operations or process. Since this routing was not documented properly in the studied organization, it became difficult for the new persons to run the whole production system. That's why; it is needed to prepare a routing sheet based on multi-level bill of material to avoid all the difficulties related to movement of the components/products and also to maximize the benefits of ERP system.

4.2.7 Do not meet delivery lead time

Due to the aforesaid canses, delivery lead-time failed all the time and customer satisfaction declined time to time. It is, therefore, necessary to solve all those aforementioned causes applying appropriate operations and production management techniques to manufacture quality products and to satisfy the customer requirement in just in time.

4.3 ANALYSIS:

Once the MPS is set, the MRP system accesses the product structure file to determine which component items needed to be needed scheduled. In this connection, it has need to know where and which workstations the component and its item are really build. So for logical manner in ERP software system needs real routing system. In this context, unit-2 reformulated their sections and made workstations for ERP systems on the behavior of product architecture. The reformulated sections and workstations with ERP process code and other related formulated format are shown in Appendices.

4.3.1 Bills of Material

Many complex products that are manufactured or assembled from a large number of components or subassemblies under a so-called make-to-order and make-to-stock environment are usually driven by customer requirements and demand forecasts. Frequently, the diversity of the finished products or subassemblies exceeds the variety of raw materials used. Hence, proper production planning to generate essential information to support production and management decision-making such as procurement from suppliers, and production and shop floor control becomes an important issue that needs special attention. Bill of Material is very important input for Material Requirement Planning (MRP). The product structure file contains a bill of material (BOM) for every item produced.

In a complex manufacturing environment of the metal department 42 basic models of sheet metal product like Almira, File Cabinet and etc., using hierarchical multilevel BOM reflecting different stages of manufacturing. The common database about bill information is used for product costing, material planning, material usage reporting, and lot tracking, analyzing variances and tracking progress through stages of manufacturing.

4.3.2 Development of Modular Bills of Material

Modularity is viewed by Ulrich and Tung [30] as, (i) similarity between the physical and the functional architecture, and (ii), minimization of incidental interactions between physical components. In brief, the research followed three broad phases [40]:

1) identification of modules in sheet metal product and mapping of function to module for basic 42 products;
2) examination of the identified modules for frequency of occurrence;
3) cataloging of module-function-from design knowledge;

Phase 1: Empirical Study Data Collection

Phase one consists of disassembling and cataloging sheet metal products to develop a classification scheme for the types of modules in a system. For the work presented here, 42 basic products were disassembled. A functional model was developed for each product. The functional basis is used to develop the functional modules [41]. The module heuristics are used to classify and recognize modules [32,42].

Phase 2: Exploring Modular Frequency

The next step is to identify the modules that repeat in many products as well as chains of modules appearing frequently in a product function structure. The approach here is to explore the occurrence of modules. The identification of module chains is as follows.

1. Apply the module heuristics to the functional model of each product to identify the various modules in product set
2. Develop a Product-Module matrix and record the presence of a module in a particular product with an 'X' in the corresponding matrix element. For an instance, the Product-Module matrix developed for a set of four consumer products is shown in Table 4.1.

Table 4.1: Product-Module Relationship Step-1

		MODULES																						
PRODUCTS	Product to Module Relationship	KFD Body Assembly Painted	KF Auto Lock Channel Painted	KF Lock Channel Painted	KF Roller Channel (L. inner) Assembly	KF Base Clamp Phosphated	KF Roller Channel (R. inner) Assembly	KF Partition Phosphated	KF Roller Channel (L. Outer) Prepared	Left Stiffener	KF Bottom Front Cover Phosphated	Right Stiffener	KF Roller Channel (R. Outer) Prepared	KF Plastics Stopper	Drawer Assembly painted	Top Assembly Painted	Bottom Assembly Painted	Side Left Assembly Painted	Right Side Assembly Painted	Back Assembly Painted	Roller Pin (Big)	Roller Pin (Small)	Roller Pin (Medium)	Cabinet Lock with Key
	4d-Filing Cabinet				X	X	X	X	X		X		X	X	X	X	X				X	X	X	X
	3d-Filing Cabinet				X	X	X	X	X		X		X	X	X	X	X				X	X	X	X
	2d-Filing Cabinet				X	X	X	X	X		X		X	X	X	X	X				X	X	X	X
	Combined Filing Cabinet		X	X		X		X					X	X	X						X	X	X	X

3. Re-arrange the columns without disturbing the rows to group together the types of modules of interest. The result of rearranging the columns of modules that operate on operations of component is shown in Table 4.2, where multilevel related modules are shown in Modular BOM. Additionally, the modules that operate on material and signal flows may be grouped together.

Table 4.2: Product-Module Matrix: Step-2

[illegible]

The above step groups products based on repeated modules. The presence of repeated or common modules indicates a large similarity between the products that can be enhanced by formally developing a common platform of some kind for this product family.

Phase 3: Cataloging Module-Function-Form Knowledge

An automated or semi-automated design template would enable the quick progression from module to function to component descriptions of a product. To enable such a progression, the existing knowledge can be stored using a module-function component hierarchy.

A module consists of several functions. Each of these functions is solved by some component or components. Shown in Table 4.2 just represents the way of modular product structure was made. In this connection, rest of the components or products modularity is design on the following way for this study. All the components used to solve a particular function from this product group are included in the Table 4.2. These databases of modular BOM allow a quick progression from abstract modular product representations to components that constitute the product.

Finally, Developed module database for different types of products and components deals with similar type, similar operations, similar materials and some times similar sections. It can be reducing the number components in products, reducing assembly time and acceleration the conceptual and embodiment design stages. Table 4.3 shows the 3D-Filing Cabinet Modular multi-level BOM as an example and others are shown in Appendices.

Table 4.3: 3D-Filing Cabinet Multi-level Modular Bill of Material

Level	F.G./Comp Code	Batch Size	Process Code	R.M./P.M./Comp. Code	Description	Unit	R.M./P.M /Comp. Qty
0	FCO P02 MS	1	027	002074	KFC Body Assembly Painted	pcs	1
0	FCO P02 MS	1	027	001906	KF Drawer Front Cover Painted	Pcs	1
0	FCO P02 MS	1	027	001907	KF Drawer Left Side Painted	Pcs	1
0	FCO P02 MS	1	027	001908	KF Drawer Right Side Painted	pcs	1
0	FCO P02 MS	1	027	001909	KF Drawer Bottom Painted	pcs	1
0	FCO P02 MS	1	027	001910	KF Drawer Back Painted	pcs	1
0	FCO P02 MS	1	027	001911	KF Drawer Inside Cover Painted	Pcs	1
0	FCO P02 MS	1	027	001912	KF Drawer Carrier Plate Prepared	pcs	2
0	FCO P02 MS	1	027	001913	KF Carrier Vertical Support Plated	pcs	2
0	FCO P02 MS	1	027	200009	Drawer Plastics Gripper	pcs	1
0	FCO P02 MS	1	027	002095	KFC Auto Lock Channel Painted	pcs	1
0	FCO P02 MS	1	027	002100	KFC Lock Channel Painted	pcs	1
0	FCO P02 MS	1	027	001916	KF Roller Channel (L. Inner) Assembly	pcs	3
0	FCO P02 MS	1	027	001917	KF Roller Channel (R. Inner) Assembly	pcs	3
0	FCO P02 MS	1	027	001918	KF Roller Channel (L. Outer) Assembly	pcs	3
0	FCO P02 MS	1	027	001919	KF Roller Channel (R. Outer) Assembly	pcs	3
0	FCO P02 MS	1	027	MKT	Cabinet Lock With Key	pcs	1
0	FCO P02 MS	1	027	MKT	Self Tapping Screw	pcs	6
1	002074	1	032	002075	KFC Body Assembly	Pcs	1
1	002074	1	032	PT100	Stoving Paint	Sft	70
2	002075	1	011	001921	KF Top Assembly Phosphated	Pcs	1
2	002075	1	011	002076	KFC Left Side Phosphated	Pcs	1
2	002075	1	011	002077	KFC Right Side Phosphated	Pcs	1
2	002075	1	011	002078	KFC Back Phosphated	Pcs	1
2	002075	1	011	001925	KF Base Clamp Phosphated	Pcs	3
2	002075	1	011	001926	KF Partition Phosphated	Pcs	2
2	002075	1	011	001927	KF Bottom Front Cover Phosphated	Pcs	1
2	002075	1	011	W100	Welding Material	Rft	
3	002076	1	030	002077	KFC Left Side Assembly	Pcs	1
3	002076	1	030	PH100	Phosphating Chemical	Sft	20
4	002077	1	011	002078	Left Side M. Body Prepared	Pcs	1
4	002077	1	011	002079	Left Stiffener Prepared	Pcs	1

4	002077	1	011	002080	Central Stiffener (L) Prepared	Pcs	1
4	002077	1	011	W100	Welding Material	Rft	
5	002078	1	012	002081	Left Side M. Body Pre-prepared	pcs	1
6	002081	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	8
5	002079	1	010	002082	Left Stiffener Bended	pcs	1
6	002082	1	012	002083	Left Stiffener Pre-prepared	pcs	1
7	002083	1	010	1101010100081	MS Sheet 0 7 NON STANDARD	Sft	1.6
5	002080	1	012	002084	Central Stffiffener (L) Pre-prepared	pcs	1
6	002084	1	010	1101010100081	MS Sheet 0 7 NON STANDARD	Sft	1
3	002077	1	030	002085	KFC Right Side Assembly	pcs	1
3	002077	1	030	PH100	Phosphating Chemical	Sft	20
4	002085	1	011	002086	Right Side M. Body Prepared	Pcs	1
4	002085	1	011	002087	Right Stiffener Prepared	Pcs	1
4	002085	1	011	002088	Central Stiffener (R) Preppared	Pcs	1
4	002085	1	011	W100	Welding material	Rft	
5	002086	1	012	002089	Right Side M. Body Pre-prepared	pcs	1
6	002089	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	7.6
5	002087	1	010	002090	Right Stiffener Bended	pcs	1.6
6	002090	1	012	002091	Right Stiffener Pre-prepared	pcs	1
7	002091	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	1.55
5	002088	1	012	002092	Central Stiffener (R) Pre-prepared	pcs	1
6	002092	1	010	1101010100081	MS Sheet 0 7 NON STANDARD	Sft	1
3	002078	1	030	002093	KFC Back Prepared	pcs	1
3	002078	1	030	PH100	Phosphating Chemical	Sft	16.4
4	002093	1	012	002094	KFC Back Pre-prepared	pcs	1
5	002094	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	8.2
1	002095	1	032	002096	KFC Auto Lock Channel Assembly	pcs	1
1	002095	1	032	PT100	Stoving Paint	Sft	3.2
2	002096	1	011	002097	KFC Auto Lock Channel Phosphated	pcs	1
2	002096	1	011	330002	KF Auto Lock Bush	pcs	3
2	002096	1	011	330003	KF Auto Lock Screw Plated	pcs	3
2	002096	1	011	MKT	KF Spring Washer and Nut	pcs	3
2	002096	1	011	W100	Welding Material	Rft	
3	002097	1	030	002098	KFC Auto Lock Channel Prepared	pcs	1
3	002097	1	030	PH100	Phosphating Chemical	Sft	1.6
4	002098	1	012	002099	KFC Auto Lock Channel Pre-prepared	pcs	1
5	002099	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	0.55
1	002100	1	032	002101	KFC Lock Channel Phosphated	pcs	1
1	002100	1	032	PT100	Stoving Paint	Sft	4
2	002101	1	030	002102	KFC Lock Channel Assembly	pcs	1
2	002101	1	030	PH100	Phosphating Chemical	sft	4
3	002102	1	011	002103	Lock Channel M. Body Prepared	pcs	1
3	002102	1	011	410102	Lock Channel Clamp Prepared	pcs	1
3	002102	1	011	W100	Welding Material	Rft	
4	002103	1	012	002104	Lock Channel M Body Pre-prepared	pcs	1
5	002104	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	0.66

In this chapter overall findings, Bill of material and Modular Bill of Materials have been discussed. The next chapter presents the database design and interfacing with customized ERP software.

CHAPTER 5

DATABASE DESIGN AND INTERFACING

5.1 INTRODUCTION

In this chapter of thesis paper, modular bill of material database are design. In this connection, using Microsoft Access database to prepared Modular BOM database. Finally, Microsoft Visual Basic 6.0 performs interfacing to Modular BOM database.

5.2 DATABASE DESIGN FOR MODULAR BOM

Modular BOM database is very important part of Materials Requirement Planning. The objective of developed Modular BOM database is to help the customized ERP software that both stores component data in intermediate and final stage and supports calculations being performed by the material requirement planning.

New data types that are being added as part of the current status of the component and finish products. The database is also being modified to support calculated quantities that can be compared directly with observations. The database system is being constructed using a three-tiered design. These three tiers can be described as-

1. Data – relational database tables and files in which all of the information about the finish products, components and raw materials and calculations are maintained
2. Analysis – all database queries, file reading/writing operations, and all calculations and analysis that are performed on the data.
3. User interface – creates all user displays and maintains all interactions with the user,

   and customized ERP software.

The system is being designed initially to use a Microsoft Access database, however we are also testing the system using an Excel database. The flow chart of the Modular BOM database shown in Fig. 5.1.

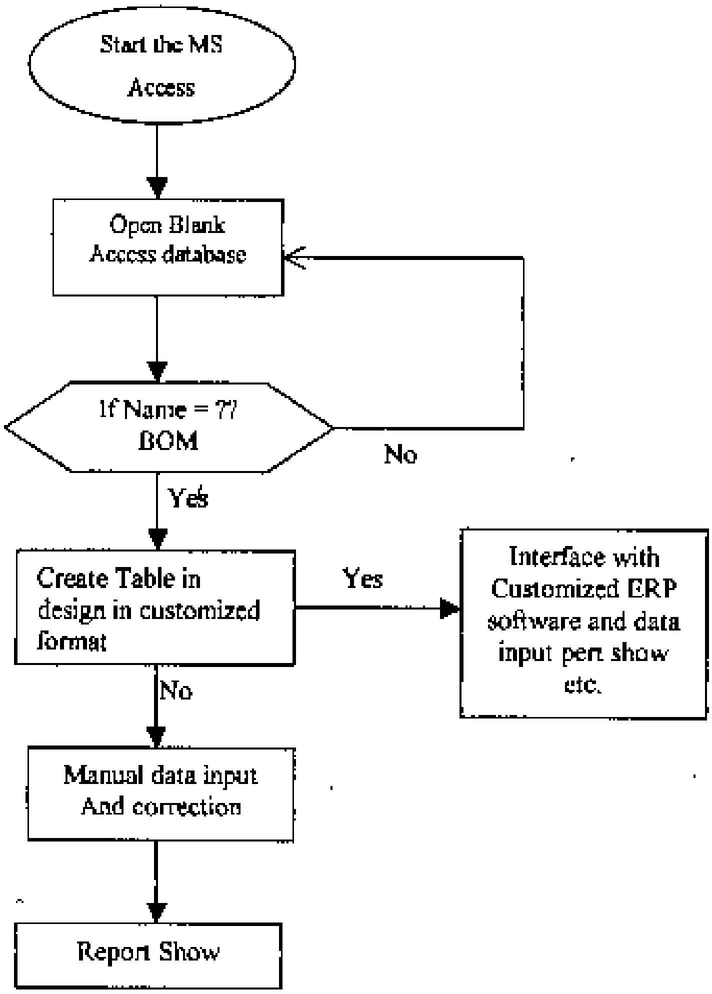

Fig.5.1: Modular BOM database Flowchart

During prepared the Modular Bill of Material Access database following step are followed:

1. At First prepare code and level database of finish products as well as finish components in the concern of multi-level hierarchical bill of material approach shown in Fig 5.2

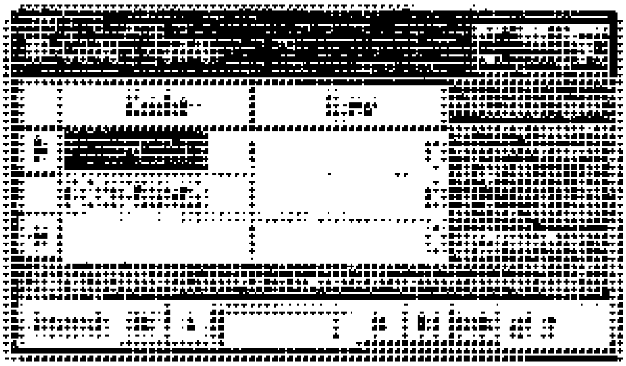

Fig 5.2: Finish Goods/RM Componet Level

2. And then prepared the Finish Goods and finish components access database shown in Fig. 5.3. Component Code, Components Name, Level, Quantity and units are represents in Finish Goods Access Database

Fig 5.3: Finsh Goods or Finish Components Table

3. And finally prepared the Raw material, finish components modular bill of Material database shown in Fig 5.4. RM PM Modular Bill of Material Database Table represents level, Finish Goods Code, Batch Code, Process Code, RM/PM/Comp. Code and Components Description, quantity and units.

RM PM : Table

Lev	F G Code	Batch Size	Process Code	RM or PM Cod	
0	FCOP03MS	1	027	001905	KFD Boc
0	FCOP02MS	1	027	001906	KF Draw
0	FCOP02MS	1	027	001907	KF Draw
0	FCOP02MS	1	027	001908	KF Draw
0	FCOP02MS	1	027	001909	KF Draw
0	FCOP02MS	1	027	001910	KF Draw
0	FCOP02MS	1	027	001911	KF Draw
0	FCOP02MS	1	027	001912	KF Draw
0	FCOP02MS	1	027	001913	KF Draw
0	FCOP02MS	1	027	001916	KF Rolle
0	FCOP03MS	1	027	001917	KF Rolle
0	FCOP02MS	1	027	001918	KF Rolle
0	FCOP02MS	1	027	001919	KF Rolle
2	002075	1	011	001921	KF Top /
2	002075	1	011	001925	KF Base
0	FCOP02MS	1	027	002074	KFC Boc
1	002074	1	032	002075	KFC Boc
2	002076	1	011	002076	KFC Lo[illegible]

Record: 1 of 26

Fig 5.4: Modular Bill of Materials Access Database

5.3 DATABASE INTERFACING

Modular BOM Database Interfacing is very important function for material requirement planning. The database-programming interface uses ADODC, a relatively recent Microsoft technology, with a higher-level interface referred to as ActiveX Data Objects (ADO), using Microsoft Jet 4.0 interface string shown in Fig. 5.5, which is a very efficient database interface string in Microsoft Visual Basic. ADO is a better choice than other methods (for example, the earlier DAO (Data Access Objects) and ODBC access methods) since it has higher performance drivers, and is the database access method that Microsoft will be using in the future in all of its products. In initial experiments with ADO, it have found that it can use it successfully with all of the development tools, and that it is generally simpler than the earlier methods, particularly for accessing multiple types of databases. It has successfully retrieved data from databases in Microsoft Access with only minor changes in code. With such a huge complex parts Modular BOM database of Metal Department, studied organization also wanted

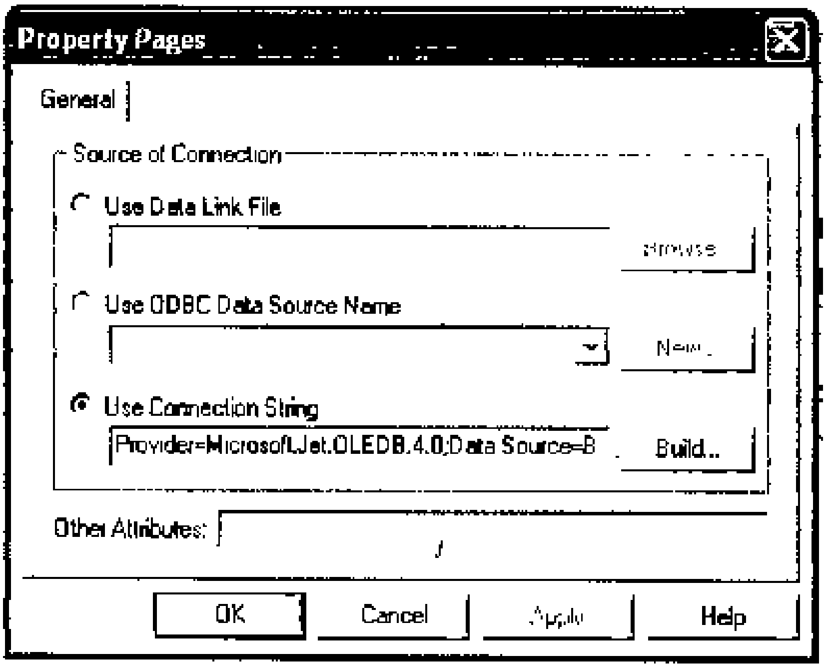

Fig 5.5: Main Interfacing Table

an interface that was compatible with Microsoft Access and Microsoft Visual Basic. It was beneficial for Metal department all sheet metal products to be able to store all the parts in a Microsoft Access database. Because of these requirement, prepared modular BOM database interfaces with customized ERP system operator interface software with Microsoft Visual Basic 6.0. Customized ERP software is designed for developing and running data acqnisition and control applications on all items of the modern ERP system, which is helpful to OTOBI limited.

During the interfacing with Modular BOM database, some forms are prepared for user free data input, report showing, searching etc. To crate a data link, followed steps are following:

1. Make new Main Form named Bill of Material, where Search and new data entry form is build shown in Fig 5.6.

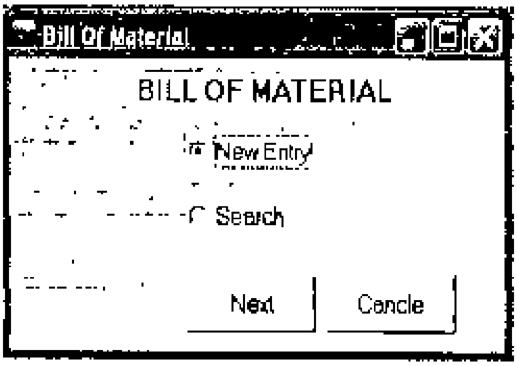

Fig 5.6: Main Form of Bill of Material

2. If Select Search open search form shown in Fig. 5.7, then Searching object search by code after that build a report is shown in Fig 5 8 to Fig 5.10 and alternatively Searching object search by level after that build a report is shown in Fig 5.11 to Fig. 5.13. In this connection, searching option are select, searching are data extracted from Modular BOM database different tables by ADODC interfacing technique.

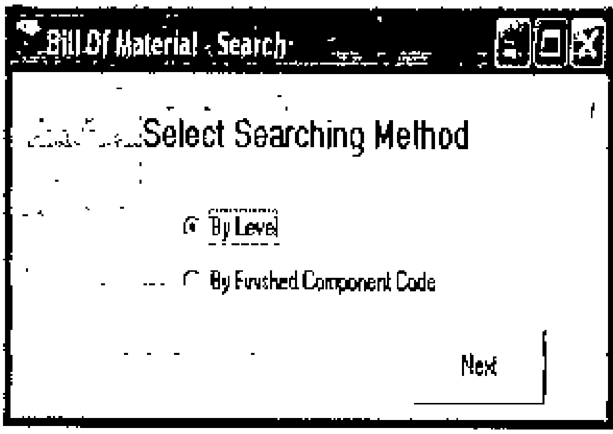

Fig. 5.7: Bill of Material Search Form

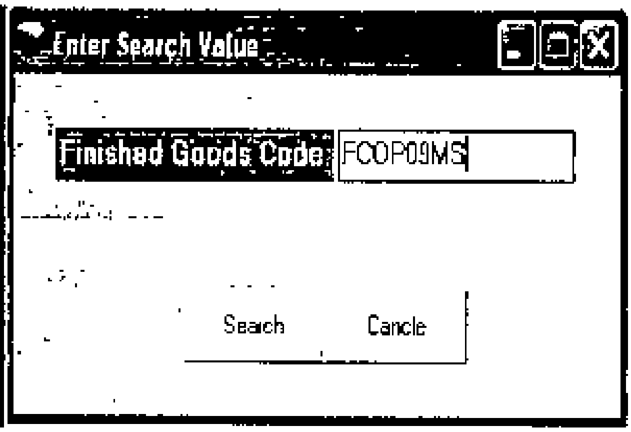

Fig. 5.8: Finish Goods Search Value Form

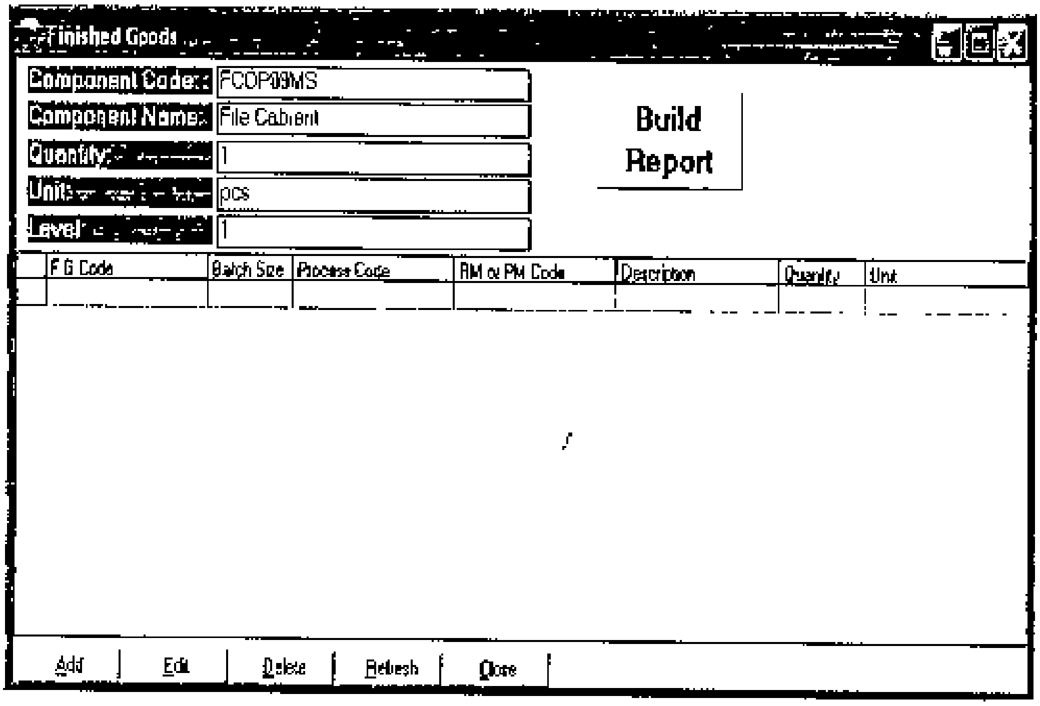

Fig. 5.9: Finish Good Search Result From

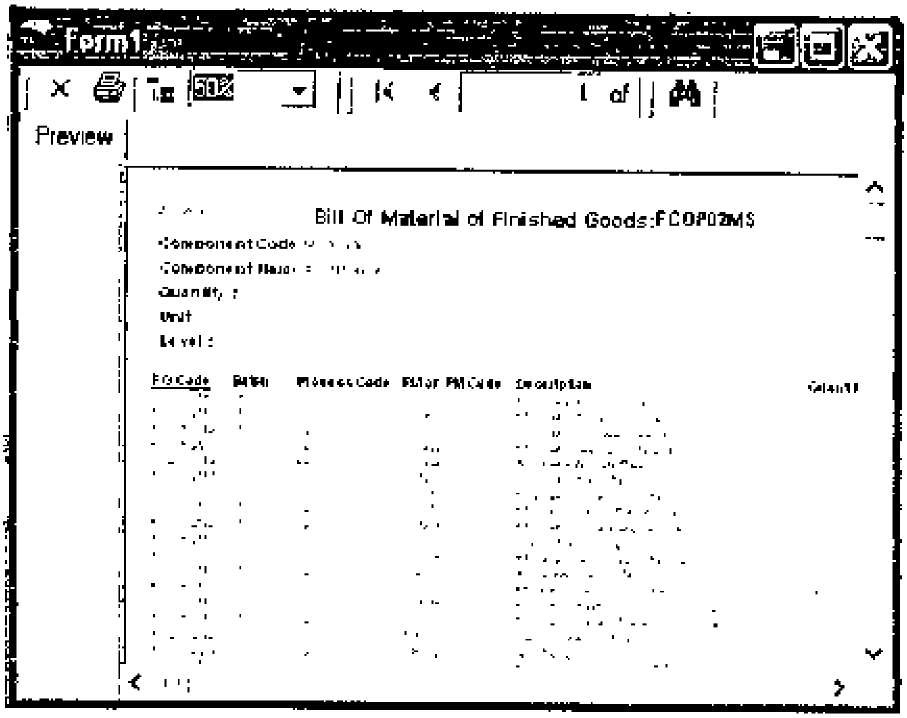

Fig 5.10: Finish Good Searching Report From

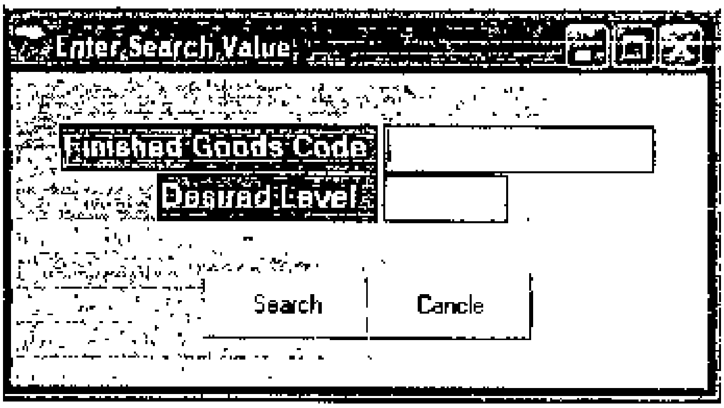

Fig. 5.11: Finish Goods Level Search Form

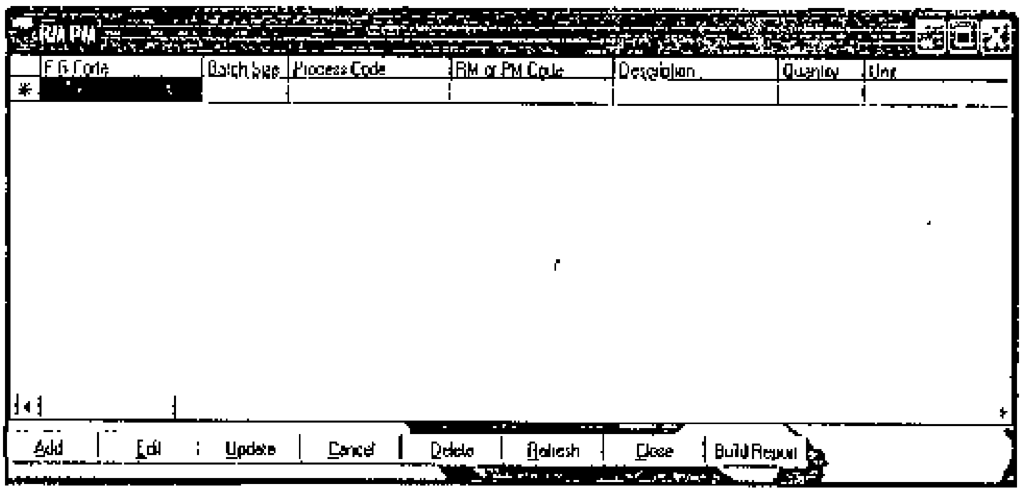

Fig. 5.12: RM/PM/Comp. Level Search Result From

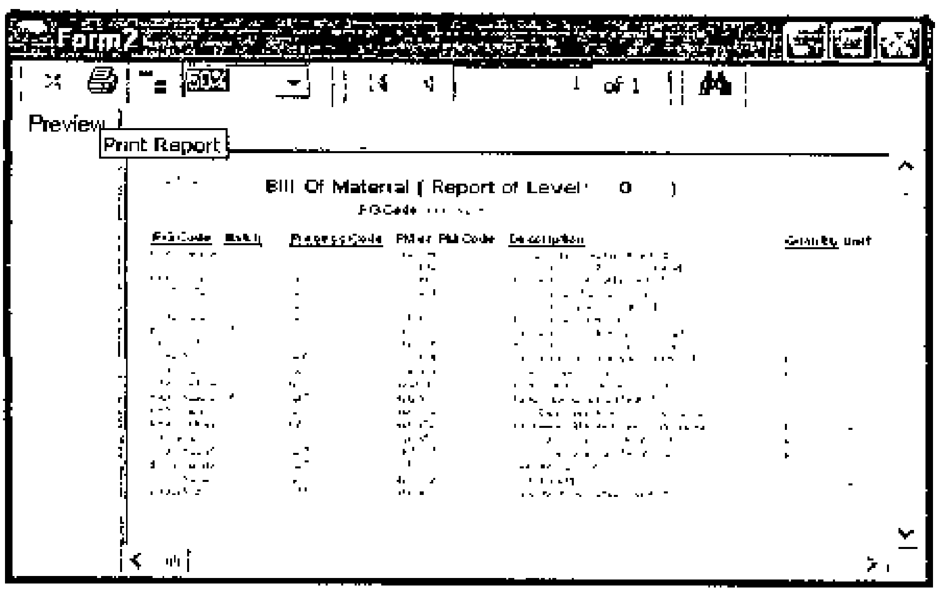

Fig 5.13: RM/PM/Comp. Level Search Report Form

3. If Select new data entry, then it opens the Level forms is shown in Fig 5.14. After data entries in level form then Finish Goods forms (data entry fields finish goods code, description, quantity and units) are open is shown in Fig 5.15 and these entered data are stored in the Finish goods Table in Modular BOM access database by the ADODC interfacing technique. And then RM PM forms (data entry fields Batch Size, Process Code, RM/PM/Component Code, description, quantity and units) are opened is shown in Fig 5.16, it also contains add (New entry), Update (update data), refresh Button features are presence for user friendly and these entered data are stored in the RM PM Table in Modular BOM access database by the ADODC interfacing technique.

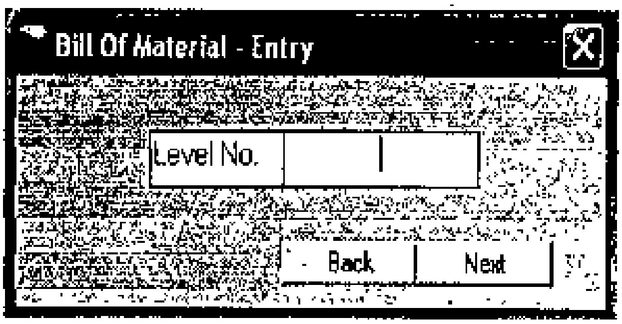

Fig. 5.14: Level Entry Form

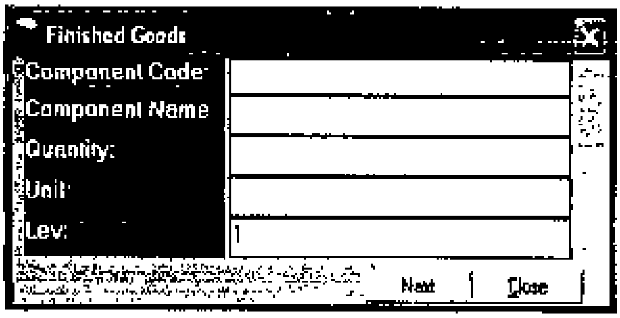

Fig. 5.15: Finish Goods Entry Form

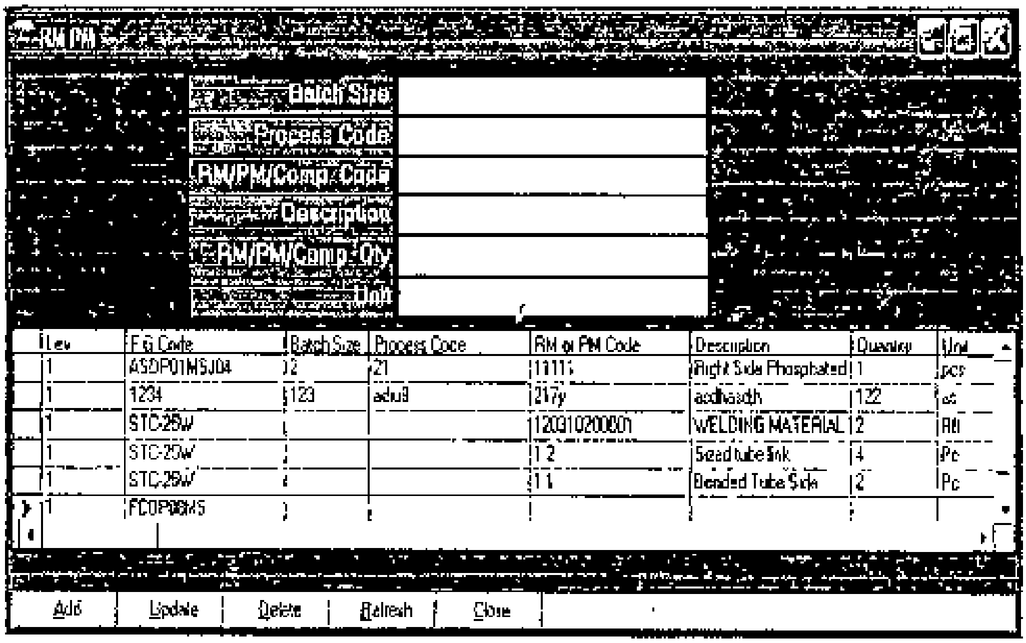

Fig. 5.16: RM/PM/Component Entry Form

Users can access the parts database through customized ERP software. With one mouse click, users can pull up custom forms developed in VBA that allow the user to easily add, change, or delete parts data, in addition to scroll through the complete parts database. Changes that users make to the database at the operator interface station are then automatically re-saved directly to Access database, eliminating the need to update stations independently.

Customized ERP also offers users an additional option that gives user additional information on their product real status. A VBA-developed custom form allows users to automatically generate reports. Users can save the pertinent part information with the processing condition to a second, Modular BOM Access database, and print out a complete report about how the process ran and how particular parts performed. This gives user a custom report based on their specific job or products

The next chapter presents conclusions of the thesis and recommendations for the future work

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSION

As the business world moves ever closer to a completely collaborative model and competitors upgrade their capabilities, to remain competitive, organizations must improve their own business practices and procedures. Companies must also increasingly share with their suppliers, distributors, and customers the critical in-house information they once aggressively protected. And functions within the company must upgrade their capability to generate and communicate timely and accurate information. To accomplish these objectives, companies are increasingly turning to enterprise resource planning (ERP) systems. This is for the reasons, this case study was undertaken primarily to make an overview of the present status of sheet metal products structure of Metal Department for successful ERP implementations in OTOBI. For the ease of ERP implementations, database for Modular Bill of Materials was prepared and also interfaced with customized ERP software. The analysis, Modular BOM database, interface etc. are, therefore based on data and information gathered from this company. On careful analysis of the findings the following conclusions can be made:

1. In this work, a modular focused design template is proposed. A specific methodology for developing design templates is presented. This template is based on the similar sheet thickness, similar type, similar operations, similar materials and some times similar sections etc. through a product or component. The template utilizes design knowledge both in the form of modular architectures and specific component solutions. It is shown that by grouping individual product or components into module chains and creating a generic design template, conceptual design and embodiment design can be performed

as a simultaneous process with a natural focus on modular design. The case of integrated different types of filing cabinet is presented as an example. The design template provides functional and component information of all the products in a product family. The current work has been carried out over a set of 42 consumer products belonging to the four classes namely Almira, Filing Cabinet, Lockers and Racks.

2. The modular BOM database system is information-processing tool, which helps to decision making in Production planning. It indicates that which amount of finished products or components can or cannot be produced at a specific time bucket according to the existing material availability, and the amount of material shortfall. Because of its ability to provide several production solutions when new customer orders arrived, it is supposed to have a favorable impact on the decision-making process and the quality of the resulting decision for production planners, sales personnel, and department managers in the manufacturing enterprises. The proposed system captures the transition of traditional production planning systems to the new ERP systems that cater to the demands of highly diversified users. This modular design approach may provide economies of scale; reduced development time; reduced order lead-time; and easier product diagnostics, maintenance, and repair.

3. Database development focused primarily on development of low-level database access functions, and prototyping to resolve design issues relating to database access, graphical displays, and user interface. Modular BOM database access issues have been resolved, and focused on the development of the user interface, development of middle tier components for connecting the database and data to the user interface, and additional development of graphical displays in the next step. The first phase of the project conceotrated on important low level details and de sign decisions. A prototype cootaining more complete modules is now under development.

6.3 RECOMMENDATIONS FOR FURTHER STUDY

Based on the present thesis work, further study can be done on OTOBI limited in different dimensions in the future. Some of them are presented below: -

1. An important future work would be developing dynamic BOM - based available-to-promise system. Web-enhanced dynamic BOM-based available-to-promise (ATP) system, which provides manufacturing companies with the ability to support the decision made by production planners and managers. With the advent of Internet technologies, the proposed Web-enhanced dynamic BOM-based ATP system is simple to use and user-friendly. It supports centric management and can easily integrate with other applications.

2. The mathematical model may be further extended by incorporating other technological, financial and organizational constraints like a novel Approach to ATP and development of new heuristic algorithm.

3. A work can be carried out to apply oracle or MS SQL server data management packages for the creation and updating the database in large volume.

4. The process or workstations effectiveness can be further restructured by machine wise process or workstation setup and generating various work center in each workstations for how a products is really build in actual time.

5. An important part of the further study to identify ways to minimize the amount of code development required through a combination of the use of commercial components and development of a well organized set of middle tier components.

6. Future work may be directed in transmission of the proposed ERP system into an expert system SAP-R/3. In this regard work of Schumann [58] shows that With novel module PP-PI, the standard software SAP-R/3 offers the opportunity to control and coordinate business processes on the plant floor. The

functionality of this module covers different working fields such as material management, process order management, inventory management, and quality management and it contains some elements of batch control. SAP also offers standard interfaces to lower level systems, as DCS or LIMS. Altogether it may be considered as backbone of a Manufacturing Execution System (MES) with strong integration into the business world.

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2. Workstations-wise routing sheet

OTOBI LIMITED www.otobi.com	for Metal Department	*Operation Sheet* **OP-02**

Sheet ID:	Finished Component Code		Date
Finished Product Name:	Unit: Pcs	Quantity: 01	Dwg No.
Materials'/Components' Codes: (1)	(2)	(3) (4)	Size

Operation									Movement				Time Req.		Man Power			Man Hr		
Op. No	Operation Description	F.Unit	Dept	Section	Station	M/C	Tools	Jigs & Fixture	F.Unit	Dept	Section	Station	Setup time (sec)	Machine time (sec)	L1	L2	L3	L1	L2	L3
	Total Operation Time:												0	0						

APPENDIX

Table 1. Workstations and Process Code

Unit	Department	Section	Workstations	Nature of Work	WS Process Code
2	Metal	Slitting	1	slitting operation	008
2	Metal	Tube mill	1	tube making	009
2	Metal	Sheet Metal	1	Metal Forming, Punching, Shearing	010
2	Metal	Sheet Metal	2	Welding, Grinding, Lock Fitting, Grinding	011
2	Metal	Sheet Metal	3	Sheet Bending	012
2	Metal	Press	1	Sheet Shearing	013
2	Metal	Press	2	Deep Drawing	014
2	Metal	Press	3	Press	015
2	Metal	Press	4	Tapping	016
2	Metal	M/C Shop	1	Capstan Lathe	017
2	Metal	M/C Shop	2	Auto lathe	018
2	Metal	M/C Shop	3	Manual Lathe	019
2	Metal	M/C Shop	4	Center Lathe	020
2	Metal	M/C Shop	Dummy 5	Miscellaneous (M/C Shop)	021
2	Metal	fabrication	1	tube cutting, bench grinding, tapering	022
2	Metal	fabrication	2	tube bending	023
2	Metal	fabrication	3	welding, punching, Drilling, Hand grinding, Polishing, leveling	024
2	Metal	fabrication	4	tube riveting	025
2	Metal	Assembly	1	Cutting, Grinding, Drilling, Straightening, welding, Polishing	026
2	Metal	Assembly	2	FC, Almirah assembling	027
2	Metal	Assembly	3	Hospital Item assembling, Bench Work	028
2	Metal	Assembly	4	Miscellaneous (Assembly)	029
2	Metal	Surface Treatment	1	Phosphating (Metal)	030
2	Metal	Surface Treatment	2	electroplating	031
2	Metal	Painting	1	Stoving Painting	032
2	Metal	Painting	2	Powder Painting	033
2	Plastic	Processing	1	Injection Moulding	034
2	Plastic	Assembly	1	Assembling Operations (Plastic Assembling)	035
2	Tool Making	Tool Making	1	Tool Making	036

Table 3. Multi-Level Modular Bill of Material of 4D Filing Cabinet

Level	F.G. (Comp/ Sub Output)	Batch Size	Process Code	RM/Comp. Code	Description	Unit	Qty
0	FCO P03 MS	1	027	001905	KFD Body Assembly Painted	pcs	1
0	FCO P03 MS	1	027	001914	KF Auto Lock Channel Painted	pcs	1
0	FCO P03 MS	1	027	001915	KF Lock Channel Painted	pcs	1
0	FCO P03 MS	1	027	001916	KF Roller Channel (L. inner) Assembly	pcs	4
0	FCO P03 MS	1	027	001917	KF Roller Channel (R. inner) Assembly	pcs	4
0	FCO P03 MS	1	027	001918	KF Roller Channel (L. Outer) Prepared	pcs	4
0	FCO P03 MS	1	027	001919	KF Roller Channel (R. Outer) Prepared	pcs	4
0	FCO P03 MS	1	027	720000	KF Plastics Stopper	pcs	4
0	FCO P03 MS	1	027	MKT	Cabinet Lock With Key	pcs	1
0	FCO P03 MS	1	027	001906	KF Drawer Front Cover Painted	Pcs	4
0	FCO P03 MS	1	027	001907	KF Drawer Left Side Painted	Pcs	4
0	FCO P03 MS	1	027	001908	KF Drawer Right Side Painted	pcs	4
0	FCO P03 MS	1	027	001909	KF Drawer Bottom Painted	pcs	4
0	FCO P03 MS	1	027	001910	KF Drawer Back Painted	pcs	4
0	FCO P03 MS	1	027	001911	KF Drawer Inside Cover Painted	Pcs	4
0	FCO P03 MS	1	027	001912	KF Drawer Carrier Plate Prepared	pcs	8
0	FCO P03 MS	1	027	001913	KF Carrier Vertical Support Plated	pcs	8
0	FCO P03 MS	1	027		Drawer Plastics Gripper	pcs	4
0	FCO P03 MS	1	027	MK3	Self Tapping Screw	pcs	8
1	001905	1	032	001920	KF Body Assembly	pcs	1
1	001905	1	032	PT100	Stoving Paint	Sft	85
2	001920	1	010	001921	KF Top Assembly Phosphated	Pcs	1
2	001920	1	010	001922	KF Left Side Phosphated	Pcs	1
2	001920	1	010	001923	KF Right Side Phosphated	Pcs	1
2	001920	1	010	001924	KF Back Phosphated	Pcs	1
2	001920	1	010	001925	KF Base Clamp Phosphated	Pcs	4
2	001920	1	010	001926	KF Partition Phosphated	Pcs	3
2	001920	1	010	001927	KF Bottom Front Cover Phosphated	Pcs	1
2	001920	1	010	W100	Welding Material	Rft	
3	001921	1	030	001928	KF Top Assembly	Pcs	1
3	001921	1	030	PH100	Phosphating Chemical	Sft	10
4	001928	1	011	001929	KF Top M. Body Prepared	Pcs	1
4	001928	1	011	001930	KF Left Angle of Top Prepared	Pcs	1
4	001928	1	011	001931	KF Right Angle of Top Prepared	Pcs	1
4	001928	1	011	001932	KF Back Angle of Top Prepared	Pcs	1
4	001928	1	011	001933	KF Front Angle of Top Prepared	Pcs	1
4	001928	1	011	001934	KF Central Stiffener Prepared	Pcs	1
4	001928	1	011	001935	L-clamp (Left) Plated	Pcs	1
4	001928	1	011	001936	L-clamp (Right) Plated	Pcs	1
4	001928	1	011	W100	Welding Material	Rft	
5	001929	1	012	001937	KF Top M. Body Pre-prepared	pcs	1
6	001937	1	010	001938	KF Top M. Body Punched	pcs	1

7	001938	1	015	001939	KF Top M. Body Sheared	Sft	1
8	001939	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	4.1
5	001930	1	015	001940	Left Angle Blanked (Top)	pcs	1
6	001940	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	0.2
5	001931	1	015	001941	Right Angle Blanked (Top)	pcs	1
6	001941	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	0.2
5	001932	1	015	001942	Back Angle Blanked (Top)	pcs	1
6	001942	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	0.18
5	001933	1	012	001943	KF Front Angle of Top Pre-prepared	pcs	1
6	001943	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	0.18
5	001934	1	012	001944	Central Stiffener Pre-prepared	pcs	1
6	001944	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	0.45
5	001935	1	031	001945	L-clamp (Left) Prepared	pcs	1
5	001935	1	031	PH200	Plating Chemical	Sft	0.4
6	001945	1	015	001946	L-clamp (Left) Blanked	pcs	1
7	001946	1	010	110101010024 7	MS Sheet 2.0 NON STANDARD	Sft	0.18
5	001936	1	031	001947	L-clamp (Right) Prepared	pcs	1
5	001936	1	031	PH200	Plating Chemical	Sft	0.4
6	001947	1	015	001948	L-clamp (Right) Blanked	pcs	1
7	001948	1	010	110101010024 7	MS Sheet 2.0 NON STANDARD	Sft	0.18
3	001922	1	030	001949	KF Left Side Assembly	Pcs	1
3	001922	1	030	PH100	Phosphating Chemical	Sft	28
4	001949	1	011	001950	Left Side M. Body Prepared	Pcs	1
4	001949	1	011	001951	Left Stiffener Prepared	Pcs	1
4	001949	1	011	001952	Central Stiffener (L) Prepared	Pcs	1
4	001949	1	011	W100	Welding Material	rft	
5	001950	1	012	001953	Left Side M. Body Pre-prepared	pcs	1
6	001953	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	9.76
5	001951	1	010	001954	Left Stiffener Bended	Pcs	1
6	001954	1	012	001955	Left Stiffener Pre-prepared	pcs	1
7	001955	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	2.1
5	001952	1	012	001956	Central Stiffener (L) Pre-prepared	pcs	1
6	001956	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	1.4
3	001923	1	030	001957	KF Right Side Assembly	Pcs	1
3	001923	1	030	PH100	Phosphating Chemical	Sft	2.8
4	001957	1	011	001958	Right Side M. Body Prepared	Pcs	1
4	001957	1	011	001959	Right Stiffener Prepared	Pcs	1
4	001957	1	011	001960	Central Stiffener (R) Prepared	Pcs	1
4	001957	1	011	W100	Welding Material	rft	
5	001958	1	012	001961	Right Side M. Body Pre-prepared	pcs	1
6	001961	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	9.76
5	001959	1	010	001962	Right Stiffener Bended	pcs	1

6	001962	1	012	001963	Right Stiffener Pre-prepared	pcs	1
7	001963	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	2.1
8	001960	1	012	001964	Central Stiffener (R) Pre-prepared	pcs	1
6	001964	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	1.4
3	001924	1	030	001965	KF Back Prepared	pcs	1
3	001924	1	030	PH100	Phosohating Chemical	Sft	22
4	001965	1	012	001966	KF Back Pre-prepared	pcs	1
5	001966	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	10.6
3	001925	1	030	001967	Base Clamp Prepared	pcs	1
3	001925	1	030	PH100	Phosohating Chemical	Sft	0.3
4	001967	1	015	001968	Base Clamp Sheared	pcs	1
5	001968	1	013	110101010020 6	MS Sheet 1.6 NON STANDARD	Sft	0.15
3	001926	1	030	001969	KF Partition Prepared	Pcs	1
3	001926	1	030		Phosphating Chemical	Sft	0.8
4	001969	1	015	001970	KF Partition sheared	pcs	1
5	001970	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	0.4
3	001927	1	030	001971	KF Bottom Front Cover Prepared	pcs	1
3	001927	1	030	PH100	Phosphating Chemical	Sft	0.2
4	001971	1	012	001972	KF Bottom Front Cover Pre-prepared	pcs	1
5	001972	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	0.1
1	001906	1	032	001973	KF Drawer Front Cover Phosphated	pcs	1
1	001906	1	032	PT100	Powder Paint	Sft	8
2	001973	1	030	001974	KF Drawer Front Cover Assembly	pcs	1
2	001973	1	030	PH100	Phosphating Chemical	Sft	8
3	001974	1	011	001975	KF Drawer Front Cover Body Prepared	pcs	1
3	001974	1	011	001976	KF Drawer Front Stiffener Prepared	pcs	1
3	001974	1	011	W100	Welding Material	Rft	
4	001975	1	015	001977	KF Drawer Front Cover Body Pre-prepared	pcs	1
5	001977	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	1.9
4	001976	1	015	001978	KF Drawer Front Stiffener Pre-prepared	Sft	1
5	001978	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	0.2
1	001907	1	032	001979	KF Drawer Left Side Phosphated	pcs	1
1	001907	1	032	PT200	Powder Paint	Sft	6
2	001979	1	030	001980	KF Drawer Left Side Assembly	pcs	1
2	001979	1	030	PH100	Phosphating Chemical	Sft	6
3	001980	1	011	001981	KF Drawer Left Side Main Body Prepared	Pcs	1
3	001980	1	011	001988	Tri-angular Clamp	Pcs	1
3	001980	1	011	001989	Rectangular Clamp	Pcs	1
3	001980	1	011	001982	Side Roller Guide	Pcs	1
3	001980	1	011	001990	Z-section Prepared	Pcs	1
3	001980	1	011	W100	Welding Material	Rft	
4	001981	1	012	001983	KF Drawer Left Side Main Body Pre-prepared	pcs	1

5	001983	1	010	1101010100081	MS Sheet 0 7 NON STANDARD	Sft	1.4
5	001983	1	012	001984	Side Roller Guide Pre-prepared	pcs	1
6	001984	1	010	1101010100081	MS Sheet 0 7 NON STANDARD	Sft	0.25
1	001908	1	032	001985	KF Drawer Right Side Phosphated	pcs	1
1	001908	1	032	PT200	Powder Paint	Sft	6
2	001985	1	030	001986	KF Drawer Right Side Assembly	pcs	1
2	001985	1	030	PH100	Phosphating Chemical	Sft	6
3	001986	1	011	001987	KF Drawer Right Side Main Body Prepared	Pcs	1
3	001986	1	011	001988	Tri-angular Clamp	Pcs	1
3	001986	1	011	001989	Rectangular Clamp	Pcs	1
3	001986	1	011	001990	Z-section Prepared	Pcs	1
3	001986	1	011	W100	Welding Material	Rft	
4	001987	1	012	001991	KF Drawer Right Side Main Body Pre-prepared	pcs	1
5	001991	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	1 4
4	001988	1	015	001992	Tri-angular Clamp Sheared	pcs	1
5	001992	1	013	1101010100165	MS Sheet 1 2 NON STANDARD	Sft	0.03
4	001989	1	015	001993	Rectangular Clamp Sheared	pcs	1
5	001993	1	013	1101010100165	MS Sheet 1.2 NON STANDARD	Sft	0 02
4	001990	1	015	001994	Z- Section Blanked	pcs	1
5	001994	1	010	1101010100165	MS Sheet 1.2 NON STANDARD	Sft	
1	001909	1	032	001995	KF Drawer Bottom Phosphated	pcs	1
1	001909	1	032	PT200	Powder Paint	Sft	5.5
2	001995	1	030	001996	KF Drawer Bottom Prepared	pcs	1
2	001995	1	030	PH100	Phosphating Chemical	Sft	5.5
3	001996	1	012	001997	KF Drawer Bottom Pre-prepared	pcs	1
4	001997	1	010	1101010100081	MS Sheet 0 7 NON STANDARD	Sft	2 7
1	001910	1	032	001998	KF Drawer Back Phosphated	pcs	1
1	001910	1	032	PT200	Powder Paint	Sft	1.6
2	001998	1	030	001999	KF Drawer Back Prepared	pcs	1
2	001998	1	030	PH100	Phosphating Chemical	Sft	1.6
3	001999	1	010	002000	KF Drawer Back Bended	pcs	1
4	002000	1	012	002001	KF Drawer Back Pre-prepared	pcs	1
5	002001	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	0 8
1	001911	1	032	002002	KF Drawer Inside Cover Phosphated	pcs	1
1	001911	1	032	PT200	Powder Paint	Sft	3
2	002002	1	030	002003	KF Drawer Inside Cover Prepared	pcs	1
2	002002	1	030	PH100	Phosphating Chemical	Sft	3
3	002003	1	015	002004	Drawer Inside Cover Blanked	pcs	1
4	002004	1	010	1101010100081	MS Sheet 0 7 NON STANDARD	Sft	1.5
1	001912	1	031	002005	KF Drawer Carrier Plate Prepared	pcs	1
1	001912	1	031	PH200	Plating Chemical	Sft	0 18
2	002005	1	015	002006	KF Drawer Carrier Plate Blanked	pcs	1

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3	002006	1	013	110101010024 7	MS Sheet 2 0 NON STANDARD	Sft	0 09
1	001913	1	031	002007	KF Carrier Vertical Support Prepared	Pcs	1
1	001913	1	031	PH200	Plating Chemical	Sft	0.14
2	002007	1	015	002008	KF Carrier Vertical Support Sheared	Pcs	1
3	002008	1	013	110101010024 7	MS Sheet 2 0 NON STANDARD	Sft	3
1		1	034	PLATIC	LDPE	gm	5
1	001914	1	032	002009	KF Auto Lock Channel Assembly	Pcs	1
1	001914	1	032	PT100	Stoving Paint	Sft	3.2
2	002009	1	011	002010	KF Auto Lock Channel Phosphated	pcs	1
2	002009	1	011		KF Auto Lock Bush	pcs	4
2	002009	1	011	002011	KF Auto Lock Screw Plated	pcs	4
2	002009	1	011	MKT	KF Spring Waser & Nut	pcs	4
2	002009	1	011	W100	Welding Material	Rft	
3	002010	1	030	002012	KF Auto Lock Channel Prepared	pcs	1
3	002010	1	030		Phosphating Chemical	Sft	1.6
4	002012	1	012	002013	KF Auto Lock Channel Pre-prepared	pcs	1
5	002013	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	0 8
1		1	034		HDPE!!!!	gm	5
1	002011	1	031	002014	KF Auto Lock Screw Prepared	Pcs	1
1	002011	1	031	P1200	Plating Chemical	Sft	0.18
2	002014	1	015	002015	KF Auto Lock Screw Drilled	pcs	1
3	002015	1	019	002016	KF Auto Lock Screw Parted	pcs	1
4	002016	1	017	110101040000 7	MS ROUND BAR 10 MM	rft	0.09
1	001915	1	032	002017	KF Lock Channel Phosphated	pcs	1
1	001915	1	032	PT100	Stoving Paint	Sft	4
2	002017	1	030	002018	KF Lock Channel Assembly	pcs	1
2	002017	1	030	PH100	Phosphating Chemical	Sft	4
3	002018	1	011	002019	Lock Channel M. Body Prepared	pcs	1
3	002018	1	011	002020	Lock Channel Clamp Prepared	pcs	4
3	002018	1	011	W100	Welding Material	Rft	
4	002019	1	012	002021	Lock Channel M. Body Pre-prepared	pcs	1
5	002021	1	010	110101010008 1	MS Sheet 0.7 NON STANDARD	Sft	0.9
4	002020	1	015	002022	Lock Channel Clamp Pre-prepared	pcs	1
5	002022	1	013	110101010016 5	MS Sheet 1 2 NON STANDARD	Sft	0.02
1	001916	1	035	002023	KF Roller Channel M. Body Prepared	Pcs	1
1	001916	1	035	002024	KF Channel Roller Pin (Big) Plated	Pcs	3
1	001916	1	035	002025	KF Channel Roller Pin (Small) Plated	Pcs	1
1	001916	1	035	002026	KF Channel Sliding Roller (Platics)	Pcs	1
1	001916	1	035	002027	KF Channel Front Roller (Platics)	Pcs	1
1	001916	1	035	002028	KF Channel Back Roller (Platics)	Pcs	1
1	001916	1	035	002029	KF Channel Middle Roller (Platics)	Pcs	2
1	001916	1	035	002030	KF Channel Plastics Stopper (Big)	pcs	1
1	001916	1	035	002031	KF Channel Plastics Stopper (Small)	pcs	1

1	001916	1	035	002032	KF Channel Roller Medium Pin Plated	pcs	2
2	002023	1	015	002033	KF Roller Channel M. Body Sheared	Pcs	1
3	002033	1	013	110101010016 5	MS Sheet 1.2 NON STANDARD	Sft	0.55
2	002024	1	031	002034	Roller Pin (Big) Prepared	pcs	1
2	002024	1	031	PH200	Plating Chemical	Sft	0.032
3	002034	1	018	110101040000 8	MS ROUND BAR 11 MM	Rft	0.04
2	002025	1	031	002035	KF Roller Pin (Small) Prepared	pcs	1
2	002025	1	031	PH200	Plating Chemical	Sft	0.0029
3	002035	1	018	110101040000 8	MS ROUND BAR 11 MM	Rft	0.04
2	002026	1	034	RM	Nylon	gm	5
2	002027	1	034	RM	Nylon	gm	5
2	002028	1	034	RM	Nylon	gm	5
2	002029	1	034	RM	Nylon	gm	5
2	002030	1	034	RM	LDPE	gm	5
2	002031	1	034	RM	LDPE	gm	5
2	002032	1	031	002036	KF Roller Medium Pin Prepared	pcs	1
2	002032	1	031	PH200	Plating Chemical	Sft	0.5
3	002036	1	018	110101040002 2	MS ROUND BAR 26 MM	Rft	0.025
1	001917	1	035	002037	KF Roller Channel M. Body Prepared	Pcs	1
1	001917	1	035	002024	KF Channel Roller Pin Big Plated	Pcs	3
1	001917	1	035	002025	KF Channel Roller Pin Small Plated	Pcs	1
1	001917	1	035	002026	KF Channel Sliding Roller (Platics)	Pcs	1
1	001917	1	035	002027	KF Channel Back Roller (Platics)	Pcs	1
1	001917	1	035	002028	KF Channel Front Roller (Platics)	Pcs	1
1	001917	1	035	002029	KF Channel Middle Roller (Platics)	Pcs	2
1	001917	1	035	002030	KF Channel Plastics Stopper (Big)	pcs	1
1	001917	1	035	590000	KF Channel Plastics Stopper (Small)	pcs	1
1	001917	1	035	002032	KF Channel Roller Medium Pin Plated	pcs	1
2	002037	1	015	002038	KF Roller Channel Blanked	Pcs	1
3	002038	1	013	110101010016 5	MS Sheet 1.2 NON STANDARD	Sft	0.5
2	001918	1	015	002039	KF Roller Channel (L Outer) Blanked	Pcs	1
3	002039	1	013	110101010018 6	MS Sheet 1.4 NON STANDARD	Sft	0.6
2	001919	1	015	002040	KF Roller Channel (R.Outer) Blanked	Pcs	1
3	002040	1	013	110101010018 6	MS Sheet 1.4 NON STANDARD	Sft	0.6
2	720000	1	034		LDPE	gm	5

Table 4. Multi-level Modular Bill of Material of 3D-Filing Cabinet

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	FCO P02 MS	1	027	002074	KFC Body Assembly Painted	pcs	1
0	FCO P02 MS	1	027	001906	KF Drawer Front Cover Painted	Pcs	1
0	FCO P02 MS	1	027	001907	KF Drawer Left Side Painted	Pcs	1
0	FCO P02 MS	1	027	001908	KF Drawer Right Side Painted	pcs	1
0	FCO P02 MS	1	027	001909	KF Drawer Bottom Painted	pcs	1
0	FCO P02 MS	1	027	001910	KF Drawer Back Painted	pcs	1
0	FCO P02 MS	1	027	001911	KF Drawer Inside Cover Painted	Pcs	1
0	FCO P02 MS	1	027	001912	KF Drawer Carrier Plate Prepared	pcs	2
0	FCO P02 MS	1	027	001913	KF Carrier Vertical Support Plated	pcs	2
0	FCO P02 MS	1	027	200009	Drawer Plastics Gripper	pcs	1
0	FCO P02 MS	1	027	002095	KFC Auto Lock Channel Painted	pcs	1
0	FCO P02 MS	1	027	002100	KFC Lock Channel Painted	pcs	1
0	FCO P02 MS	1	027	001916	KF Roller Channel (L. inner) Assembly	pcs	3
0	FCO P02 MS	1	027	001917	KF Roller Channel (R inner) Assembly	pcs	3
0	FCO P02 MS	1	027	001918	KF Roller Channel (L. Outer) Assembly	pcs	3
0	FCO P02 MS	1	027	001919	KF Roller Channel (R. Outer) Assembly	pcs	3
0	FCO P02 MS	1	027	MKT	Cabinet Lock With Key	pcs	1
0	FCO P02 MS	1	027	MKT	Self Tapping Screw	pcs	6
1	002074	1	032	002075	KFC Body Assembly	Pcs	1
1	002074	1	032	PT100	Stoving Paint	Sft	70
2	002075	1	011	001921	KF Top Assembly Phosphated	Pcs	1
2	002075	1	011	002076	KFC Left Side Phosphated	Pcs	1
2	002075	1	011	002077	KFC Right Side Phosphated	Pcs	1
2	002075	1	011	002078	KFC Back Phosphated	Pcs	1
2	002075	1	011	001925	KF Base Clamp Phosphated	Pcs	3
2	002075	1	011	001926	KF Partition Phosphated	Pcs	2
2	002075	1	011	001927	KF Bottom Front Cover Phosphated	Pcs	1
2	002075	1	011	W100	Welding Material	Rft	
3	002076	1	030	002077	KFC Left Side Assembly	Pcs	1
3	002076	1	030	PH100	Phosphating Chemical	Sft	20
4	002077	1	011	002078	Left Side M Body Prepared	Pcs	1
4	002077	1	011	002079	Left Stiffener Prepared	Pcs	1
4	002077	1	011	002080	Central Stiffener (L) Prepared	Pcs	1
4	002077	1	011	W100	Welding Material	Rft	
5	002078	1	012	002081	Left Side M. Body Pre-prepared	pcs	1
6	002081	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	8
5	002079	1	010	002082	Left Stiffener Bended	pcs	1
6	002082	1	012	002083	Left Stiffener Pre-prepared	pcs	1
7	002083	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	1.6
5	002080	1	012	002084	Central Stiffener (L) Pre-prepared	pcs	1
6	002084	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	1

3	002077	1	030	002085	KFC Right Side Assembly	pcs	1
3	002077	1	030	PH100	Phosphating Chemical	Sft	20
4	002085	1	011	002086	Right Side M. Body Prepared	Pcs	1
4	002085	1	011	002087	Right Stiffener Prepared	Pcs	1
4	002085	1	011	002088	Central Stiffener (R) Preppared	Pcs	1
4	002085	1	011	W100	Welding material	Rft	
5	002086	1	012	002089	Right Side M. Body Pre-prepared	pcs	1
6	002089	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	7 6
5	002087	1	010	002090	Right Stiffener Bended	pcs	1.6
6	002090	1	012	002091	Right Stiffener Pre-prepared	pcs	1
7	002091	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	1.55
5	002088	1	012	002092	Central Stiffener (R) Pre-prepared	pcs	1
6	002092	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	1
3	002078	1	030	002093	KFC Back Prepared	pcs	1
3	002078	1	030	PH100	Phosphating Chemical	Sft	16.4
4	002093	1	012	002094	KFC Back Pre-prepared	pcs	1
5	002094	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	8.2
1	002095	1	032	002096	KFC Auto Lock Channel Assembly	pcs	1
1	002095	1	032	PT100	Stoving Paint	Sft	3.2
2	002096	1	011	002097	KFC Auto Lock Channel Phosphated	pcs	1
2	002096	1	011	330002	KF Auto Lock Bush	pcs	3
2	002096	1	011	330003	KF Auto Lock Screw Plated	pcs	3
2	002096	1	011	MKT	KF Spring Washer and Nut	pcs	3
2	002096	1	011	W100	Welding Material	Rft	
3	002097	1	030	002098	KFC Auto Lock Channel Prepared	pcs	1
3	002097	1	030	PH100	Phosphating Chemical	Sft	1.6
4	002098	1	012	002099	KFC Auto Lock Channel Pre-prepared	pcs	1
5	002099	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	0.55
1	002100	1	032	002101	KFC Lock Channel Phosphated	pcs	1
1	002100	1	032	PT100	Stoving Paint	Sft	4
2	002101	1	030	002102	KFC Lock Channel Assembly	pcs	1
2	002101	1	030	PH100	Phosphating Chemical	sft	4
3	002102	1	011	002103	Lock Channel M. Body Prepared	pcs	1
3	002102	1	011	410102	Lock Channel Clamp Prepared	pcs	1
3	002102	1	011	W100	Welding Material	Rft	
4	002103	1	012	002104	Lock Channel M. Body Pre-prepared	pcs	1
5	002104	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	0.86

Table 5. Multi-Level Modular Bill of Material of 2D-Filing Cabinet

Level	P. Comp. Code	Batch Size	Phase Code	R.M./P.M./Comp. Code	Description	Unit	Qty
0	FCO P01 MS	1	027	002041	KFB Body Assembly Painted	pcs	1
0	FCO P01 MS	1	027	001906	KF Drawer Front Cover Painted	Pcs	1
0	FCO P01 MS	1	027	001907	KF Drawer Left Side Painted	Pcs	1
0	FCO P01 MS	1	027	001908	KF Drawer Right Side Painted	pcs	1
0	FCO P01 MS	1	027	001909	KF Drawer Bottom Painted	pcs	1
0	FCO P01 MS	1	027	001910	KF Drawer Back Painted	pcs	1
0	FCO P01 MS	1	027	001911	KF Drawer Inside Cover Painted	Pcs	1
0	FCO P01 MS	1	027	001912	KF Drawer Carrier Plate Prepared	pcs	2
0	FCO P01 MS	1	027	001913	KF Carrier Vertical Support Plated	pcs	2
0	FCO P01 MS	1	027	PL	Drawer Plastics Gripper	pcs	1
0	FCO P01 MS	1	027	002042	KFB Auto Lock Channel Painted	pcs	1
0	FCO P01 MS	1	027	002043	KFB Lock Channel Painted	pcs	1
0	FCO P01 MS	1	027	001916	KF Roller Channel (L. inner) Assembly	pcs	2
0	FCO P01 MS	1	027	001917	KF Roller Channel (R. inner) Assembly	pcs	2
0	FCO P01 MS	1	027	001918	KF Roller Channel (L. Outer) Assembly	pcs	2
0	FCO P01 MS	1	027	001919	KF Roller Channel (R. Outer) Assembly	pcs	2
0	FCO P01 MS	1	027	MKT	Cabinet Lock With Key	pcs	1
0	FCO P01 MS	1	027	MKT	Self Tapping Screw	pcs	8
1	002041	1	032	002044	KFB Body Assembly	Pcs	1
1	002041	1	032	PT100	Stoving Paint	Sft	60
2	002044	1	011	001921	KF Top Assembly Phosphated	Pcs	1
2	002044	1	011	002045	KFB Left Side Phosphated	Pcs	1
2	002044	1	011	002046	KFB Right Side Phosphated	Pcs	1
2	002044	1	011	002047	KFB Back Phosphated	Pcs	1
2	002044	1	011	001925	KF Base Clamp Phosphated	Pcs	3
2	002044	1	011	001926	KF Partition Phosphated	Pcs	2
2	002044	1	011	001927	KF Bottom Front Cover Phosphated	Pcs	1
2	002044	1	011	W100	Welding Material	Rft	
3	002045	1	030	002048	KFB Left Side Assembly	Pcs	1
3	002045	1	030	PH100	Phosphating Chemical	Sft	15
4	002048	1	011	002049	Left Side M. Body Prepared	Pcs	1
4	002048	1	011	002050	Left Stiffener Prepared	Pcs	1
4	002048	1	011	002051	Central Stiffener (L) Prepared	Pcs	1
4	002048	1	011	W100	Welding Material	Rft	
5	002049	1	012	002052	Left Side M. Body Pre-prepared	pcs	1
6	002052	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	6
5	002050	1	010	KFB 1A112.1	Left Stiffener Bended	pcs	1
6	002053	1	012	KFB 1A1121.1	Left Stiffener Pre-prepared	pcs	1
7	002054	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	1
5	002051	1	012	KFB 1A113.1	Central Stiffener (L) Pre-prepared	pcs	1

6	002055	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	0.7
3	002046	1	030	002056	KFB Right Side Assembly	pcs	1
3	002046	1	030	PH100	Phosphating Chemical	Sft	15
4	002056	1	011	002057	Right Side M. Body Prepared	Pcs	1
4	002056	1	011	002058	Right Stiffener Prepared	Pcs	1
4	002056	1	011	002059	Central Stiffener (R) Prepared	Pcs	1
4	002056	1	011	W100	Welding material	Rft	
5	002057	1	012	002060	Right Side M. Body Pre-prepared	pcs	1
6	002060	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	6
5	002058	1	010	002061	Right Stiffener Bended	pcs	1
6	002061	1	012	002062	Right Stiffener Pre-prepared	pcs	1
7	002062	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	1
5	002059	1	012	002063	Central Stiffener (R) Pre-prepared	pcs	1
6	002063	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	1
3	002047	1	030	002064	KFB Back Prepared	pcs	1
3	002047	1	030	PH100	Phosphating Chemical	Sft	12
4	002064	1	012	002065	KFB Back Pre-prepared	pcs	1
5	002065	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	6
1	002042	1	032	002066	KFB Auto Lock Channel Assembly	pcs	1
1	002042	1	032	PT100	Stoving Paint	Sft	6
2	002066	1	011	002067	KFB Auto Lock Channel Phosphated	pcs	1
2	002066	1	011	PL	KF Auto Lock Bush	pcs	2
2	002066	1	011	002011	KF Auto Lock Screw Plated	pcs	2
2	002066	1	011	MKT	KF Spring Washer and Nut	pcs	2
2	002066	1	011	W100	Welding Material	Rft	
3	002067	1	030	002068	KFB Auto Lock Channel Prepared	pcs	1
3	002067	1	030	PH100	Phosphating Chemical	Sft	1.5
4	002068	1	012	002069	KFB Auto Lock Channel Pre-prepared	pcs	1
5	002069	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	0.35
1	002043	1	032	002070	KFB Lock Channel Phosphated	pcs	1
1	002043	1	032	PT100	Stoving Paint	Sft	3
2	002070	1	030	002071	KFB Lock Channel Assembly	pcs	1
2	002070	1	030	PH100	Phosphating Chemical	Sft	3
3	002071	1	011	002072	Lock Channel Prepared	pcs	1
3	002071	1	011	410102	Lock Channel Clamp Prepared	pcs	1
3	002071	1	011	W100	Welding Material	Rft	
4	002072	1	012	002073	Lock Channel Pre-prepared	pcs	1
5	002073	1	010	1101010100081	MS Sheet 0.7 NON STANDARD	Sft	0.45

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