A DECISION SUPPORT SYSTEM FOR PRODUCTION PLANNING AND PRE-COST ESTIMATION ACTIVITIES IN AN APPAREL COMPANY

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ABSTRACT

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In this study, a specific decision support system is designed and developed for Production Planning and Marketing Department of an apparel company. The developed system involves two modules with user friendly interface or data input and query. The system is designed to provide support in the following fields of decision making; pre cost estimation, capacity planning, master production planning and production scheduling. A detailed analysis of the existing system is conducted and Microsoft Access is used for the development of software. The cost and benefits of the implementing the system are also discussed in addition to basics, sample reports and the user interface of the developed program.

Keywords: Decision Support Systems, Production Planning, Pre-Cost Estimation, Apparel

ÖZ

BİR KONFEKSİYON FABRİKASI İÇİN MALİYET TAHMİNİ VE ÜRETİM PLANLAMAYA AKTİVİTELERİ İÇİN BİR KARAR DESTEK SİSTEMİ

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Bu çalışmada bir konfeksiyon fabrikasında üretim planlama ve pazarlama departmanları için özel bir karar destek sistemi tasarlanmış ve geliştirilmesi amaçlanmıştır. Geliştirilen system, kullanıcı dostu bilgi giriş ve sorgulama arayüzlerine sahip, iki ana modül içermektedir. Sistem şu karar verme alanlarında destek vermek üzere tasarlanmıştır: model ön maliyet çalışmaları, kapasite ve ana üretim planlaması ile üretim hatlarının çizelgelenmesi. Mevcut sistemin detaylı analizi yapılarak Microsoft Access programı yazılım geliştirmek için kullanılmaktadır. Geliştirilen programın temelleri, örnek rapor ve arayüzlere ek olarak, programın kullanıma sunulmasıyla birlikte oluşacak fayda ve yükleri de tartışılmıştır.

Anahtar Kelimeler: Karar Destek Sistemleri, Üretim Planlama, Ön Maliyet Analizi, Konfeksiyon

To My Beloved Family

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DSS : Decision Support System

EIS : Executive Information Systems

ES : Expert Systems

GAMS : General Algebraic Modeling System

GNP : Gross National Product

IGIAD: Entrepreneurial Businessmen Association of Istanbul

KS : Knowledge System

LS : Language System

MIS : Management Information System

OIS : Office Information Systems

PPS : Problem-Processing System

TIM: Turkish Exporters' Assembly

TPS : Transaction Processing Systems

CHAPTER 1

INTRODUCTION

Turkish textile and garment sector has been the engine of employment since the 1950s. According to sector shares in Gross National Product (GNP), in employment and in contribution to exportation, textile and garment sector is the biggest sector in Turkey. The sector has a share of 11.4% of total employment, 16.3% of GNP and 18.5% of total exportation. Its exports were 18.8 billion dollar in 2009. Garment's share in this exportation is 13.3 billion dollar which is the second biggest amount after automotive sector. (TIM, 2010) Turkey is the fourth biggest garment exporter in the world. Turkey textile sector satisfies 4% of the demand of the world market. (IGIAD, 2010)

With the economic changes since the 1980s, Turkey's textile sector has become an significantly important part of the global textile and apparel production network, production rate of textile and garment sector has increased significantly. However, after the 1990s, particularly the Customs Union agreement signed in 1996, textile sector has slowly begun to enter in trouble. Because of removal of quotas on China in 2005, it has come under pressure from global competition. Happy days of "sell what you produce" has finished. There are a lot of major competitors in the market. Competition in global world market, especially competition with firms in China is getting harder day by day. Under these conditions, garment producers in Turkey are taking seriously of using all of resources efficiently, having more flexible production system to meet changes in the market and sending goods to customer as early as possible to satisfy the customer expectation, utilizing workforce effectively, accessing higher productivity levels etc. Because of these reasons, complexity of managing the production process tends to increase; therefore firms need to renew their self from technological aspect. Because of the fact that a huge amount of information needs to be gathered, processed, transmitted and used. The use of tools management information systems is no longer an optional extra for manufacturers who desire to compete with rivals in the global textile and garments market where key factors are price and speed-to-market. "Just in-time" production method is possible with using information systems. Besides, since margins are driven lower because of severe competing environment, information systems can contribute to secure necessary cost saving in the manufacturing process.

Decision support systems, in general, bring many benefits for production planning and marketing department of a manufacturing company, such as decision quality, improved communication, cost reduction, increased productivity, time savings, improved customer and employee satisfaction (Turban, 1998)

The purpose of this thesis is to develop a specific decision support system for middle management of the production planning and marketing departments of a ready-made clothing factory. The system consists of two modules which are production planning and pre-cost estimation modules.

Production planning module focuses on determining delivery date of orders and scheduling of the production lines. It is designed to use production capacity efficiently, prevent problems arising from idle capacity and capacity shortage. Decision of determining delivery date of orders is made with the help of software instead of traditionally manual way. That provides to decrease mistakes done by the users, response to customers in a short time, to use resources effectively and to decrease loss. In the module, the first level of the production planning addresses the long-term aspect of production planning. It determines weekly production quantities as well as overtime and subcontracting levels so as to minimize total production cost and determine delivery date of orders. The second level of the production planning addresses scheduling production lines with the help of an optimization model. The objective function of the scheduling problem is minimizing tardiness and setup cost. Setups are needed whenever a switch is made to a job of another product family. For reasons of efficiency, it is preferred to continue with orders for products belonging to the same family as long as possible. However, the need to finish orders as close as possible to their required due dates (as is the ultimate goal in Just In Time manufacturing systems) may conflict with the efficiency objective. In general, a trade-off has to be made between efficiency on the one hand and a high degree of customer service on the other hand. Mixed Integer Programming is presented to solve problem optimally.

The major purpose of the pre cost estimation module is to calculate total cost which consists of fabric, material and labor costs and price to give customer under different profit margin conditions in a short time with using technology instead of calculating manually and respond to customer in giving information about price quicker to be one step ahead of other competitors.

Data are collected and stored both as a hardcopy and softcopy in the current system. Since they did not have any database system, they had to enter and store the same data in different files. Different documents are prepared using same data. Inconsistencies are seen among data in different documents. The purpose of the developed information system is to integrate information from different divisions of the organization and use this information for production planning and pre-cost estimation processes.

In the current system, some problems are faced by the Company, such as, paying compensation for late delivery, to illustrate, they had to pay 10.500 € to their customers in 2009 because of late delivery. The Company received so many customer complaints about not sending goods on time, so they had to ship goods by plane instead of truck. Complaints are also about not replying customer mails on time when they ask about price. Lastly, since the scheduling is done manually instead of using scientific methods, production efficiency is in lower level and setup cost is higher that it could be.

The thesis is organized as follows:

After this introductory chapter, chapter 2 aims to produce basic definitions of decision, decision making, managerial decision making, information systems, management information systems and decision support systems (DSS). In the second part of the chapter, manufacturing DSS studies in literature is reviewed. Chapter 3 gives on giving a general information about factory and supplying a brief explanation about manufacturing process and operations in production planning, besides problem definition, necessity of study and objectives of the system is explained in this chapter. In chapter 4, the proposed approach is given, methodology of the study is clarified. Chapter 5 supplies DSS development with constructed modules. Chapter 6 focuses on an application and analysis of results. Finally, concluding remarks about decision support system developed and some recommendations are given for further studies in chapter 7.

CHAPTER 2

LITERATURE REVIEW

2.1. Decision and Decision Making

Mallach (2000) described decision as reasoned choice among alternatives. Each decision is characterized by a decision statement, a set of alternatives and a set of decision making criteria. The decision statement states what we are trying to decide, the alternatives are the possible decisions we can make and lastly decision making criteria are what we want to optimize in a decision.

Simon (1960) divided decision process in to five stages; Intelligence (in the military sense of gathering information), design (Identifying the alternatives, structuring how the decision will be made), choice (Picking an alternative or making the judgment), Implementation and Evaluation (added later by the author). Each stage can be structured (automated) or unstructured. "Structured" means that there is an algorithm, mathematical formula, or decision rule for accomplishing the entire stage. Any decision stage that is not structured is unstructured. In a **structured decision** all decision stages are structured. In an **unstructured decision** all stages are unstructured. A **semi-structured decision** is one in which part, but not all of the decision is structured.

Anthony (1965) classified decision scope levels in to three levels as follows;
A strategic planning is one which will affect the entire organization or a major part of it, for a long time period. **A tactical planning** as called management

control planning, will affect how a part of the organization does business for a limited time into the future. The last one is **operational control** which is one that affects a particular activity currently taking place in the organization, but has little impact on the future.

Gory and Scott-Morten (1971) extended Simon's earlier concept and combined it with management control taxonomy by Anthony (1965) and categorized decision types as follow;

Table 2.1. Decision Support Frameworks (Gory and Scott-Morten, 1971)

	Type of Control		
Type of Decision	**Operational Control**	**Managerial Control (Tactical Planning)**	**Strategic Planning**
Structured	Accounts receivable Accounts payable Order entry	Budget analysis Short-term forecasting Personnel reports Make-or- buy	Financial management Investment portfolio Warehouse location Distribution systems
Semi-structured	Production scheduling Inventory control	Credit evaluation Budget preparation Plant layout Project scheduling Reward system design Inventory categorization	Building a new plant Mergers&acquisitions New product planning Compensation planning Quality assurance Hr policies Inventory planning
Unstructured	Buying software Approving loans Operating a help desk Selecting a cover for a magazine	Negotiating Recruiting an executive Buying hardware Lobbying	R&D planning New tech. Development Social responsibility planning

2.2. Information Systems

Alter (1996) described an information system as a system that uses information technology to capture, transmit, store, retrieve, manipulate, or display information used in one or more business processes. Information technology consists of logical software and physical hardware systems to provide flow of information, storage and manipulation.

2.2.1. Types of Information Systems

Zwass (1992) grouped the information systems as follows:

- Transaction Processing Systems (TPS)
- Executive Information Systems (EIS)
- Expert Systems (ES)
- Office Information Systems (OIS)
- Management Information Systems (MIS)
- Decision Support Systems (DSS)

TPS helps the business operations of the company. It supports decisions being made as part of a transaction while collecting and storing data about transaction. Applications of TPS are payroll, inventory, record keeping, production and sales information.

EIS provides person who make managerial decisions flexible access to information for seeing operating results. Applications of EIS are support to top management decision and environmental scanning.

ES are knowledge-based programs; they support to evaluate some complex situation that requires expert knowledge. Applications are diagnosis, strategic planning, internal control planning, maintenance strategies and narrow domain.

OIS supports information and communication operations tasks for daily office life and organizations of business. It covers a lot of tools such as multimedia communication systems, spreadsheet and word processors.

2.3. Management Information Systems

Olson & Courtney, 1992 stated as MISs exist to store and retrieve data in an efficient manner, as well as to provide management at all levels with information, through reports or databases, to answer queries. MISs cover all of systems supporting decision making for management level. Applications of MIS are production control, sales forecasting and monitoring.

2.4. Decision Support System

2.4.1. Definitions and History

In the book written by Power (2007), it is informed as Information Systems researchers and technologists have built and investigated Decision Support Systems (DSS) for approximately 40 years. Era of DSS began with building model-driven DSS in the late 1960s, theory developments in the 1970s, and the implementation of financial planning systems, spreadsheet DSS and Group DSS in the early and mid 80s. Data warehouses, Executive Information Systems, OLAP and Business Intelligence evolved in the late 1980s and early 1990s. Finally, the chronicle ends with knowledge-driven DSS and the implementation of Web-based DSS in the mid-1990s.

Table 2.2 Evolution of DSS concepts (Power, 2002)

1960s	Scott Morton's management decision support project Interactive systems research organization Decision-making theory development
1970s	Brand Aid research Alter's field study Hols apple research
1980s	Key DSS books Group DSS prototypes Executive information systems (EIS) PC expert systems
1990s	Business intelligence/OLAP Data warehousing Web-based systems/portals Data mining

During 1970s, the era of decision support systems made its appearance. Concept and application areas of DSS came into view in 1972. (McNurlin and Sprague,1989). Sprague (1982) pointed out that concepts of DSS formulated in the beginning of the 1970s by Michael Scott Morton as "*Management Decision Systems*".

Little (1970) defined DSS as a model based set of procedures to assist a manager in his decision making. According to him, a successful DSS should have the attributes as follows; Simple, Robust, Easy to Control, Adaptive, Complete on important issues and easy to communicate with.

Scott-Morton (1971) stated as DSS is an interactive computer based systems supporting management decision making to use data and models to solve unstructured problems.

Geritty (1971) designed a DSS for portfolio management to support investment managers in their daily administration of a client of stock portfolio. The concept of DSS that firstly appeared with this study includes an effective blend of human intelligence, information technology and software which interact closely to solve complex problems .

Keen and Scott-Morton (1978) pointed out that DSS couple the intellectual resources of individuals with the capabilities of the computer to improve the quality of decisions. It is a computer-based support system for management decision makers who deal with the semi-structured problems.

Keen(1980) described the term DSS to situations where a ‘final’ system can be developed only through an adaptive process of learning and evaluation.

Robert Bonczek, Clyde Holsapple, and Andrew Whinston (1981) identified four essential "aspects" or general components that were common to all DSS;

1. A language system (LS) that specifies all messages a specific DSS can accept;
2. A presentation system (PS) for all messages a DSS can emit;
3. A knowledge system (KS) for all knowledge a DSS has;
4. A problem-processing system (PPS) that is the "software engine" that tries to recognize and solve problems during the use of a specific DSS.

According to Mittra (1986), a decision support system is a computer-based information system that provides appropriate data in an easily understandable form that helps the decision maker.

Leigh (1986) described DSS as a set of computer-based tools used by a manager in connection with his/her problem solving and decision making duties.

Silv (1991) stated as a DSS is a computer based information system that affects or is intended to affect how people make decisions.

Zwass (1992) applied the term DSS interactive information systems that assist decision maker in approaching ill-structured problems by offering analytical models and access to databases.

According to Hicks (1993), a DSS is an integrated set of computer tools that allow a decision maker to interact directly with computers to create information useful in making unanticipated semi-structured and unstructured decisions.

Turban (1993) described as a DSS in an interactive, flexible and adaptable computer based information system that utilizes decision rules, models and model base coupled with a comprehensive database and the decision maker's own insights, leading to specific, implementable decisions in solving problems that would not be amenable to management science optimization models per second. Thus, a DSS supports complex decision making and increases its effectiveness.

Stai (1997) pointed out a DSS is an organized collection of people, procedures, software, databases and devices used to support problem-specific decision making.

Obri (1999) described DSS as computer based information systems that provide interactive information support to managers during the decision making process.

Hahn and Engelen (2000) distinguished two types of computer-based DSS:

1. Data-oriented DSS are primarily concerned with retrieval, analysis and presentation of data.

2. Model-oriented DSS include activities such as simulation, goal seeking and optimization.

2.4.2. Characteristics of a DSS

Turban and Aronson noted their list is an ideal set. They stated as because there is no consensus on exactly what a DSS is, there is obviously no agreement on standard characteristics and capabilities of DSS.

Alter (1980) identified three major characteristics of DSS as follows:
1. DSS are designed specifically to facilitate decision processes,
2. DSS should support rather than automate decision making, and
3. DSS should be able to respond quickly to the changing needs of decision makers.

Turban (1993) categorized the common characteristics of DSS as follows;

1. Provide support in semi-structured and unstructured situations, includes human judgment and computerized information. Such problems cannot be solved by other computerized systems such as EDP or MIS.
2. Support for various managerial level ranging from top executives to line managers.
3. Support to individuals and groups.
4. Support to interdependent and/or sequential decisions.
5. Support all phases of the decision-making process.
6. Support a variety of decision-making processes and Styles.
7. DSS must be adaptive over time. Changing conditions will no be problem for DSS that must be flexible so user can add, delete, combine,change or rearrange basic elements.
8. Have user friendly interfaces. It should be easy to use.

9. Goal of DSS is that improve effectiveness (accuracy,timeliness,quality) of decision making rather than its efficiency (cost of making the decision, including the charges for computer time).
10. The decision maker controls the decision-making process. She/he has to complete the overall steps.
11. End-users can build simple systems. DSS should be easy to construct.
12. Utilizes models for analysis.
13. Provides access to a variety of data sources, formats, and types. DSS should lea to new demands and the refinement of the system.

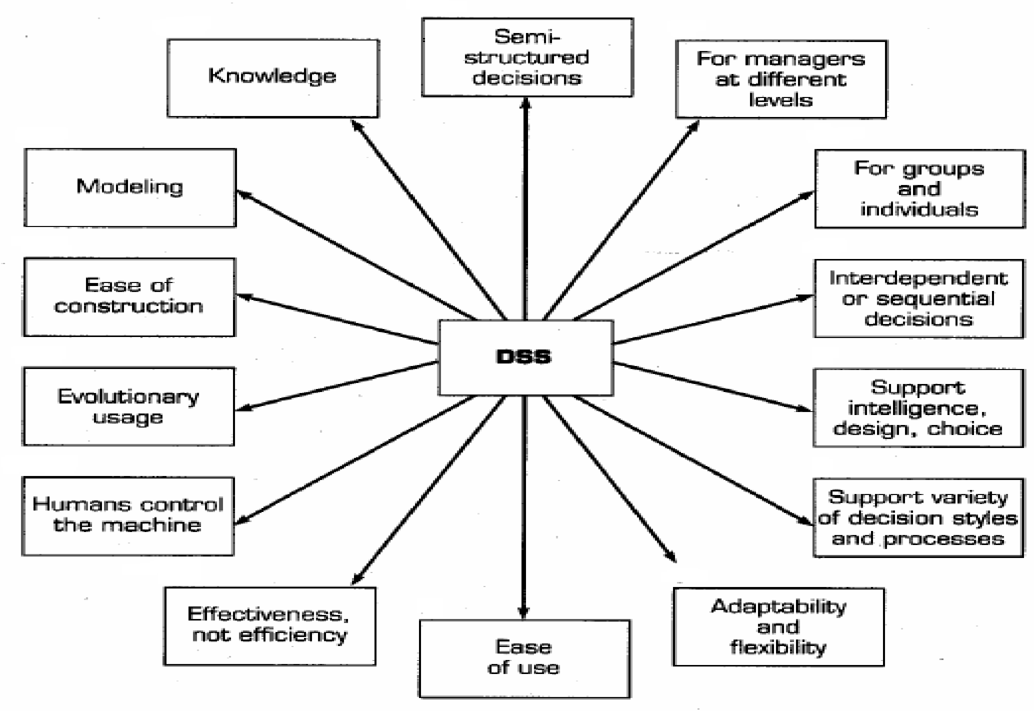

Figure 2. 1 The Characteristics and Capabilities of DSS (Turban,1995)

2.4.3. Components of DSS

A DSS is classified in to the following components by Turban (2001):

1. Data Management Subsystem
2. Model Management Subsystem
3. Knowledge-based (Management) Subsystem
4. User Interface Subsystem
5. User

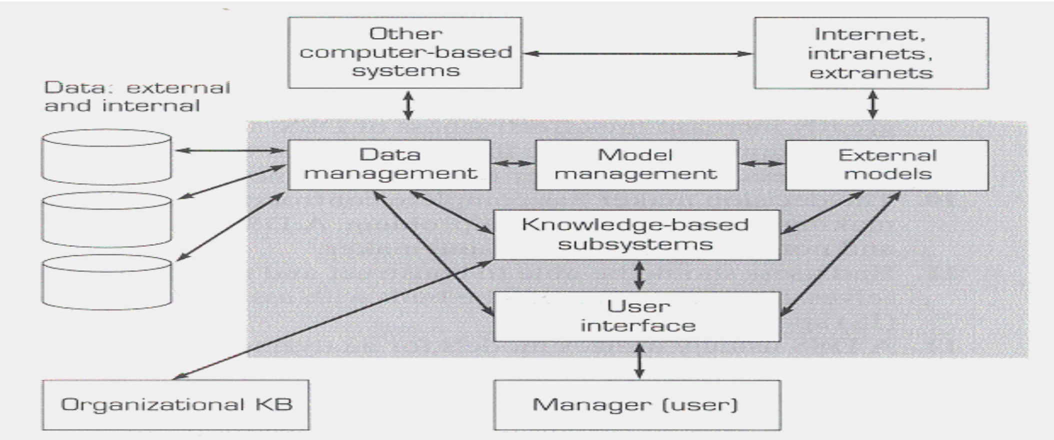

Figure 2. 2 A schematic view of DSS (Turban,2001)

1. Data Management Subsystem consists of DSS database, database management system (DBMS), data directory, query facility. It contains all required data by the DSS.

Turban (2001) is categorized the Capabilities of DBMS in a DSS by as follows;

- Captures/extracts data for inclusion in a DSS database
- Updates (adding's, deletes, edits, changes) data records and files
- Interrelates data from different sources
- Retrieves data from the database for queries and reports
- Provides comprehensive data security (protection from unauthorized access, recovery capabilities, etc.)

• Handles personal and unofficial data so that users can experiment with alternative solutions based on their own judgment
• Performs complex data manipulation tasks based on queries
• Tracks data use within the DSS
• Manages data through a data dictionary.

2. Model Management Subsystem, analog of the database management subsystem, includes model base, model base management system, modeling language model directory, model execution, integration and command for analytic purposes. It is commonly seen that model management is the most difficult component in a DSS to design because of the fact that selection of best algorithms from the huge repertoire of mathematical models is so hard.

Model Management Subsystem is classified in to four groups;

- **Strategic Models**: Non routine mergers, impact analysis, capital budgeting
- **Tactical Models**: Allocation & Control labor requirements, sales promotion planning
- **Operational Models**: Routine-day-to-day production scheduling, inventory control, quality control
- **Analytical Models**: SAS, SPSS, OR, data mining

3. Knowledge Based Subsystem provides expertise in solving complex unstructured and semi-structured problems. An advanced DSS have a knowledge based (management) component, since it leads to intelligent DSS, such as data mining.

4. The User Interface (Dialog) Subsystem includes all communication between a user and the DSS. It has to be user-friendly such that a non-computer-oriented user is able to use the DSS.

5. User whose judgments and cognitive style are important for a successful DSS. Different user patterns for the users the manager, the decision maker. Users can be managers, staff specialists or intermediaries (Staff assistant, expert tool user, business (system) analyst, GSS facilitator).

2.4.4. Types of DSS

Alter (1977) reported the result of an empirical investigation of 56 applications of DSS. Based on these observations, Alter classified seven types of DSS.

1. **File Drawer**: Query systems (look up answers)
2. **Data Analysis**: Exploratory statistical analysis. (Forecasting, Relationship Identification)
3. **Analysis Information Systems** : Access to a series of databases and general models (Spreadsheet Systems)
4. **Accounting Models**: Calculate consequences of planned actions based on assumptions. (Monetary Simulations)
5. **Representational Models** : Estimate consequences of actions based on less structured models (Simulations)
6. **Optimization Models:** Identify optimum solution (Linear Programming)
7. **Suggestion Models:** More structured models, concluding with a recommended action. (Expert Systems)

2.4.5. Manufacturing Information Technology Studies in Literature

Aim of this study is developing a DSS for a production planning system in a manufacturing environment. Thus, a brief review of related studies in the literature is presented in this section.

History of IT studies in Manufacturing

Kathuria and Anandarajan (1999) stated as studies of manufacturing companies indicate that over half their capital expenditures involve some form of Information Technology (IT) (Cooper & Zmud, 1990), which has the potential to provide a competitive advantage for these companies (Earl, 1993; Ives & Jarvanpaa, 1991). Researchers have, however, pointed out that the mere introduction of IT itself does not confer competitive advantage, but the choice of IT should stem from an understanding of the business and any desired changes in the business (Grover & Malhotra, 1997; Huff & Beattie, 1985). The need for alignment between the business needs and the characteristics of the IT application has been consistently emphasized in the Information Systems (IS) as well as the Manufacturing Strategy literature (Malone & Rockart, 1991 ; McFarlan, 1984; Berry & Hill, 1992). This fact has been further highlighted by Cerveny and Scott (1989), among others, who found that not all users of a widely used IT application in manufacturing, the Material Requirements Planning (MRP) systems, had derived the potential benefits of these systems. This has been attributed to the misfit between the manufacturing needs and priorities of the users and the Characteristics of the IT application-MRP (Krajewski & Ritzman, 1992). To avoid the potential misfit described above, many researchers have developed models and frameworks over the years. For instance, Parsons (1983) emphasized the need for alignment of IT applications with the generic strategies-low cost or differentiation of firms. Hayes and Wheelwright (1984) and Skinner (1969,1983) emphasized the importance of aligning systems for manufacturing, planning and control, as well as for quality management with the manufacturing strategy of the company. Cooper and Zmud (1990), based on an empirical study, proposed that the choice of IT applications for inventory management should be consistent with the process structure (Job, Batch, Line, Continuous) of a company. Integrating these various concepts, Kathuria and Igbaria (1997) developed an integrated framework which suggests that an IT application should be aligned with both the competitive priorities (Cost, Quality, Flexibility, Delivery, etc.) and the process structure of an organization in a manufacturing environment. Research has shown that such decision aids have been extremely beneficial to companies, especially in terms of enabling them to respond quicker to changing competitive and market conditions (Jungthirapanich, 1992; Powell, Hall, & Klein, 1992; Price, Malley, & Balsmeier, 1994).

IS Studies in Literature

Howard, Kochhar and Dilworth(1999) described as a generic reference architecture for a manufacturing planning and control (MPC) system, which is tested in the context of the functional specification of MPC systems in medium-sized batch manufacturing companies. While the proposed reference architecture is an adaptation of the manufacturing resource planning (MRPII) model, it can also represent other approaches such as multilevel finite capacity scheduling and hybrid systems which incorporate pull control (e.g. kanban). Furthermore, it is not as functionally rigid as the MRPII approach and can support the development of manufacturing planning and control systems to support the identified business processes. It is shown how the reference architecture can be used to represent companies who operate very different MPC approaches. It is also shown that the architecture can support different projects (i.e. business process re-engineering, performance measurement and the implementation of computerized MPC systems). Field tests demonstrate that the architecture is generic, has a broad application, yet is detailed enough usefully to represent the functionality of a suitable MPC system in individual manufacturing environments.

Wortman, Euwe, Taal and Wiers (1996) gave as a review of capacity planning techniques from which today's standard software packages for production control make their choice. The following techniques are discussed in the paper: four variants of the rough cut capacity check, capacity requirements planning with infinite and finite loading, input/output planning without and with individual work orders, and a number of sequencing techniques. They have also mentioned aspects of interaction between techniques and human planners arc in the paper.

DSS Studies in Literature

Suranjan, Shimon and Whinston (1985) published a survey paper as it addresses the issue of decision support in computer-integrated manufacturing (CIM). Because of the complexity of the decision making process in manufacturing systems from the multilevel nature of the planning hierarchy, they emphasize the importance of adopting an integrated view of the planning hierarchy. They provide a framework for the development of a DSS for integrated manufacturing control.

Timurçin (1989) described as a framework for a DSS in order to support rescheduling decisions in a manufacture-to-order system.

Guida, Marchesi and Basaglia (1992) described as the experience in developing and putting into operation two Knowledge Based Decision Support System (KBDSS) to support manufacturing top managers in the analysis phase of their decision making process. The two KBDSS have been used by Tyre Cmpany managers and their staff since 1991 to monitor and check the achievement of the stated productivity goals in all the factories and to diagnose causes of unsatisfactory performance. The KBDSS approach has been adopted within the Key Indicators for Factory Performance Evaluation (KIFPE) project which is an ambitious joint effort . The paper focused on two specific KBDSS developed within the project which are KIFPE-TYP, such as KIFPE for tyre productivity and KIFPE-UR, i.e., KIFPE for machine usage.

Price, Sharp and Muhlemann (1992) developed a decision support system to aid the production decisions of smaller companies. In the paper, it is stated as the influence on the system design of the difficulties experienced by smaller enterprises in specifying their system requirements is considered. A dataflow feedback loop, which is the basic system element, is described. A taxonomy is defined which based on the dataflow loop and which comprises sets of canonical function classes and canonical data classes. The roles of the canonical data classes in the initial development of data models and in other aspects of the design, development and implementation of the production planning and control systems are discussed in their study.

Hsu, Pritula and Thompson (1993) developed a DSS called MacMerl for scheduling. The system weaves together numeric and symbolic computing techniques to form a 'scheduler's workbench'. MacMerl includes two components; the first one is a Scheduling Kernel which includes a Generative Scheduler, a Constraint Checker, and a Reactive Scheduler. The second one is a Manual Scheduler which permits the human to create or modify schedules and includes a critiquer as well as access to routines in the Scheduling Kernel. They intend to solve *mixed-initiative scheduling* problem in which the human and the machine interact in a coherent and cooperative manner to solve complex production scheduling problems. It is emphasized that although the schedules generated by the system is not optimal, those are as good as the generated by experts.

Kleijnen (1993) wrote a case study concerning a practical DSS for production planning of a metal tube factory. A simulation model is built in the study which gives a survey on the use of statistical designs for what-if or sensitivity analysis in simulation. This analysis uses regression analysis to approximate the input/output transformation that is implied by the simulation model. The DSS concentrated on the bottleneck process within total production system. Conclusion of the study is that these statistical techniques give more general results, in less time in the simulation studies.

Sharifi and Keulen (1994) described a dynamic land use planning system , a DSS for land use planning at farm enterprise level. The system is a Geographic Information System (GIS) with a powerful process model that follows the logic of the decision-making process and makes use of an integrated planning model for planning at different levels i.e. tactical and operational. The integrated model includes a simulation model for estimation productivity of each feasible land use, a linear model to design best suitable plan that maximizes the benefit of the system under a given set of constraints (tactical plan), and a spatial decision model to translate the tactical plan into an actual operational plan.

Muhlemann (1995) developed a DSS designed in such a way as it met the majority of the needs of the smaller manufacturing enterprise (SME) for production planning and control and could readily be modified to meet user specific requirements. The system was based on a general model of the production process. He reported the results of a longitudinal study involving implementation within one particular SME and a different mode of operation in a second company. It demonstrates the evolution of the usage, which developed from a program which is being used essentially to track transactions to a system which was being used to support and extend major production decision making. The study illustrates the use of the system as a 'change agent', supported by an action learning environment. This is facilitated by the sound production management practice embodied within the software, which enables organizations to improve the quality of production management decisions.

Tsubone, Matsuura and Kimura (1995) developed a DSS for production planning. They took under consideration of two major functions; physical performance analysis and choice analysis. The physical performance analysis, through using a simulation model as the main tool, is aimed to find problems in production system by measuring the impact of decision variables on the system performance such as unfilled order rate for market demand, ratio of setup time, average inventory level of finished products and part items, and frequency of re-planning. On the other side, the second is to guide for selecting an alternative or setting the decision variables value, if management can, on the basis of the physical performance analysis results, provide a ranking, preference, or acceptable limits in terms of their contribution or importance to the production system.

In the paper written by Cunnigham, Higgins and Browne (1996), the framework for a decision support tool for planning bills-of-material is presented. This tool generates a set of modular planning bills-of-material from the manufacturing bills-of-material for a company. The tool attempts to consolidate options in a product family which are specific. The force with which the tool attempts to consolidate two or more options is dependent on the financial control parameters. As well as having a minimum amount of common material, the financial value of such a match must also be sufficiently high value to be worth planning together. The tool also examines the long-term inventory effect of planning two or more options as common. A prototype is also presented in the study.

Karacapilidis (1996) presented work done on designing a DSS for the management of production in textile production systems focusing on the Master Production Scheduling problem. The system is also related to two well-known production control systems, namely MRP-II and Optimized Production Technology. After a short discussion of the model based management system, the paper gives a comprehensive analysis and synthesis of the MPS procedure in such an environment. This procedure has been developed by taking into account the specific features of the industry as well as some particular methods and heuristics that management adopts.

Grabot, Blanc and Binda (1996) developed a DSS about shop-floors short term production and inventory control level in order to react to unpredictable events such as machine failures, absence of operators or changes in the workshop environment, often called Product Activity Control (PAC). This DSS may be used, either in order to slightly modify an existing schedule, or to choose the scheduling hypothesis. This DSS uses fuzzy logic and theory of possibility because of the imprecision and uncertainty of the information managed, first to model the objectives, then to spread the expected consequences of an imprecisely known event.

Boyar (1997) introduced a DSS which is designed to provide a tool for production planning and controlling production activities for a broiler producer. The developed system includes two subsystems. Production control subsystem is composed of a relational database and a model base with reports and queries for statistics analysis. On the other hand, model base components, such as forecasting and simulation, are used in production planning subsystem to provide support in the estimation of future production levels.

Özdamar, Bozyel and Birbil (1998) proposed a Hierarchical Decision Support System (HDSS) for production planning in order to facilitate the production planning task for end-users by providing an easy-to-use tool which involves powerful planning procedures at all planning levels. The end-user can work out the plan interactively with the DSS tool while benefiting from the algorithmic components of the system. HDSS leads to capacity-feasible material acquisition and manufacturing plans since it provides capacity-feasible Master Production Schedules. The HDSS is integrated with MRP through the Master Production Schedule (at the end item level) which is transferred to MRP. The feasibility at all planning levels is preserved through database manipulations which enable communication among different planning hierarchies. The key features of the proposed system are the ease of data manipulation and the highly interactive nature of the system provided by the user-interface.

Sundararajan, Srinivasan, Staehle and Zimmers (1998) discussed the application of a Decision Support System (DSS) for making operational decisions efficiently which are aligned with the profitability of the food company. A model is developed for determining the optimum production scenario for every week based on the trade-offs between service levels, costs, inventories, changeovers and capacity. This paper discusses the application of one such system that has helped a food products company to make operational decisions.

Halsall and Price (1999) developed a DSS to support production planning and control in smaller companies. It is described in the paper that how a prototype DSS was developed and validated using data from a manufacturer of fencing materials. A hybrid relational database/object-oriented approach to modeling the manufacturing process is outlined. Static and slowly changing data about the manufacturing system were stored on a relational database, while more dynamic production planning information was built into an object model. The system made use of a `Bill of Production' for each manufactured item that contained both materials and operation information, and was constructed at the time it was required from information held on the database.

Riane, Artiba and Iassinovski (2001) presented a production system organized in serial shops (hybrid flowshop). A generic simulation model was presented and some features of its development environment were highlighted. The DSS is composed of two main ingredients: (1) decomposition into planning and scheduling, and (2) closed loop or feedback mechanism. Special attention is also paid to the interaction between loading and scheduling. The feedback mechanism is done by simulation. In fact, a simulation model is developed for the whole production system taking into account all its specific characteristics. The DSS is endowed with a graphical user interface to continually provide the decision-maker with the most up to date information.

Farrell and Maness (2005) developed relational database approach which was used to create an integrated linear programming-based decision support system that can be used to analyze production planning issues in a wide variety of secondary wood product manufacturers. The flexibility of the resultant system indicated the potential to analyze production strategies in the highly dynamic environment characteristic of secondary manufacturers.

Silva, Figueira , Lisboa and Barman (2006) developed a multiple criteria mixed integer linear programming model to solve aggregate production planning. The model has been developed to optimize three performance criteria for a set of workforce, production, and inventory-related constraints. The performance criteria include: profit, late orders, and the changes in the workforce level. In order to enhance its application in practice, a decision support system based on the model has also been included. It is illustrated to the use of the decision support system by applying the model to solve an actual aggregate planning problem faced by a Portuguese firm that produces construction products.

Dengiz, Bektas, Ultanir (2006) discussed the design of a decision support system (DSS) based on simulation optimization integrated with a regression meta-model, which helps the decision makers evaluate the effect of manufacturing technologies on the performance of an organization and determine the inputs that affect the performance. The proposed DSS involves analysis and evaluation of system behavior, as well as the optimization of the system configuration for a given range of parameter values. The proposed DSS model also enables the decision makers to perform sensitivity analysis quickly introduced a study which aim is of two folds. The first is to represent a simulation optimization based on DSS application for a real system by considering all the required steps. The second is to analyze the performance of the current production system and determine the optimum working conditions by simulation with greatly reduced cost, time, and effort. They developed the simulation system called diamond tool manufacturing system to predict the number of machines and the number of workers necessary to maintain desired levels of production for a company in Ankara, Turkey.

Kis, Erdős, Márkus, Váncza (2004) developed a DSS in order to create a realistic production plan for project-oriented production management with variable-intensity tasks, where the flow of information and material is captured by 'feeding-precedence' constraints between the tasks. Its graphical user interface helps human planners develop a number of plan variants, organized in a tree hierarchy. Planning with variable intensity tasks and feeding precedence constraints results in more accurate production plans. This, along with the combination of project execution and resource capacity planning leads to a better due-date observance and to a better use of resources. As a result, more customer orders can be accepted and production costs are reduced. The system is suitable for solving production-planning problems in order to make manufacturing where the tasks of a project represent aggregated activities. Another domain of application exists when only the production must be scheduled, but on different time horizons. A long-term plan (thirty weeks) can be generated by the planning module, and based on this; the weekly schedules can be obtained by an appropriate short term scheduler.

Bowers and Agarwal (1995) wrote a paper about developing a model for production planning of Tanner Companies which is an apparel factory. In the early 1990s, the company had a 74 percent on-time delivery rate and high levels of work in process. To increase on-time deliveries and raise customer service levels, the company focused on production planning and scheduling for the first time. In developing a short-term planning system, they began by designing a garment information system which provided the basis for an analytical heuristic-based scheduling model. During the development process, they actively involved users and managers at all levels to ensure employee support and smooth installation. As a result, the scheduling model was a big success. In one year, it decreased WIP levels by $200,000 and increased on-time deliveries to over 90 percent. The garment information and scheduling system has been well received and has become an integral part of daily operations at Tanner Companies.

In the master thesis of Hasgül (2005), she developed a DSS for aggregate production planning. The purpose of Decision Support System is to assist to manager to improve the effectiveness of decision making about semi-structured and unstructured problems. She compared costs of three alternatives which are constant working power, flexible working power and optimization. In the alternative of constant working power, subcontracting and overtime can be done; in addition the side effects of firing workers are avoided. In the flexible working power alternative, hiring and firing is often done and in the last alternative, optimization model uses mixing strategy of other two alternatives.

Expert Decision Support Systems Studies in Literature

Biswass, Oliff and Sen (1988) presented expert decision support systems. Aim of the system called OASES (Operations Analysis Expert System) in the production domain is to emulate a consultant and aid management in trouble shooting manufacturing processes. General cause analysis and specific cause analysis are implemented for a fiberglass manufacturing process.

Borch and Hartvigsen (1991) gave an overview of strategic planning and decision-making in small firms, together with a discussion of the use of knowledge-based systems in strategic market planning. Furthermore, they describe the STRATEX system, which is a knowledge-based system for strategic market-planning in the export trade of fish and fisheries products.

Ehrenberg (1990) presented briefly the possibility of combining DSS with expert system technology for management of inventories. An exemplary part of knowledge base for material disposition is described and some implementations of prototypes are discussed. The name of the system is EXBEST which combines database and DSS for material planning process.

Intelligent DSS Studies in Literature

In the paper written by Chan, Jiang, Tang (2000), "an integrated approach for the automatic design of FMS is reported, which uses simulation and multi-criteria decision-making techniques. The design process consists of the construction and testing of alternative designs using simulation methods. The selection of the most suitable design (based on the multi-criteria decision-making technique, the analytic hierarchy process (AHP)) is employed to analyze the output from the FMS simulation models. Intelligent tools (such as expert systems, fuzzy systems and neural networks), are developed for supporting the FMS design process. Active X technique is used for the actual integration of the FMS automatic design process and the intelligent decision support process. The integration of simulation and multi-criteria decision support methods is usable and promising methodology in FMS design."

Matsatsinis and Siskos (1999) developed an intelligent DSS, named MARKEX, which is an implementation of this methodology. The system acts as a consultant for marketers, providing visual support to enhance understanding and to overcome lack of expertise. The databases of the system are the results of consumer surveys, as well as financial information of the enterprises involved in the decision making process. The system's model base encompasses statistical analysis, preference analysis and consumer choice models. MARKEX incorporates partial knowledge bases to support decision makers in different stages of the product development process.

Scheduling Studies in Literature

The paper written by Süer and Tummaluri (2008) has dealt with assigning operators to various operations in a labor intensive cellular environment. The operator skill levels and skill-based operation times are used as opposed to the classical approach of using standard times. A three-phase approach is developed to tackle the entire problem: (1) finding alternative cell configurations; (2) loading cells and finding crew sizes; (3) assigning operators to operations. A multi-period analysis is performed to study the main issues in the paper. Mathematical models are used in all phases. Two heuristic approaches (Max, MaxMin) are developed for operator assignment and both heuristics are compared and their impacts on operator learning and forgetting are compared as well.

Tomastik (1996) wrote a paper about scheduling flexible manufacturing systems for apparel production. According to him, Since a flexible manufacturing system used for apparel production, the scheduling problem is to decide when to set up a cell and consequently begin garment production in the cell, and to decide the quantity of machines to allocate to each cell, under the constraints of limited machines. In the paper, an accurate and low-order integer programming model which integrates scheduling and resource allocation is developed. Insight is provided into how the model relates to the operation of a real factory. The model is solved using the Lagrangian relaxation methodology, and a new bundle method is used for optimizing the Lagrangian dual function. The combination of an accurate low-order model, Lagrangian relaxation, and the bundle method is shown to be very practical. Testing is performed using data from a real factory producing 10 to 40 lots per week (between 4500 and 8900 garments total) on 105 machines of nine different types.

Süer (1997) presented a mathematical model to minimize the number of tardy jobs in a multi-period environment in a cellular manufacturing where the results of optimal solution might bring the advantage that a company may need in a tough competitive environment.

Paper written by Süer and Bera (1998) focused on simultaneous solution of cell loading and cell size determination in labor intensive manufacturing cells. The study performed is a multi-period analysis where decisions are made for the several periods in future. The objective is to maximize the number of products that can be completed with the available capacity in all of the periods considered. A two-phase solution methodology is proposed. In the first phase, alternative cell sizes are generated for various manpower levels and optimal manpower allocation is performed. In the second phase, two mathematical models are proposed to perform cell loading and determine the cell size simultaneously.

Wong and Chan (2001) described the development of an effective artificial intelligence technique in the clothing manufacturing process. Genetic Algorithm (GA), incorporated with earliness and tardiness production scheduling and planning (ETPSP) method to plan the clothing manufacturing process. Additionally, a segmentation strategy is developed to divide the production-planning period to overcome the problem of chromosome selection in GA. Through the proposed method, they have minimized the inventory costs and special transportation costs by air, and have avoided customer claims on discounted selling prices of garments: The due dates required by the customers are satisfied.

Georgiadis, Levis,Tsiakis, Sanidiotis,Pantelides, Papageorgiou (2005) presented the development and implementation of a production scheduling system for production of a large-scale industrial system for the manufacturing of electrical appliances. Two different optimization strategies have been employed relying on different software developments, namely the RTN (Resource Task Network) and the STN (State-Time Network), are proposed to integrate information available in the different production units and stages with formal algorithmic tools. Optimization results indicate that significant economic benefits can be achieved while ensuring full customer satisfaction as opposed to normal practices followed in the company relying on human expertise.

Hegde G.G., Kalathur S., Tadikamalla P.R., Maurer J., Abraham K.P. (1998) reported the development and implementation process of a production planning system for a carbon products manufacturer. The model developed for the company provides an optimal production sequence by minimizing the setup costs. Initially, the optimal sequence obtained faced hurdles at the implementation stage because of lack of integration of information systems among different corporate units, and the insensitivity of the traditional productivity measurement standards which do not account for the costs of quality but over-emphasize the capacity utilization instead. Such hurdles were overcome by addressing to performance measurement issues and information systems integration. The integration of information in a timely fashion turned out to be a major factor in successful implementation of the system.

Silva, José Figueira, João Lisboa , Samir Barman (2006) presented a multiple criteria mixed integer linear programming (MCMILP) model to solve aggregate production planning (APP) to a Portuguese firm that produces construction materials. The model is developed with the following performance criteria: (1) maximize profit, (2) minimize late orders, and (3) minimize work force level changes. It includes certain operational features such as partial inflexibility of the work force, legal restrictions on workload, work force size (workers to be hired and downsized), workers in training, and production and inventory capacity. The purpose is to determine the number of workers for each worker type, the number of overtime hours, the inventory level for each product category, and the level of subcontracting in order to meet the forecasted demand for a planning period of 12 months. Additionally, a decision support system (DSS) based on the MCMILP model is proposed.

Guo, Wong, Leung, Fan and Chan (2006) constructed a universal mathematical model of the JSS (Job Shop Scheduling) problem in a mixed- and multi-product assembly environment for apparel assembly process where the production scheduling and resource allocation problems are optimized in terms of a genetic optimization process. The objective of the model is to minimize the total penalties of earliness and tardiness by deciding when to start each orders production and how to assign the operations to machines (operators). A genetic optimization process is then presented to solve this model, in which a new chromosome representation, a heuristic initialization process and modified crossover and mutation operators are proposed. Three experiments using industrial data are illustrated to evaluate the performance of the proposed method.

Chen, Hsaio and Ju sun (2009) presented grouping genetic algorithm (GGA) for assembly line balancing problem of sewing lines in garment industry. It allocates workload and among machines as evenly as possible, so the minimum mean absolute deviations (MAD) can be minimized. It is concluded that GGA performs better than genetic algorithm.

Defersha and Chen (2009) presented a mathematical model for a flexible job-shop scheduling problem incorporating sequence-dependent setup time, attached or detached setup time, machine release dates, and time lag requirements. They assume that the jobs have sequence dependent setup time, where research considering this issue in job-shop scheduling is limited. In order to efficiently solve the developed model, they propose a parallel genetic algorithm that runs on a parallel computing platform.

Tomastik, Luh and Liu (1995) developed an integer programming model which integrates scheduling and resource allocation. The approach decides the quantity of machines and stations to allocate to each cell, and the time to setup and begin processing the production lot for each cell. The model is solved by using the Lagrangian relaxation technique, and a new bundle method is used to optimize the Lagrangian dual function. Testing is performed using data from a real factory and numerical results show that high quality schedules are efficiently generated on personal computers.

Wong and Chan (2001) have addressed the integration of a real hybrid flow-shop (HFS) and earliness and tardiness scheduling problem in the apparel industry. In the paper, a new model of two-tier hierarchy of garment manufacturing scheduling system has been designed. The first objective of this paper is to plan a master production schedule (MPS) for the factory so that the costs are minimized when the production orders are completed before and after the delivery dates required by the customers. The second objective is to minimize the completion time of the pre-sewing operations in the cutting department while the production quantities required by the sewing department at several predetermined times can be fulfilled by the cutting department. Experimentation is conducted and the results show the excellent performance of the proposed scheduling model for the apparel industry.

Lee, Abernathy and Ho (2000) modeled an apparel manufacturing system characterized by the co-existence of the two production lines, i.e. traditional, long lead time production line and flexible, short lead time production line. Their goal is to find strategies which decide: (i) the fraction of the total production capacity to be allocated to each individual line, and (ii) the production schedules so as to maximize the overall products.

Following such a review, it was decided to tackle problems which are specified in introduction chapter in the following manner;

The aim of this study is the same as of those done for Tanner Companies by Bowers and Agarwal (1995) and is to increase on-time deliveries, correspondingly to raise customer service levels with lowest cost. Because of this purpose, the application of a model driven decision support system helping to make operational and tactical decisions for a manufacturing planning and control system of a medium-sized apparel company are discussed to improve the quality of production management decision like study of Muhlemann (1995). As Karacapilidis (1996) did, optimization technique is used for scheduling. Farrell and Maness (2005) developed a linear programming-based decision support system for production planning of a secondary wood product manufacturing which is flexible as system mentioned in this thesis. However, the production system is product-to-order in apparel sector that means each product type is different than others; production for inventory cannot be an option. In the study of

Hasgül (2005), she compared costs of alternatives to find the strategy out about whether to produce order in the factory with increasing labor capacity or to use outsource capacity, whereas we select to calculate and show labor cost if it is produced in the factory to the decision maker, so after receiving order price from sub-contractor, decision-maker will decide where to produce.

In general, in the literature for the production planning of apparel manufacturing system, genetic algorithm for assembly line balancing of sewing lines has been used, as it can be clearly seen in studies done by Guo, Wong, Leung, Fan and Chan (2006) and Chen, Hsaio and Ju sun (2009), Süer (1997) Tummaluri (2008) . However in our study, our mathematical model does not include assigning operations, machines and operators. Since in the current system, managers of the production lines do this job very well with their experiences. Company does not need such a help. Our objective function aims not only to minimize tardy jobs in a multi-period environment in a cellular manufacturing but also to minimize set-up cost.

CHAPTER 3

SYSTEM ANALYSIS AND PROBLEM DEFINITION

3.1. General Information about Company

The Company, family owned, was founded in 1995 at Mersin Free Zone, after 3 years from its foundation, it is decided to establish other factories located in Mersin Free Zone to increase production capacity. The company has 3 factories now, additionally other factories in Mersin free zone are sometimes used as a subcontractor by the company when the capacity is not sufficient for orders. It carries its activities with over than 800 well-trained experienced persons working on a total covered area of 8.660 sq. Meters, Being specialized in women clothing. In house capacity is 250.000 pieces of shirts/month. Its' turnover in 2009 is 8.000.000 Euros.

It produces two kinds of products. One of them which is called CMT (Cutting-Making-Trimming) includes only subcontracting operations. Customers prepare patterns of the garments, supply fabric and accessories for this kind of orders. Fabric and accessories belong to customer; the factory is responsible only for cutting, sewing and final processes. The other type of product includes not only cutting, sewing and final operations but also model design, preparing patterns of the model, finding suppliers for fabric and accessories.

Goods are sent mainly to customers in Germany, Holland, Belgium, and France.

The Company has a functional organizational structure, the six functions, production, marketing, production planning and purchasing, quality management, human resources and finance and lastly quality assurance departments are directly reporting to the General Manager who is the owner of the company. The schematic representation of the organization is shown in Appendix A.

3.2. Manufacturing Basics

Basic operational activities will be presented in this section. Marketing, purchasing and production planning departments' activities will be explained in detail, as it can be clearly described in Figure 3.1.

Marketing department agrees with the customer about orders. Price information to give to customer is received after pre-cost estimation process and delivery date information received from production planning department after master production planning process, if price and delivery date are appropriate for the customer, order agreement is done between the customer and the company. The customer sends order information. Production planning department does material resource planning according to order information entered by marketing department. After then, purchasing department supplies fabric and accessories according to MRP results. After receiving fabric and accessories, production that includes cutting, sewing, ironing, quality control and packaging processes starts, packaging departments make check list that includes information of how many pieces of garment are sent per size for the order, lastly transportation takes place.

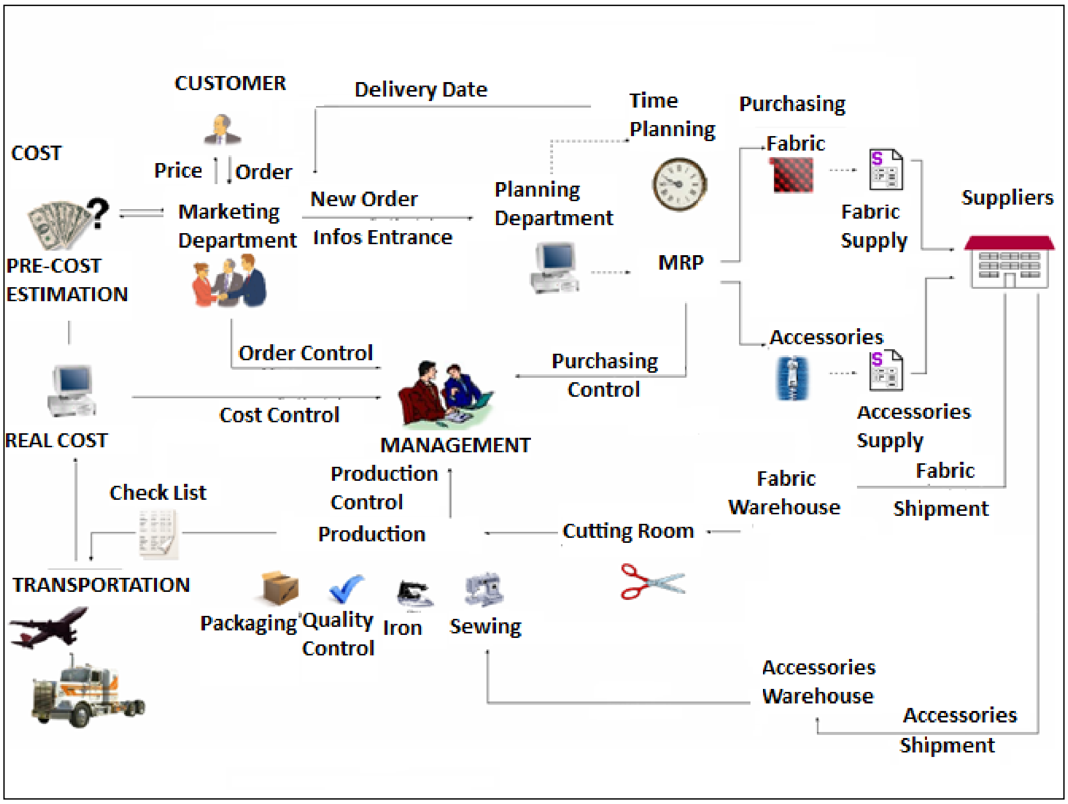

Figure 3.1 System Analysis

Since each order is different, there is no repetition of the same order, production for inventory is not possible, and production is make-to-order. Because of that reason product life cycle is short, it means that production is in small batches. Moreover, order quantities are becoming smaller and style of orders changes dramatically. Lastly, customer demand is unpredictable, market trend is fluctuating and because of international competition, quick response became so crucial for apparel companies. If the order cannot be transported on time promised before, the company need to be sent by air instead of truck, that means extra costs and also the manufacturer has to pay compensation for late delivery, in addition late deliveries effect reputation of the company, it causes losing customers.

After taking into consideration all of the factors mentioned above production planning is the most complicated and also the most important operation for the company.

General Manager of the company who is marketing manager as well communicates with customer and decides on the price and delivery date of order based on his experiences. He does not use any scientific way for this. Thus, the firm has faced production planning problem. It had to pay 10.500 € to their customers in 2009 because of late delivery and they received so many customer complaints about not sending goods on time.

General Manager has to gather information from different departments. Such as, he needs to have information of costs of fabric and accessories from purchasing department, production scheduling information from production planning department, information about production rate from production department. Hence there is a need for an efficient database.

This is the beginning point of our approach that develops this decision support system for production planning for operational and tactical decisions in such an environment.

The proposed approach suggests a specific decision support system (DSS) to help general manager and production planning department in their semi-structured problems. To proposed system is divided into two parts as “production planning” and “pre-cost estimation”. Production planning module focuses on determining delivery date of orders and scheduling of the production lines. The major purpose of the pre-cost estimation module is to calculate total cost which consists of fabric, material and labor costs.

3.3. The Drawbacks of the System, Necessity of the Study

The developed system is necessary due to the following reasons: difficulties of the production and capacity planning high cost of late deliveries, there is no tool to support decision making and lastly data are stored in different files.

As it was explained before, production planning issue in apparel sector is getting complicated day by day because of international competition environment, fluctuanting demand, small order quantities and different style of orders as well as quick response to customer is getting more important in such an environment. In consequence of complex production planning, some problems arise. Sometimes so many orders are accepted to be sent at the same time that the capacity is not sufficient for it. Shortage of capacity problem is faced during this period. Over-time option or subcontracting is used at this time, but most of time, the result is chancing delivery date of some orders, it effects subsequent orders. However sometimes, there are less capacity requirements than normal capacity. It means idle of capacity and extra labor cost.

General Manager decides delivery date of order when contract of it is received on his own experiences without getting help of any tools to support decision making, although there is list of possible decisions that needs decision support system. Since he does not use any DSS, the company faces high compensations for late delivery. To illustrate, the company had to pay a huge amount of money to their customers in 2009. Moreover, the company receives customer complaints about late delivery, it causes losing customer in such a high competitive environment.

There is no existing functional information system; the information is stored in different files. The users have to collect data they need from different files, sometimes the same data have to be stored in different files. This signals necessity of a specific information system.

The way of conducting proposed system with the current system is described in chapter 4.

CHAPTER 4

THE PROPOSED APPROACH

The proposed system suggests a specific decision support system to help production planning head and general manager in their semi-structured problem. The flow chart of the system is represented in Figure 4.1. Product definition is done by production planning and marketing departments, it includes pre-cost estimation. After then, purchasing and production are realized by purchasing and production departments as cooperation between them can be seen clearly in flow chart in figure 4.1. It consists of two parts as “production planning” and “ pre-cost estimation”. Production planning subsystem focuses on determining delivery date of orders and scheduling of the production lines. Tables, queries and forms are established in relational database. Production planning module consists of model-base components including mathematical model for optimization of production scheduling. The major purpose of the pre-cost estimation module is to calculate the total cost which consists of fabric, accessories and labor costs. All of the data are stored in the same database instead of different files, and tables, queries and forms are established to calculate total cost of order.

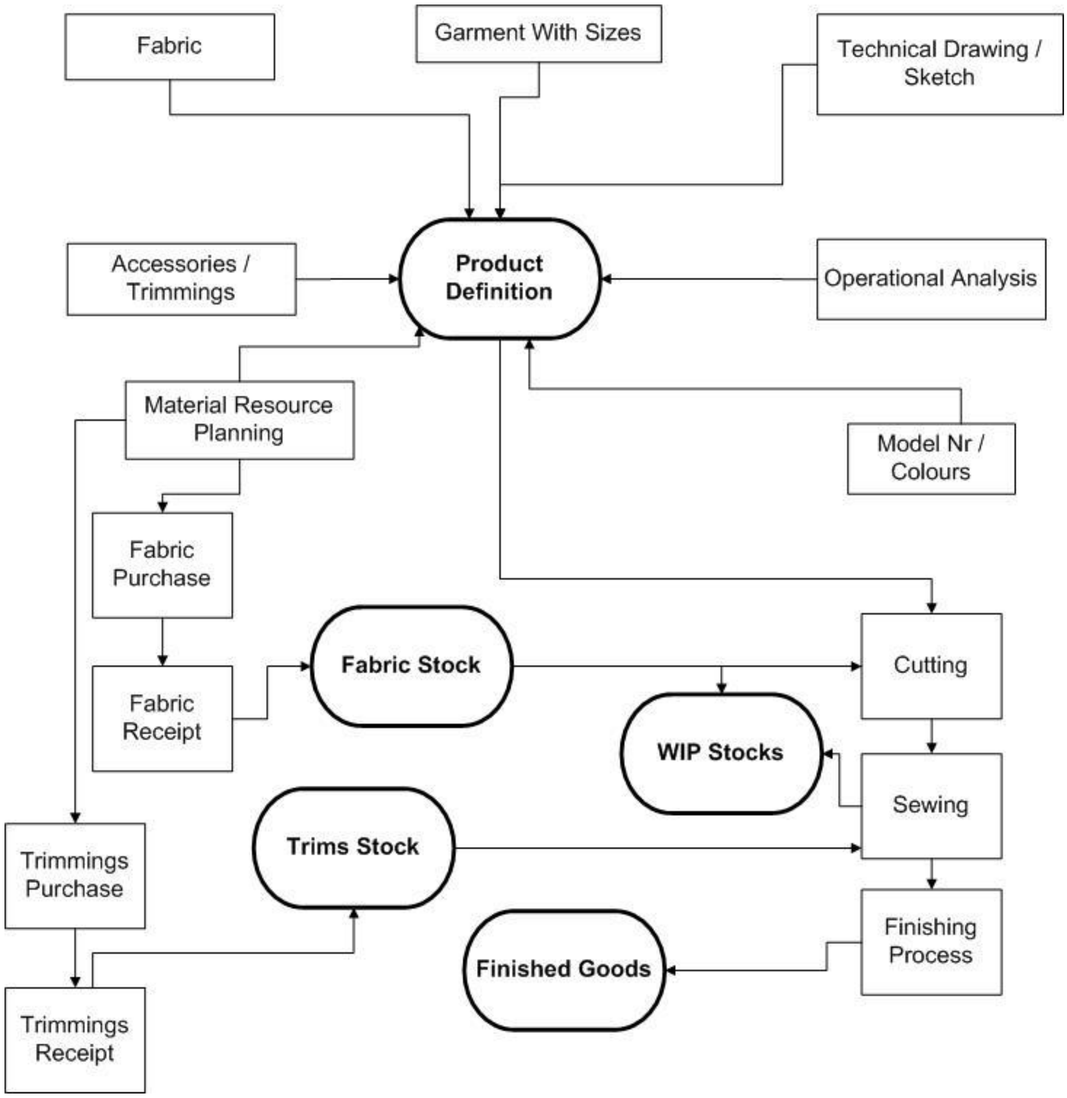

Figure 4.1 Flow Chart of the System

4.1. Production Planning Module

Production planning and scheduling problem defines two sub problems to be solved. One of them is the *allocation problem which is* to decide which resources should be allocated to produce the given orders. The other one is the *sequencing problem* which is to determine when each order will be produced. Morton & Pentico (1993) described that scheduling problems are often complicated by large numbers of constraints relating activities to each other, resources to activities and to each other, and either resources or activities to events external to the system. Pinedo (1995) stated that the scheduling function in an organization or system has to interface with many other functions. In Figure 4.2, information flow diagram in a manufacturing system is shown.

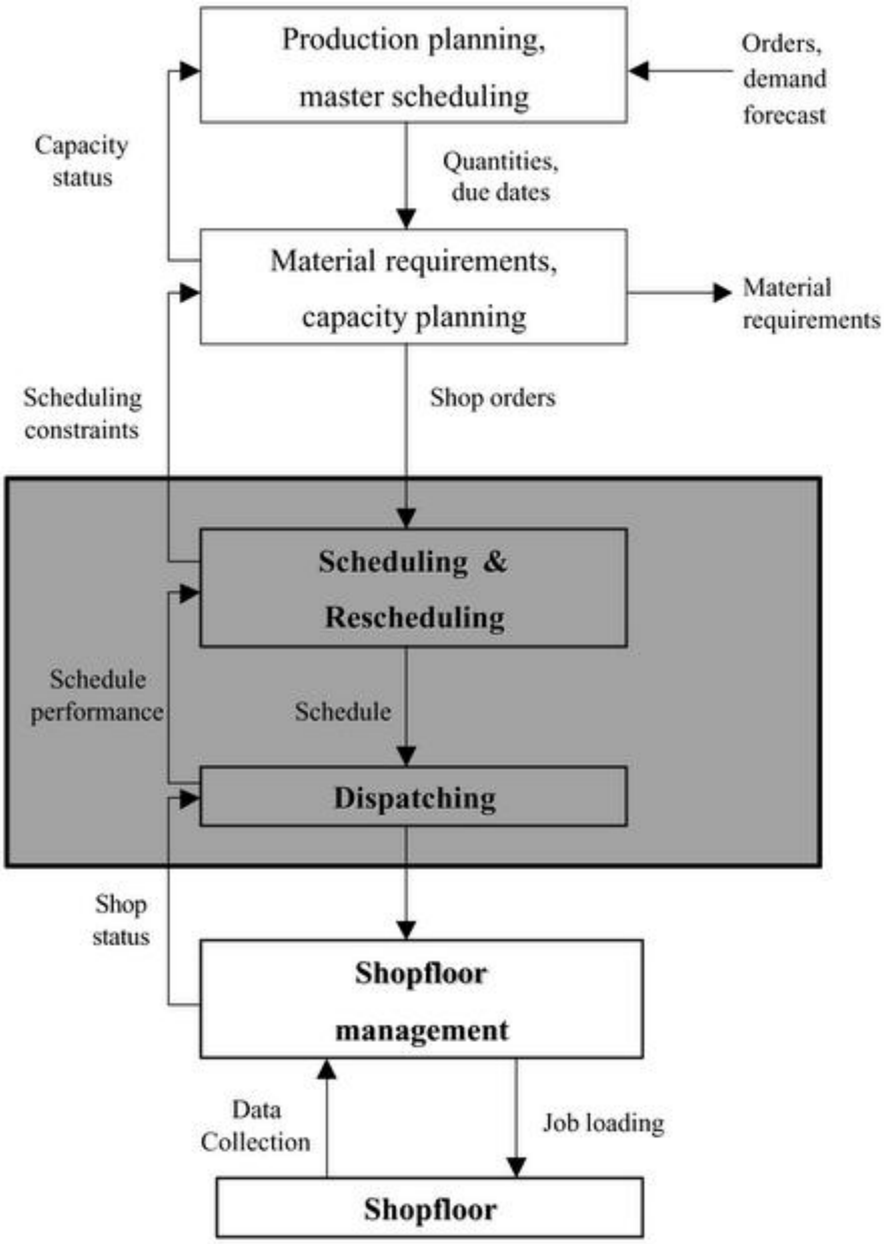

Figure 4.2. Information flow diagram in a manufacturing system (Pinedo, 1995)

The proposed approach, instead of decisions based on general managers experience, suggests a system as follows; to solve allocation problem, after receiving order, according to sketch of the garment, time-study department calculates standard time of the order that means time necessity to produce one garment is computed, and then how many pieces can be produced with 25 workers in 9 hours and how many days the order takes to be produced are calculated. The purchasing manager finds appropriate fabric and accessories for the order and informs production planning department about receiving dates and their costs. Taking into consideration this information in addition to in-house and subcontractors capacities, production planning department determines delivery date of order. Thus, master production scheduling is done. After then they inform marketing department about cost and optimum delivery date of the order.

If marketing department agrees on price and delivery date with the customer, production planning department starts to control fabric and accessories of the order. Material resource is planned by production planning department and the purchasing department supplies necessities according to this information. After then, production planning department starts to follow the order, controls if it can be started when it is planned, if there is shortage of any accessories, if they can be delivered on time.

After fabric and accessories are arrived, cutting, sewing, washing (optional), final process, packaging, shipping process will be done. For these production processes, in-house capacity can be used or they can be assigned to subcontractors. Production planning department decides where to produce and which product line(s) will produce the order with the help of output of the GAMS. Shop floor management is done by managers of the production lines.

In the proposed system, there is a production planning subsystem which is model based. Owing to tables, forms and queries in the system, the user will decide most appropriate delivery date of order easily and production scheduling will be done through mathemathical program. The program will find best scheduling and then delivery date will be seen in the output of the program as well.

The production planning module is designed to overcome the drawbacks of the current system. It also provides user friendly interfaces. The system has to include current data and correct calculations to generate reliable reports. To realize necessary updates, data entry screen is designed. The appearance of these screens is given in Appendix B.

4.1.1. Optimization

Since export oriented apparel factories production is on the make-to-order basis instead of make-to-stock, there is no option like inventory of goods that can be sold in future. Because of that reason, production planning is so complicated and vital in apparel sector. To prevent idle and shortage capacity, an optimization model is constructed.

The most important process in apparel sector is sewing, it includes a huge number of operations, and thus high workforce is been using in assembly line, because of that reason, scheduling of the production lines is very complex issue. It is very crucial to increase workforce efficiency, decrease set-up time and finish production of orders on time. Since managers of the sewing lines use their experience to assign tasks to workers based on sequencing of task and required standard time, it is thought that it is not necessary to compute optimum assignment of tasks and machines to workers like line balancing problem in this case. In this study, it is aimed to minimize tardiness and set-up costs and times and find appropriate delivery dates of orders. Tardiness of an order is difference between completion time of production and due date of the order. The purpose is finishing the production just on time and increase labor utilization.

Assumptions

The assumptions of the mathematical model are listed below;

1. Each production line has same workforce capacity. They involve 25 workers/work stations.
2. Efficiency of each production line is the same.
3. The sewing line includes all kind of machines. There is no limitation of specified number of machines.
4. Setup time when switching to same family is ignored. It is taken as zero because of family-based set-up times.
5. Each order can assign at least one sewing line.
6. Set-up time is taken based on family of order. It is independent from family of previous order. Similarity between families is ignored.
7. All data are integer values.

Definitions

The problem mentioned in this study can be defined as follows; there are n orders, m sewing lines and h positions. Each order has a processing time $P_{1;}$ $P_{2;}$ $P_{3;}$. . . . .;$P_{n,}$ an arriving date $A_{1;}$ $A_{2;}$ $A_{3;}$. . . . .;$A_{n,}$ a due date $DD_{1;}DD_{2;}$ $DD_{3;}$. . . . .;DD_n and a family index $F_{1;}$ $F_{2;}$ $F_{3;}$. . . . .;$F_{n.}$

Orders are grouped based on family type. They are divided in to six families which are shirt, trousers, skirt, dress, jacket and tricot tunic. Thus, Fi = {5; shirt, 7; trousers, 6; skirt, 3; dress, 0; jacket, 4;tricot tunic}. Each family has a set-up time $S_{1;}$ $S_{2;}$ $S_{3;}$. . . . .;$S_{6.}$ A setup is required whenever the family of previous order is different than the next one. If consecutive order is of the same type, it does not require a set up. While there is setup time and cost for switching family, setup times and costs for interfamily are larger than zero.

A binary variable is defined in the problem as a decision variable, X_{ijt} which takes value 1 if order i is produced at t^{th} position in line j . Otherwise it takes 0. The other decision variable is completion date of order i produced in line j at t^{th} position, C_{ijt}.

Our model is a kind of scheduling with family setup times.

Notation

Notation which is used in this problem is as follows;

Indices

i=index of order	*i=1,...,n*
j= index of line	*j=1,....,m*
t=index of position	*t=1,....,h*

Parameters

P_i= *Processing time of order i*
A_i = *Arriving date of order i*
DD_i= *Due date of order i*
Fi= Family of product i
S_i=*Set-up time of product family i*
D_i = *Demand of order i*

Decision Variables

$$X_{ijt} = \begin{cases} 1 & \text{order } i \text{ is produced at position } t \text{ in line } j, \\ 0 & \text{o.w} \end{cases}$$

C_{ijt}= *Completion date of order i produced at position t of line j*

T_i= *Tardiness of order i* = B_i-DD_i

B_i = *Finishing date of production of order i*

ST_{jt}= *Set-up time in terms f day for the order produced at position t in line j*

U_{ijt} = *Amount of order i produced in line j at position t*

ST_{jt}= $\sum_i Si * Xijt$ *if set-up is needed to produce order i*; *0 Set-up is not needed; previous order in the sequence belongs to same family*

Z_{jt}= *1 if order i produced at position t in line j is different than the previous order*; *0 o.w.*

Mathematical Model

$$\text{Min} \sum_i Ti + \varepsilon * \sum_i \sum_j \sum_t Zjt * Si \qquad (1)$$

s.t.

$$\sum_j \sum_t Xijt \geq 1 \qquad i= 1,\dots,.n \qquad (2)$$

$$\sum_i Xijt \leq 1 \qquad j=1,\dots,m\ ,\ t=1,\dots,.h \qquad (3)$$

$$A_i * Xijt \leq \sum_j \sum_t (Cijt- Uijt/P_i) \qquad i=1,\dots,n\ ,j=1,\dots,m,\ t=1,\dots,h \qquad (4)$$

$$T_i \geq B_i- DD_i \qquad i=1,\dots,n \qquad (5)$$

$$C_{ijt} \geq \sum_k C_{kjt-1} + U_{ijt}/P_i - M*(1- X_{ijt})+ ST_{jt} \qquad i=1,\dots,.n\ ,j=1,\dots,.m,\ t=1,\dots,.h \qquad (6)$$

$$C_{ij1} \geq U_{ij1}/P_i - M*(1- X_{ij1}) + ST_{j1} \qquad i=1,\dots,n,\ j=1,\dots,.m \qquad (7)$$

$$ST_{jt} \geq \sum_i Si * X_{ijt} - M*(1- Z_{jt}) \qquad j=1,\dots,m,\ t=1,\dots,h \qquad (8)$$

$$M*Z_{jt} \geq \sum_i Fi * X_{ijt} - \sum_i Fi * X_{ijt-1} \qquad j=1,\dots,m,\ t=1,\dots,h \qquad (9)$$

$$M*Z_{jt} \geq \sum_i Fi * X_{ijt-1} - \sum_i Fi * X_{ijt} - M*(1-\sum_i X_{ijt}) \qquad j=1,\dots,m,\ t=1,\dots,h \qquad (10)$$

$C_{ijt+1} \leq M * \sum_k X_{kjt}$ $\quad$ *i=1,...,n, j=1,...,m, t=1,...,h-1* (11)

$B_i \geq Cijt$ $\quad$ *i=1,.....,n, j=1,...,m, t=1,...,h* (12)

$D_i = \sum_j \sum_t U_{ijt}$ $\quad$ *i=1,.....,n* (13)

$C_{ijt}, ST_{jt}, U_{ijt}, B_i, T_i \geq 0, \quad X_{ijt} = (0,1)$ $\quad$ *i=1,...,.n,j=1,...,m, t=1,..,h* (14)

First objective is to minimize tardiness and second objective of the model is to minimize set-up time. ε is sufficiently small positive number and M is sufficiently large positive number. Constraint sets (2) ensure that each order is assigned to at least one line and constraint sets (3) satisfy the requirement that at most one order can be assigned position of each line. Constraint sets (4) satisfy the requirement that accessories and fabric must be available before the start of production for order i. Constraint set (5) gives the definition of T_i, which is to be minimized in the objective function (1) . Tardiness of order i is difference between completion time and due date of order i. Constraint sets (6) ensure that earliest completion time of order i in line j at position t equals to the sum total of completion time of previous order, set-up time of order i if it is necessary and processing time of order i. M is a large enough nonnegative number, It guarantees that if order i is assigned in line j at position t, C_{ijt} takes value. Constraint sets (7) are given since in constraint sets (6) previous orders position is described as t-1 and t is described to start take value from 1. When t takes value 1, previous orders completion time will be seen as C_{ij0} which is not described. To prevent this, this constraint has to be added. Constraint sets (8), (9), (10) calculate set-up time if family of previous order is different. M, a large nonnegative number, has the effect of eliminating constraints of (9) and (10) it guarantees that only one of the constraints must hold. Constraint sets (11) satisfy that if there is not any job in predecessor position, completion time of job cannot take value. This constraint sets provide sequence. Since C_{ijt} takes value each position, the biggest one equals to finishing date of production of order i. Constraint sets (12) helps to find value of B_i . Constraint sets of (13) ensure that total sum of amount of production each line at each position equals to total demand for each order. The non-negativity restrictions for C_{ijt}, $S_{ijt,}$ and 0-1 restrictions of X_{ijt} are specified in (14).

Output of the GAMS optimization program is given in Appendix E.

According to output of the program, tardiness values of all orders are zero and there are setups for ten times. The scheduling is presented as below in Table 4.1. When we look at the scheduling at the first line, it is clearly seen that order 1 is assigned at first position in first production line and there is a setup. Order 6 is assigned at second position in first production line and there is not any setup because order 1 and 6 belong to same family, there is no family difference. For the third and forth position, order 1 is produced in first production line, and then for the fifth position order 6 is produced. For the sixth position order 9 is produced in first production line and there is a setup since families of orders 6 and 9 is different. After order 9, order 14 and order 8 are produced, respectively. At eight position in first line, there is a setup, because order 14 and order 8 belong to different family. Gantt charts of first, second, third and forth production lines is presented in tables 4.2, 4.3,4.4 and 4.5, respectively.

Table 4.1. Result of the Mathematical Program

Positions Lines	1	2	3	4	5	6	7	8
1	1	6	1	1	6	9	14	8
2	5	5	7	12	5	13	7	12
3	2	4	10	8	8	10	11	15
4	3	8	4	8	10	10	10	-

Table 4.2. Gantt Chart for the First Production Line

Positions / orders	1	2	3	4	5	6	7	8
1	■		■	■				
2								
3								
4								
5								
6		■			■			
7								
8								■
9						■		
10								
11								
12								
13								
14							■	
15								

Table 4.3. Gantt Chart for the Second Production Line

Positions / orders	1	2	3	4	5	6	7	8
1								
2								
3								
4								
5	■	■			■			
6								
7			■				■	
8								
9								
10								
11								
12				■				■
13						■		
14								
15								

Table 4.4. Gantt Chart for the Third Production Line

Positions / orders	1	2	3	4	5	6	7	8
1								
2	■							
3								
4		■						
5								
6								
7								
8				■	■			
9								
10			■			■		
11							■	
12								
13								
14								
15								■

Table 4.5. Gantt Chart for the Fourth Production Line

Positions / orders	1	2	3	4	5	6	7	8
1								
2								
3	■							
4			■					
5								
6								
7								
8		■		■				
9								
10					■	■	■	
11								
12								
13								
14								
15								

4.2. Pre- Cost Estimation Module

According to information received from time-study department, the labor cost is calculated, purchasing department finds the most appropriate suppliers for both fabric and accessories and then these costs and overhead costs will be added to labor cost. Finally after adding profit, price which will be proposed to customer is determined.

In the pre-cost estimation module, information of fabric, material and labor costs is calculated and gathered together to be seen in one page instead of different spreadsheets. User friendly interfaces are provided in the module. In addition, due to the fact that necessary updates have to be realized before running reports and queries, data entry screen is designed. The appearance and description of these screens are presented in Appendix B.

CHAPTER 5

DSS DEVELOPMENT

The Decision Support System is designed to be used for production planning and pre-cost estimation activities of an apparel company. The conceptual framework of proposed decision support system has been discussed in Chapter 4. Its modeling methodology has also been presented. This chapter is devoted to the illustration of the methodology of the decision support system.

As it can be clearly seen in context diagram of the proposed system which is represented in Figure 5.1, major decisions are about delivery date and price of the order. Customer sends order information through contract including technical drawing of model in order to calculate production cost with analyzing of operations, especially in sewing line. Customer also sends information about fabric and accessories suppliers and the date of their arrival if the order is CMT that means it is a sub-production order, the firm is responsible only for production including cutting, sewing, trimming. Fabric and accessories are bought by customer instead of the firm. Based on this information, the company has to send most appropriate delivery date and price of the order as soon as possible, since customers request quick response. If the order type is not CMT, the company has to arrange fabric and accessories, therefore, when the contract is received, the purchasing department has to find most appropriate supplier based on some criteria that correspond to price, quality and due date. Purchasing department enters supplier and price data of fabric and accessories to the system. Work study department calculates standard time based on operation analysis of the order that is done with technical drawing. Production planning department receives standard time of order from the system and prepares working plan and also it calculates the necessary amount of fabric and accessories that purchasing department needs while ordering them. The system calculates unit production cost based on information entered from planning and purchasing department, such as, unit fabric and materials necessity and labor cost from production planning department and also cost of fabric and accessories from purchasing department. General Manager who agrees on orders with customer receives this data and after adding profit, he determines price to inform customer. If it is decided that there is no in-house capacity according to master production plan, order information is sent to subcontractors located in Mersin Free Zone and receive their proposals if they have capacity. After then, decision of assigning the order to subcontractor is made.

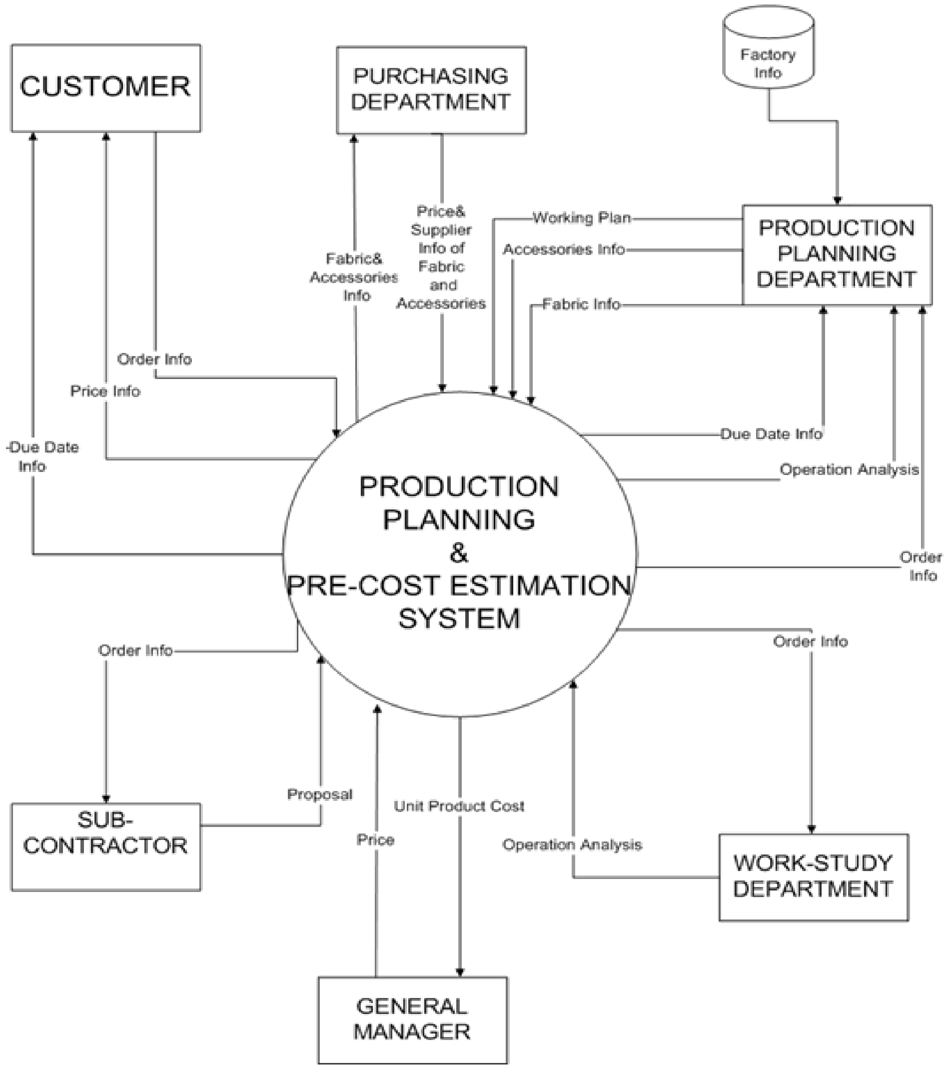

Figure 5.1. Context Diagram

5.1. Description of the DSS Software

The developed Decision Support System is composed of three main modules. These are Database, Model Base and User-Interface Modules.

5.1.1. Database Module

The proposed system needs to manage great amount of data. Therefore, a relational database using Microsoft Access is designed as a basis for the proposed system. A relational database consists of tables, each of which is assigned to unique name. A table (relations) is a collection of data values set up in columns and rows. Thus, the fundamental structure of the relational database is a table. A row in a table represents a relationship among a set of values. Each column, often called an attribute, also must have a name (field name), preferably one suggesting the property or characteristics that its values represent. The system enters user provided data to the tables in the database. The system uses data in the relational database, and calculates material requirements, unit production cost, master production planning and production scheduling. To design database, entities in the system are determined first, the main entities in the system are;

- Order
- Customer
- Fabric
- Factory
- Labor
- Accessories
- Model
- Plan

Due to the fact that there is a close correspondence between entities, it is determined that there are one-to-one and one-to-many relationships between them. According to determined relationships, the entity-relationship diagram is presented in Figure 5.2. Information stored in the tables is clearly seen in the diagram. In the table of customer, customer identity number is primary key (P.K.) that means each customer has unique number in the system to be recognized easily. Customer name, customer mail address, shipping address, city, zip code, country and phone number of customer are stored in the each column of the table. Customer ID data is stored in order table as well, because it is primary key of another table, it seems as foreign key (F.K.) on the order table. Data stored in each column of the order table is order ID, Customer ID, Factory Name, Model Nr, Quantity, Cost, Order Name, Price, Due Date, Planned Production Starting Date, Planned Product Finishing Date of the order and Explanation. In the Model Table, Data of Model Number which is unique (P.K.), Order ID, Setup time of the order and picture of the technical drawing, model group which can be skirt, trousers, dress, shirt, and knitted tunic are stored. The relationship between Customer and Order tables is 1: N because of the fact that one customer can have N number orders, but one order belongs to only one customer. Each order has a unique model number since each style of order is different than the others. One model number belongs to one order number. Therefore, the relationship between order and model tables is 1:1. In the factory table, data of factory ID which is primary key, factory type which can be subcontractor or not, productivity, line cost per minute, labor, machine capacity of per factory is stored. Because of the fact that one order must be produced in one factory, one factory can produce N number orders at the same time there can be no order assignment to one factory if it is subcontractor; therefore the relationship between factory and order tables is 1:N. In accessories table, data of material ID (P.K), Order ID (F.K), Material Name which can be button, label, zipper, etc. quantity received, price, supplier and receiving date of accessories is stored. Since one button can be used both a skirt and a jacket and two kind of buttons can be used for one order, the relationship between accessories and order tables are N:N like fabric and order tables. Unit standard time of each order is stored in labor table. One order has only one specified standard time data, so the relationship between them is 1:1. The relationship diagram provided by Microsoft Access for designed database is given in the Appendix C.

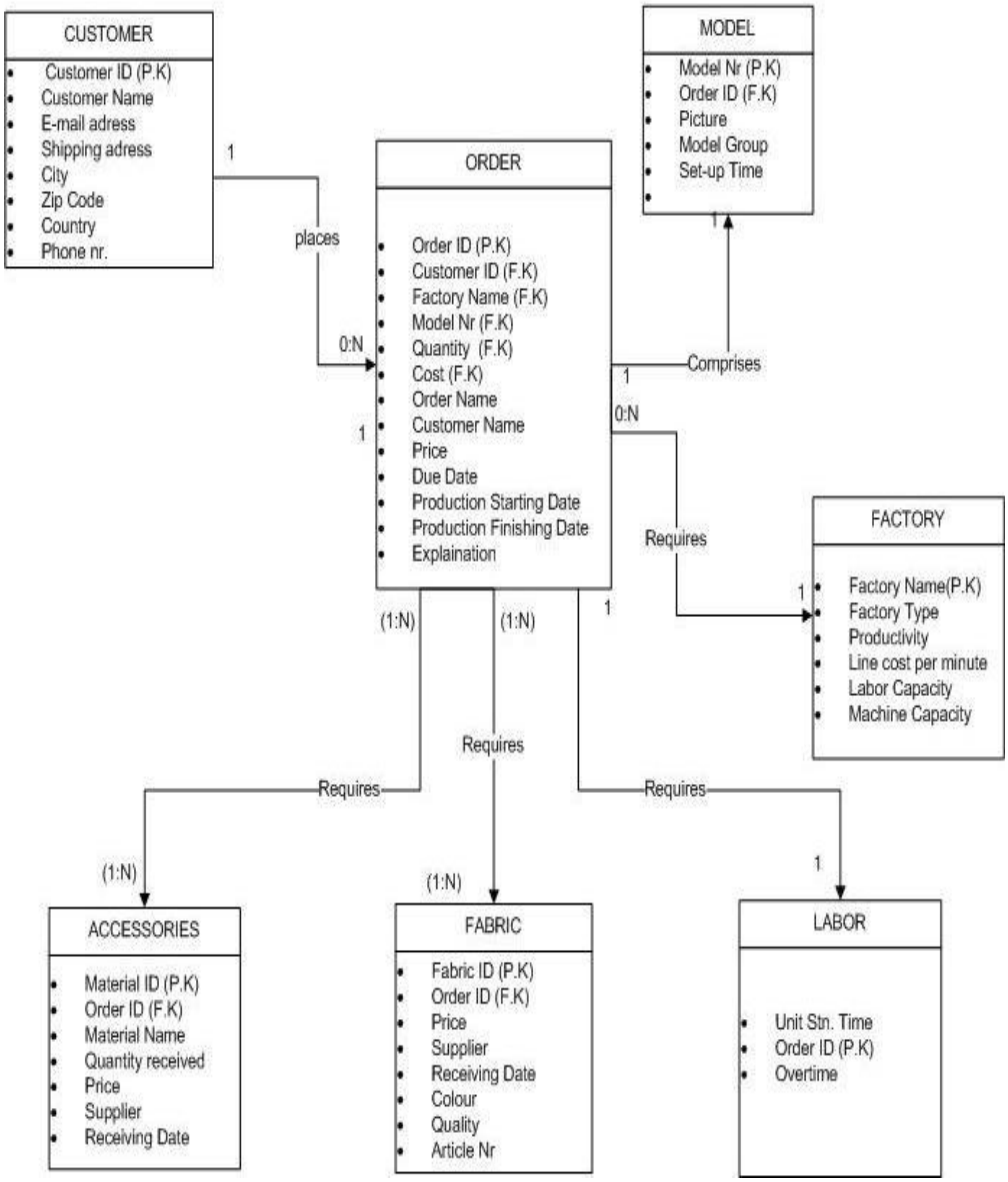

Figure 5.2. Entity Relationship Diagram

Stephens R., Plew (2002) stated that normalization is a process or set of guidelines used to optimally design a database to reduce redundant data, benefits of normalization are as follows;

- Greater overall database organization
- Reduction of redundant data
- Data consistency within the database
- A much more flexible database design
- A better handle on database security

There are different levels of normalization named as normal forms. The following are the three most common normal forms in the normalization process:

- ✓ The first normal form
- ✓ The second normal form
- ✓ The third normal form

- The database is in the first normal form if following conditions are met (Wikipedia,2010)
    - Primary key is seen to each table.
    - There are no repeating groups.

- The database is in the second normal form if following conditions are met:
    - Requirements for the first normal form are met.
    - In this normal form, each column must depend on the entire primary key.

- The database is in the third normal form if following conditions are met:
    - Requirements for the second normal form are met.
    - Each column must depend directly on the primary key.

The developed database is included in the third normal form because there is no repetition of any coloumn and all of the columns depend directly on the primary key in the tables.

5.1.2. Model Base Module

Data Analysis Tools: a query language is a language in which a user requests information from the database. Database system products require “user friendly” query language. Querying mechanisms have been developed for the user to observe the following performance characteristics in Microsoft Access.

- ✓ Unit Product Cost which includes fabric, accessories and labor costs.
- ✓ Total production reports on a weekly basis for each factory.
- ✓ Work in process orders.
- ✓ Ready to production orders that means all of accessories and fabric are received; fabric, accessories, model, pattern and drawings for cloth spreading are confirmed.
- ✓ Master production planning. Capacity requirements for each factory on a weekly basis are calculated.
- ✓ Capacity fulfillment on a weekly basis.
- ✓ Capacity requirements on a monthly basis for each customer.
- ✓ Turnover on a monthly basis for each factory.
- ✓ Turnover on a monthly basis for each customer.
- ✓ Data will be input for GAMS optimization program. Such as, order ID, latest arriving date of fabric and accessories, setup time, demand quantity, due date, etc.

5.1.3. User Interface Module

The user interface module is the part of a product or system, which the user comes into contact. This module provides a runtime support environment, which manages the interaction with the program. The structure of user interface module is shown in Figure 5.3.

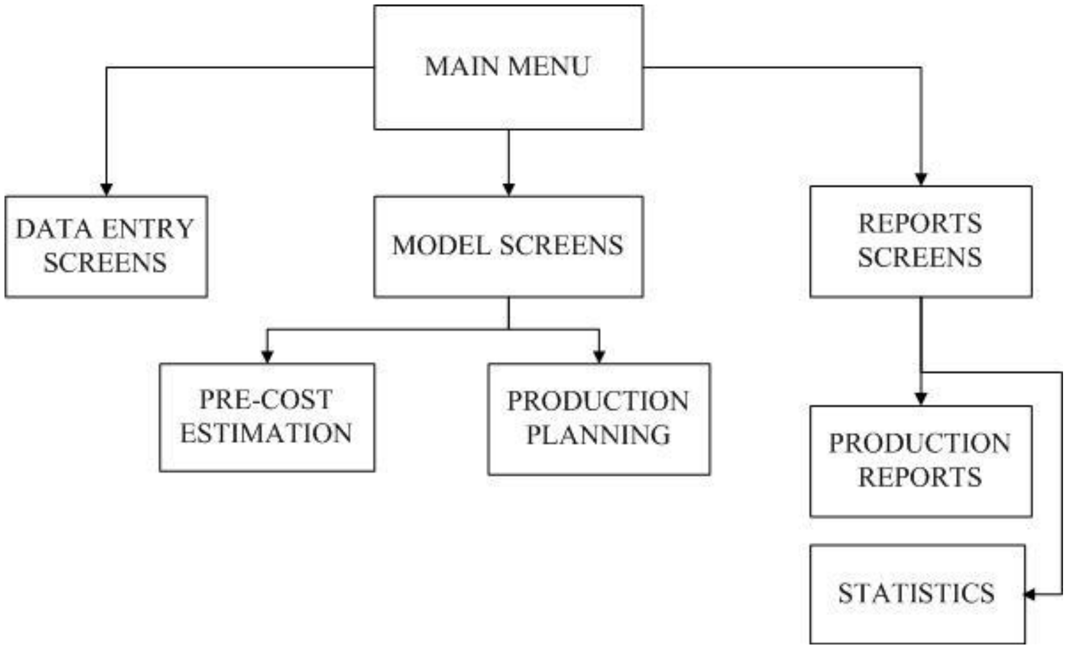

Figure 5.3. The Structure of User Interface Module

Program starts with main menu screen which is given in Appendix B shown in Figure B.1. The relational database program has three sub-main screens on the main menu. These screens are Data Entry Screen (Bilgi Giriş Ekranları) , Model Screens (Model Ekranları) and Report Screens (Rapor Ekranları) Pre-cost estimation and production planning programs based on model can be reached through the model screens. Production reports and various statistics are reached through the reports screen.

Data Entry Screens

Sometimes user does not want to enter information in tables, so user friendly forms are designed to input information.

- Order Input Screen: When an order is first received, all information about it is entered via this screen which is showed in Appendix B in Figure E.2. Order Name, Order ID, Customer ID, Customer Name, Model ID, Quantity, Due Date, Price, fabric ID, accessories ID, fabric& accessories supplier, fabric& accessories receiving date, and Factory data are entered.
- Customer (Müşteri) Input Screen: There exist fields about entering Customer Name, Customer ID, Shipping address, City, zip code, Country, mail address, Telephone number.
- Factory Input Screen: Factory ID, labor and machine capacity, Productivity level data are entered via this screen.

Model Screens

The buttons under model screen named as pre-cost estimation and production planning are used for seeing unit product cost and master production planning. pre-cost estimation button navigates you pre-cost estimation analysis form. Under the production planning menu, it is easy to reach master production planning, order plan and factory plans. Screens are given in Appendix B.

Report Screens

The buttons under the reports screen named as (Raporlar). Production reports (üretim raporları) and statistics (istatistikler) are used to take production plan on weekly basis, monthly basis, work-in process orders, ready-to-production orders some statistics like sales statistics and turnover on monthly basis . These are presented in Appendix B.

CHAPTER 6

CONCLUSION

In this thesis, a specific decision support system is developed for an apparel firm to help production planning and pre-cost estimation activities. A database is designed for effective integration of information used in the system, and models are included to the designed system to prepare production scheduling and calculate pre cost estimation.

In this thesis problems for production planning in high competitive environment are analysed. It is observed that in the current system, production planning is being carried out in a traditional manual way. That causes paying compensation for late delivery, sending goods by plane instead of truck and receiving customer complaints about late delivery. In addition to that, data is collected and stored both hardcopy and softcopy during these activities, there is no database to integrate data from different departments. Different documents are prepared for using the same data. Inconsistencies are seen among data in different documents. The purpose of the developed information system is to integrate information from different divisions of the organization and use this information for production planning and pre-cost estimation processes.

Throughout the studies conducted to design the decision support system, current method of handling jobs is examined, drawbacks of the current system is identified and a more powerful model leading to more satisfactory results is developed.

This thesis includes two major DSS subsystems for “production planning” in semi-structured environment and “pre-cost estimation” activities. It is observed that production planning module is neccessary to implement production activities smoothly with possible minimum cost as well as satisfy customer. The pre-cost estimation sub system is neccessary to respond to customers quickly to inform them about the price.

The major benefits of the developed system in terms of supporting the decision making process for production planning and pre-cost estimation problem of an apparel company are as follows:

- Production scheduling is done by using mathemathical programing. This provides scientific approach to the existing production planning, which has traditional determination of delivery date based on experience. That prevents problems of idle capacity and shortage of capacity which are major drawbacks of the current system.

- Primary objective of the optimization programme is minimizing tardiness of orders, as a result, early production is realized, optimum production scheduling is achieved through the programme. This minimizes compensation cost because of late delivery.

- Due to secondary objective of the optimization program is to minimize setup time, the consequence is that optimum order sequencing in sewing line in order to have minimum setup time is provided.

- Because of using computer technology effectively, the firm responds quicker to customer, that makes the customer satisfied.

- An effective and accurate system for calculating pre-cost estimation is developed because of developed information system.
- Data are entered to the system easily, the required production performances are obtained from the system reliably and fast according to the existing production data management.

- Production data are easily handled to relate to the production system when there is a problem about production performances. To achieve this, the proposed system has some analysis tools such as graphical utilities and reports.

- Information for production planning, pre-cost estimation is stored in a well organized way. As a consequence of this, consistent information among departments can be achieved.

- Since data in different files are gathered together and integrated in a well organized way, the proposed system reduces the efforts for documents organization.

Besides benefits of the proposed decision support system to the apperal company, the major contribution of this thesis is a general decision spport system approach in production planning for a high competitive market.

On the other hand, there are some drawbacks of the developed system. The possible future work for the proposed decision support system can be summarized as follows, To enhance visualization of the decision support system, other programmes, such as Visual Basic can be used to create more user friendly interfaces.

For sewing process, an additional optimization model can be designed in order to solve line balancing problem. Line balancing is done by manager of the line with his own experience. A scientific method can be used instead of traditional one.

Boundary of the system can be enhanced. The system is used only by planning, production, purchasing and marketing departments. However, other departments, such as sales, accounting can be included in the system. Documents they need can be put into the system. For instance, fabric, trimmings, accessories and garments bill and also sales invoices can be added into system. Therefore, accounting and sales departments are involved in the system.

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APPENDIX A

ORGANIZATIONAL CHART OF THE COMPANY

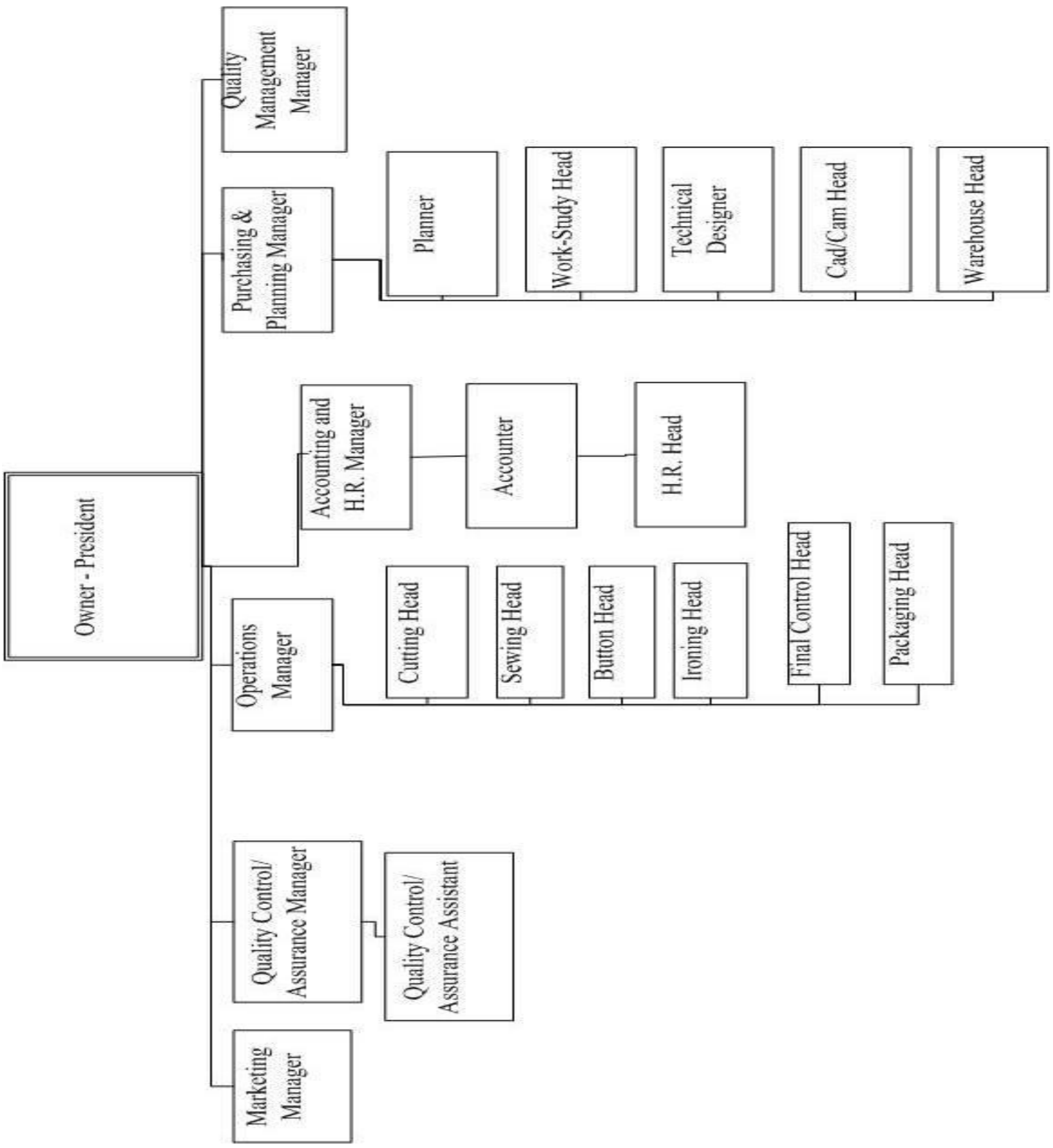


Figure A.1 Organizational Chart of the Company

APPENDIX B

SCREENS

B.1. Main Screen

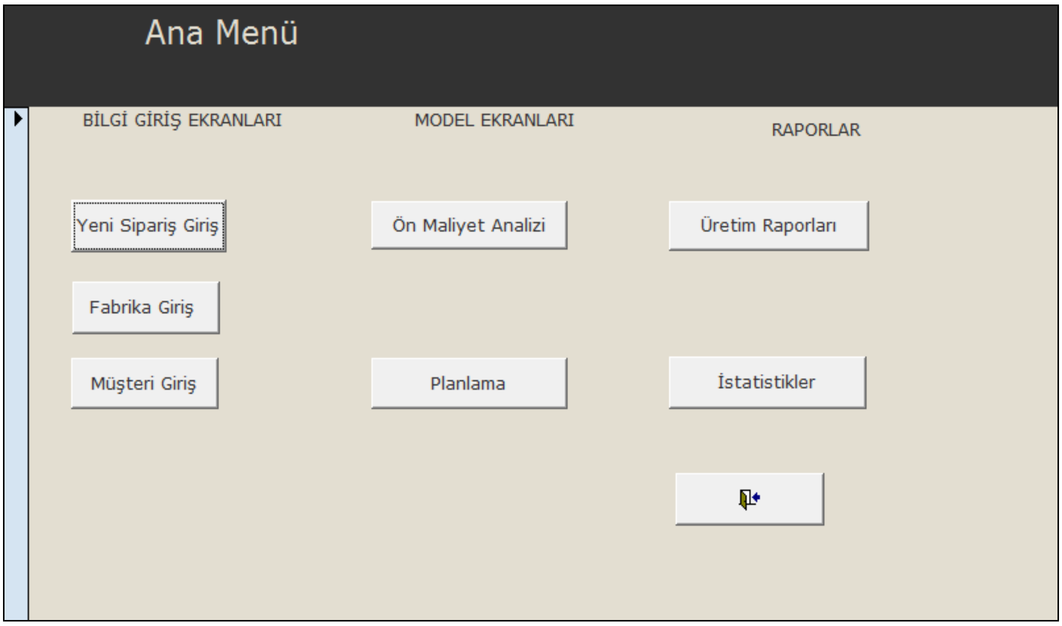


Figure B.2 Main Menu Screen

When you open the program, you see the main screen illustrated above in Figure B.1. If you want to enter a new order, you will click “yeni sipariş giriş” button, and then you see screen presented in Figure B.2.1. If you want to define a new factory like a sub-contractor, you will click button of “Fabrika Giriş”, after then you will see screen illustrated in Figure B.2.2. If you want to define a new customer, you’ll click button of “Müşteri Giriş” and then you will face with the screen presented in Figure B.2.3. After defining new order, factory or customer you can save and quit from these screens.

If you want to see queries results about pre cost estimation calculation and planning, you will click “ön maliyet analizi” and “planlama” buttons, after then you will see screens presented in Figure B.3.1 and Figure B.3.2., respectively.

When you want to see production reports, you will click the button of “üretim raporları” and for statistics, you will click “istatistikler” button, after then you will see sub-menus which can be seen in Figure B.4.1.1 and Figure B.4.2.1 for production reports and statistics respectively.

B.2. Data Entry Screens

Figure B.3.1 Defining a New Order Screen

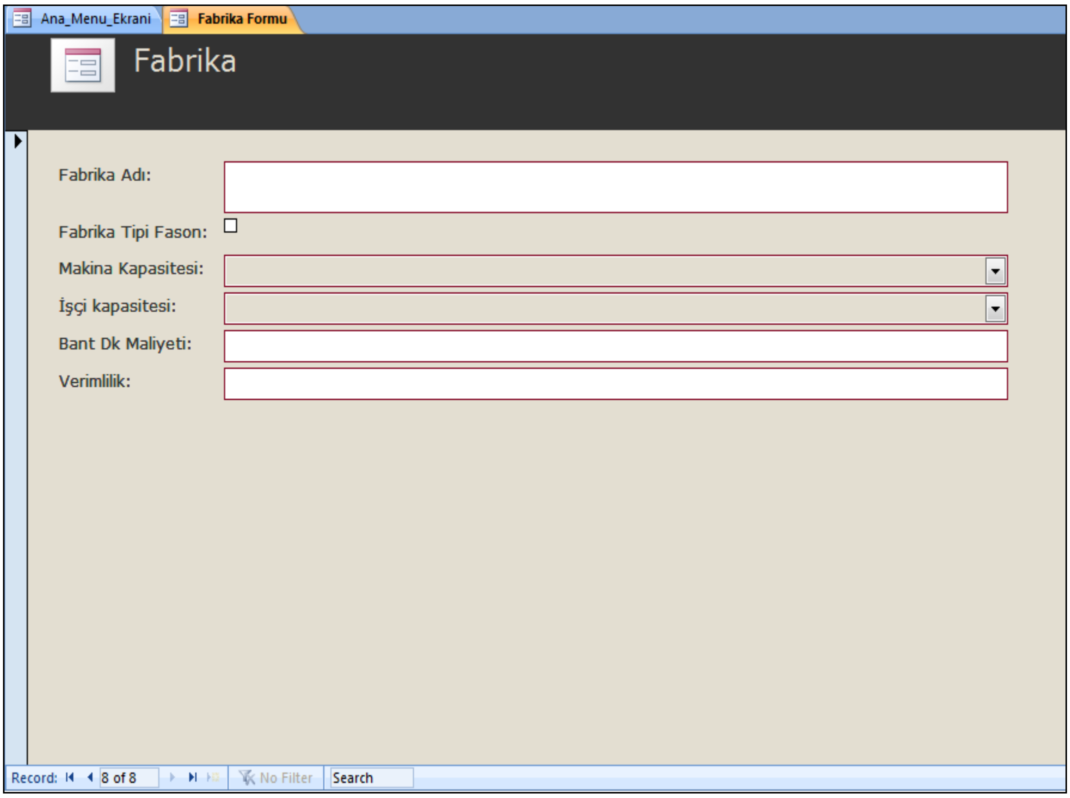


Figure B.4.2 Defining a New Factory Screen

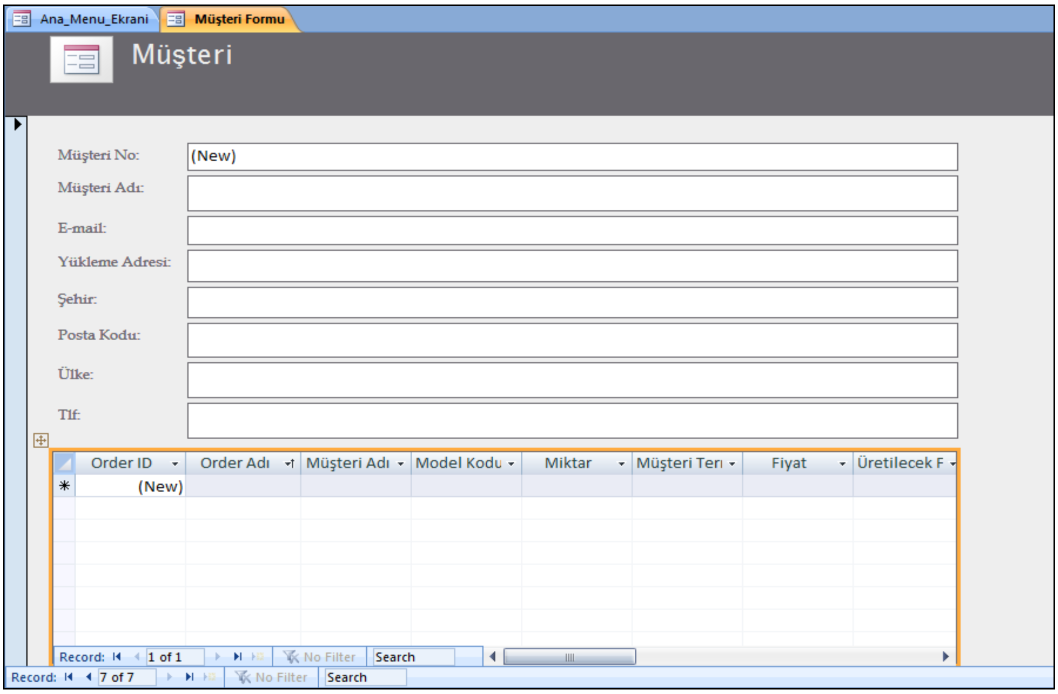


Figure B.5.3 Defining a New Customer Screen

B.3. Model Screens

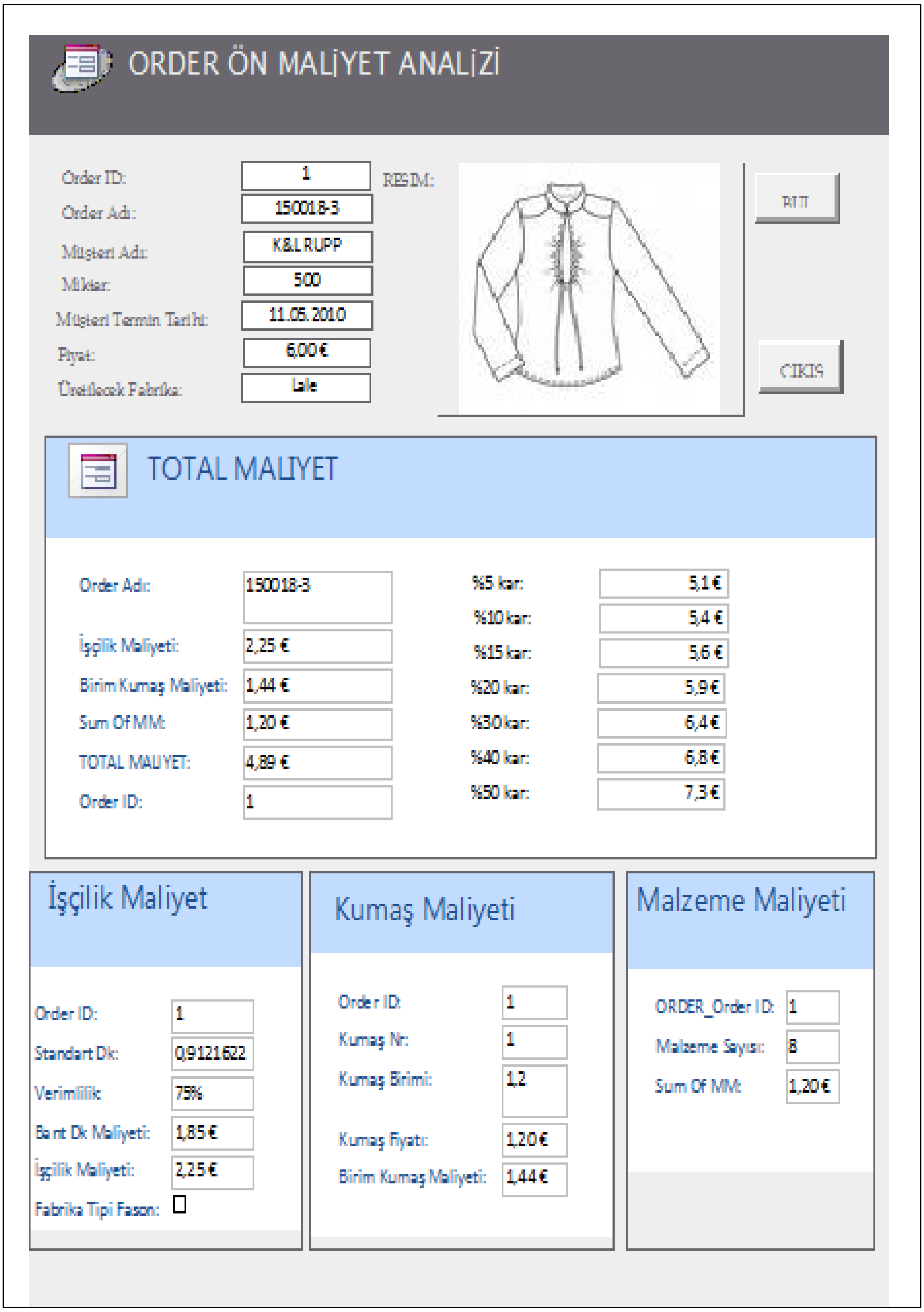


Figure B.6.1 Order Pre-Cost Estimation Report

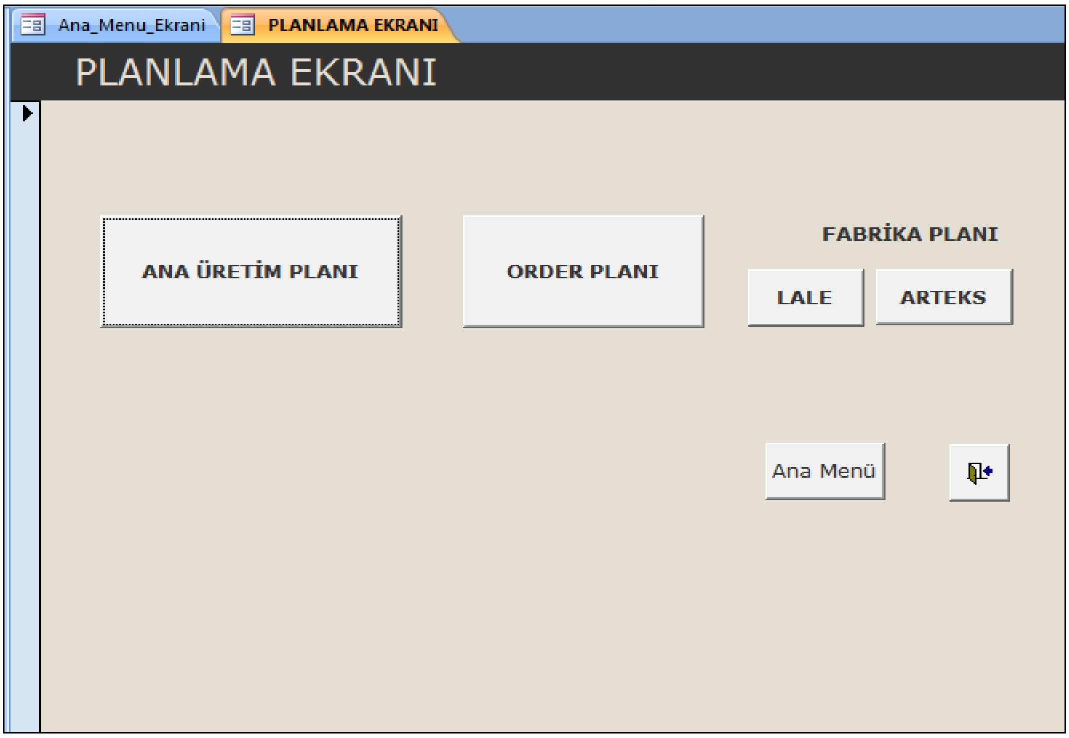
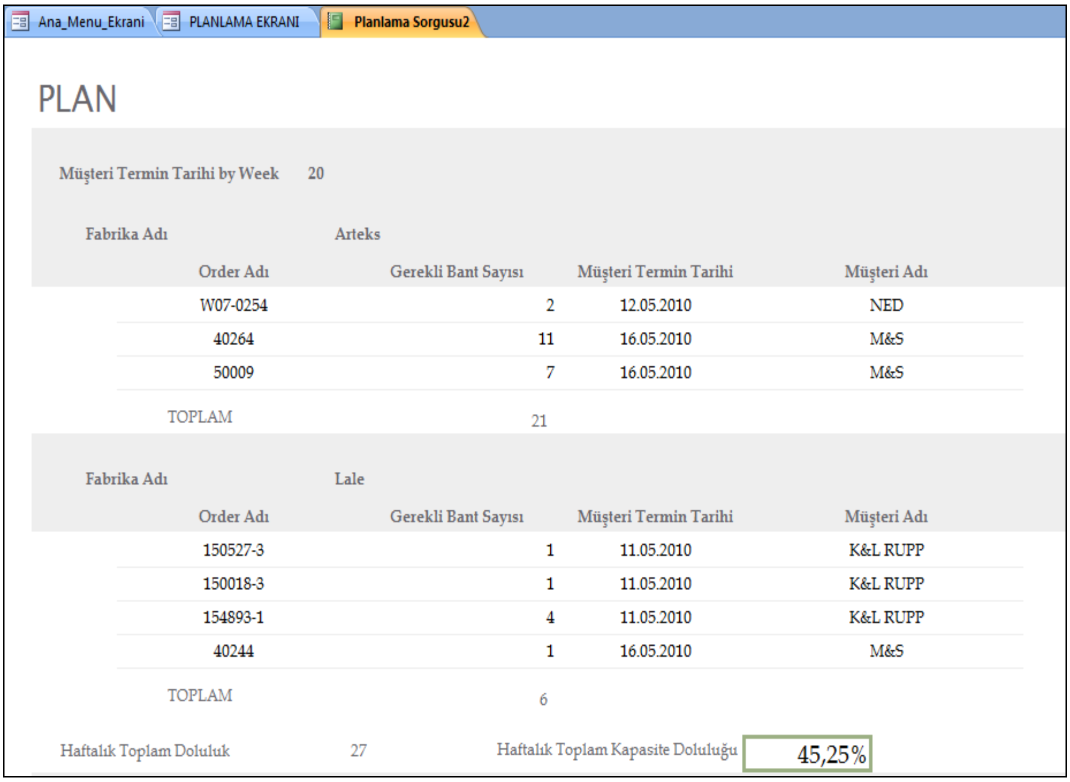


Figure B.7.2. Planning Screen

Planning sub menu is presented in Figure B.3.2. above, if user want to see master production plan, she will click button of "Ana Üretim Planı" , after then the screen illustrated in figure B.3.3. is seen. Master production plan for each week can be clearly seen in the query. User easily sees idle and shortage of capacity for each week through the master production plan query and have a chance to balance the plan with rescheduling.

If the user wants to see data about planning for each order separately, she will click the button of "order planı" and then the screen illustrated in Figure B.3.4. appears. The aim of this query is to follow the orders and inform customer about situation of the order easily.

Lastly, when user wants to see plans for each factory separately, she will click "lale" or "arteks" to see production plan for factory of lale or arteks as presented in Figure B.3.5 and Figure B.3.6.



Ana_Menu_Ekrani | PLANLAMA EKRANI | Planlama Sorgusu2

PLAN

Müşteri Termin Tarihi by Week 20

Fabrika Adı Arteks

Order Adı	Gerekli Bant Sayısı	Müşteri Termin Tarihi	Müşteri Adı
W07-0254	2	12.05.2010	NED
40264	11	16.05.2010	M&S
50009	7	16.05.2010	M&S
TOPLAM	21		

Fabrika Adı Lale

Order Adı	Gerekli Bant Sayısı	Müşteri Termin Tarihi	Müşteri Adı
150527-3	1	11.05.2010	K&L RUPP
150018-3	1	11.05.2010	K&L RUPP
154893-1	4	11.05.2010	K&L RUPP
40244	1	16.05.2010	M&S
TOPLAM	6		

Haftalık Toplam Doluluk 27 Haftalık Toplam Kapasite Doluluğu 45,25%

Figure B.8.3. Master Production Plan Screen

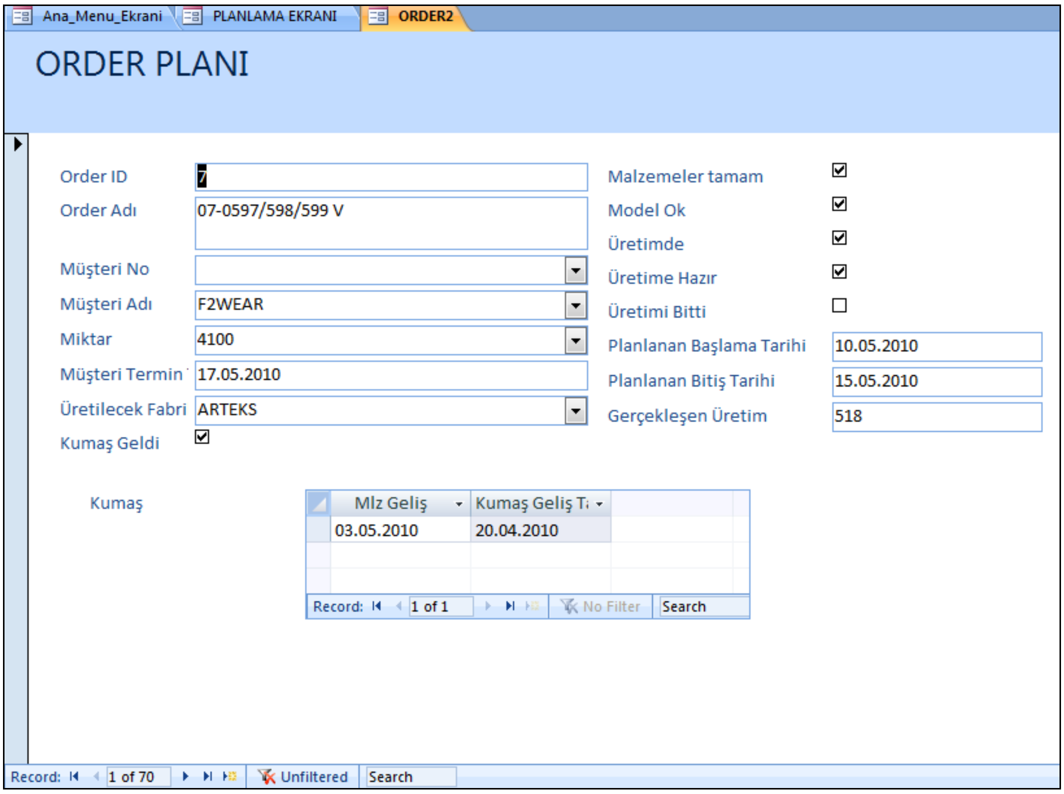
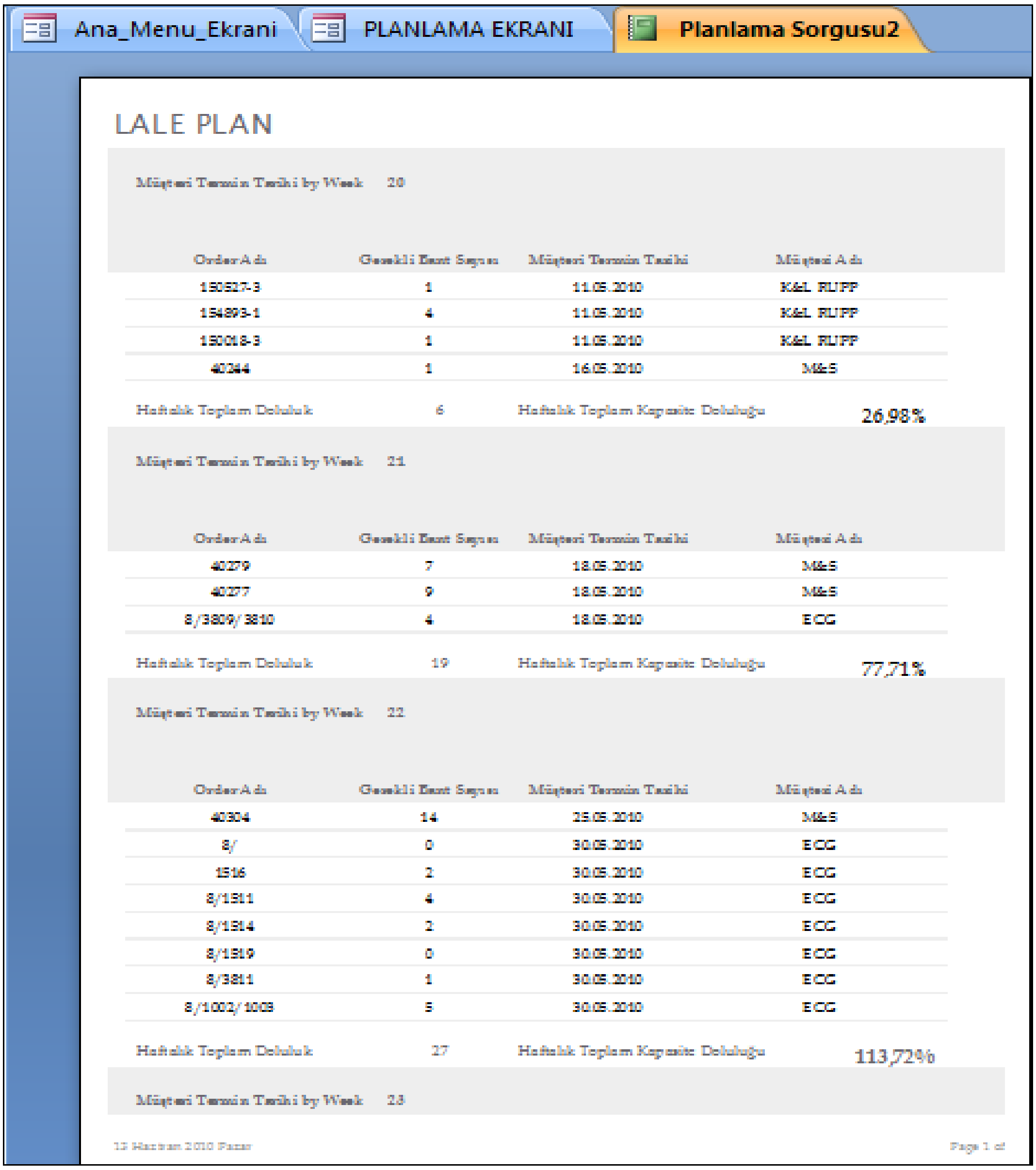


Figure B.9.4. Order Plan Screen



Ana_Menu_Ekrani | PLANLAMA EKRANI | Planlama Sorgusu2

LALE PLAN

Müşteri Termin Tarihi by Week 20

Order Adı	Gerekli Bant Sayısı	Müşteri Termin Tarihi	Müşteri Adı
150527-3	1	11.05.2010	K&L RUPP
154893-1	4	11.05.2010	K&L RUPP
150018-3	1	11.05.2010	K&L RUPP
40244	1	16.05.2010	M&S

Haftalık Toplam Doluluk 6 Haftalık Toplam Kapasite Doluluğu 26,98%

Müşteri Termin Tarihi by Week 21

Order Adı	Gerekli Bant Sayısı	Müşteri Termin Tarihi	Müşteri Adı
40279	7	18.05.2010	M&S
40277	9	18.05.2010	M&S
8/3809/3810	4	18.05.2010	ECG

Haftalık Toplam Doluluk 19 Haftalık Toplam Kapasite Doluluğu 77,71%

Müşteri Termin Tarihi by Week 22

Order Adı	Gerekli Bant Sayısı	Müşteri Termin Tarihi	Müşteri Adı
40304	14	25.05.2010	M&S
8/	0	30.05.2010	ECG
1516	2	30.05.2010	ECG
8/1511	4	30.05.2010	ECG
8/1514	2	30.05.2010	ECG
8/1519	0	30.05.2010	ECG
8/3811	1	30.05.2010	ECG
8/1002/1003	5	30.05.2010	ECG

Haftalık Toplam Doluluk 27 Haftalık Toplam Kapasite Doluluğu 113,72%

Müşteri Termin Tarihi by Week 23

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Figure B.10.5. Production Plan Screen of Factory of Lale

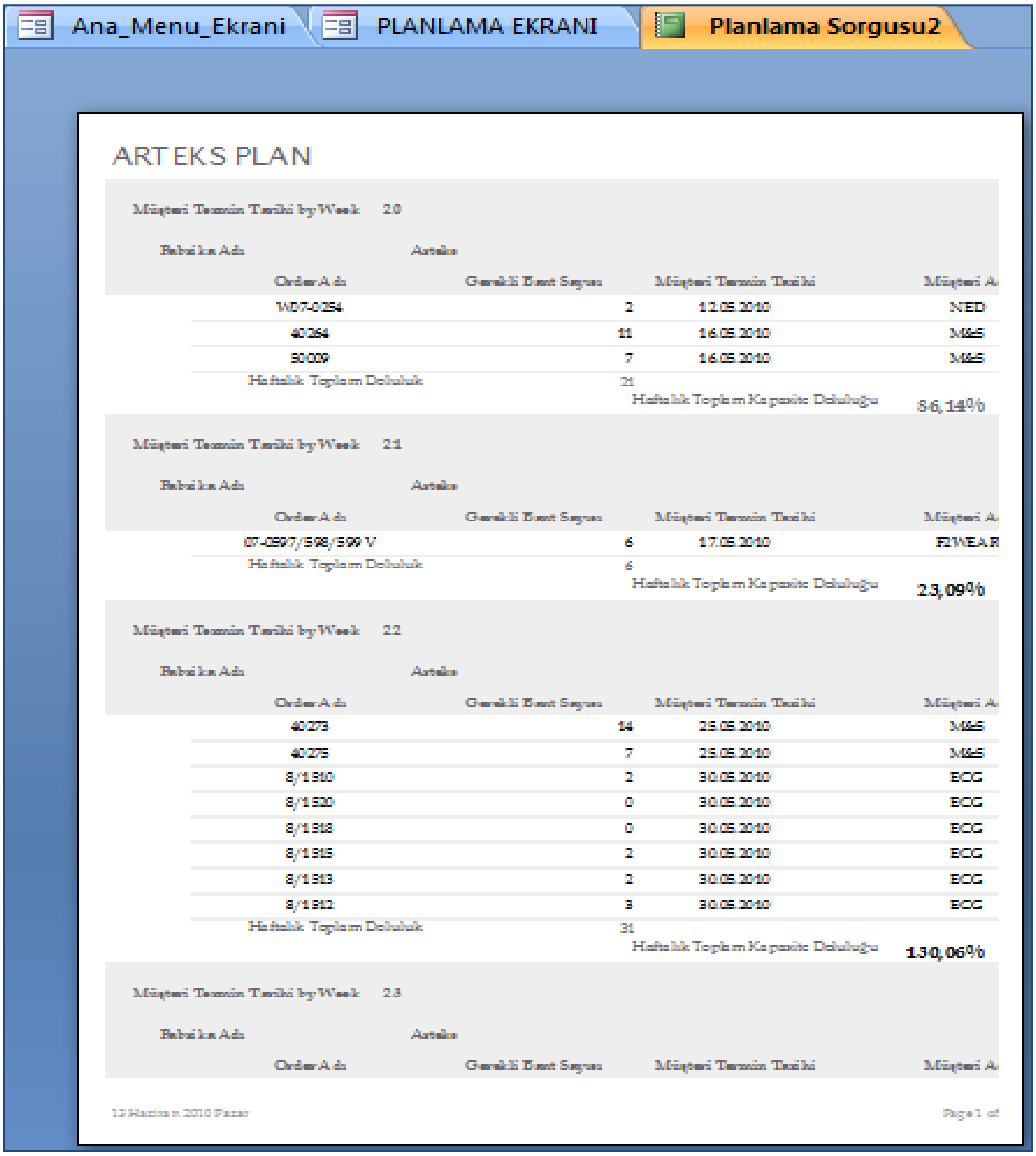


Figure B.11.6. Production Plan Screen of Factory of Arteks

B.4. Reports Screens

B.4.1. Production Reports

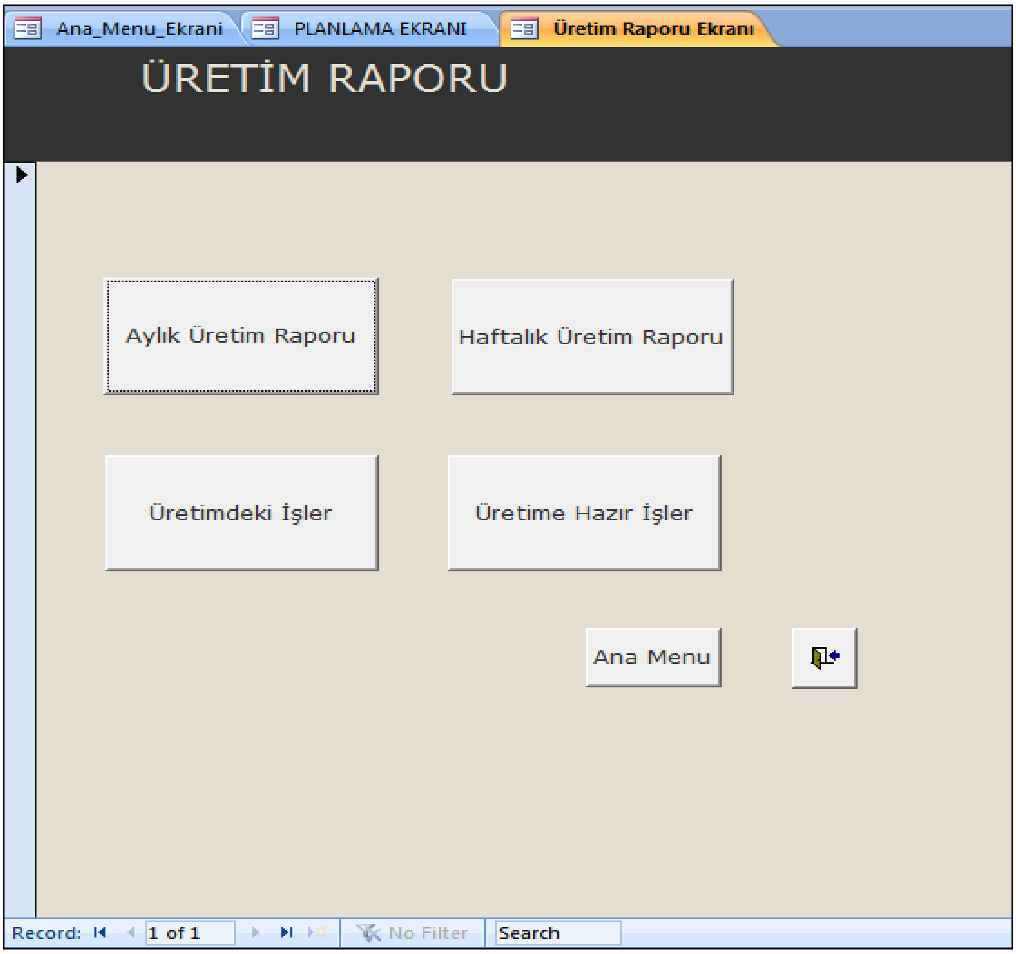


Figure B. 12.1.1. Sub-Menu of Production Report

When user clicks reports button in main menu, the screen illustrated in Figure B.4.1.1. is seen. If the user wants to see Monthly Production report, she clicks "aylık üretim raporu" button, in order to see weekly production report for each factory, user will click "haftalık üretim raporu" button. If she wants to see work in process orders, she will click "üretimdeki işler" button, in order to learn orders which are ready for production, she will click "üretime hazır işler" button. To return main screen and quit the screen, there are buttons in the last line of the screen. Production reports on montly basis for may given in figure B.4.1.2. is seen after clicking “aylık üretim raporu”. Button of “Haftalık Üretim Raporu” “Üretimdeki İşler” and “Üretime Hazır İşler” navigate to report seen in Figure B.4.1.3. , Figure B.4.1.4 and Figure B.4.1.4., respectively.

Müşteri Termin Tarihi **Mayıs 2010**

Fabrika Adı 1-Bermudo

Müşteri Adı	Order Adı	Müşteri Termin Tarihi	Gerçekleşen Üretim	Gerçekleşen Verimlilik
F2WEAR	07-0653/6	18.05.2010	896	71,98%
HCT	1800	18.05.2010	635	71,99%
F2WEAR	07-0707/7	18.05.2010	362	72,02%
HCT	1805	18.05.2010	457	72,05%
F2WEAR	07-0671	19.05.2010	457	72,05%
F2WEAR	07-0708M	25.05.2010	1279	72,02%
			4086	72,02%

Fabrika Adı Arteks

Müşteri Adı	Order Adı	Müşteri Termin Tarihi	Gerçekleşen Üretim	Gerçekleşen Verimlilik
NED	W07-0254	12.05.2010	466	69,97%
M&S	50009	16.05.2010	643	70,00%
M&S	40264	16.05.2010	478	69,98%
F2WEAR	07-0597/5	17.05.2010	518	70,00%
M&S	40273	25.05.2010	352	70,03%
M&S	40275	25.05.2010	746	70,01%
ECG	8/1510	30.05.2010	307	70,07%
ECG	8/1512	30.05.2010	266	70,09%
ECG	8/1515	30.05.2010	284	70,08%
ECG	8/1518	30.05.2010	264	69,96%
ECG	8/1520	30.05.2010	405	69,93%
ECG	8/1513	30.05.2010	334	69,96%
			5063	70,01%

Fabrika Adı	KL konf.			
Müşteri Adı	**Order Adı**	**Müşteri Termin Tarihi**	**Gerçekleşen Üretim**	**Gerçekleşen Verimlilik**
F2WEAR	07-0641C	17.05.2010		
F2WEAR	07-0617C	25.05.2010		

Fabrika Adı	Lale			
Müşteri Adı	**Order Adı**	**Müşteri Termin Tarihi**	**Gerçekleşen Üretim**	**Gerçekleşen Verimlilik**
K&L RUPP	150527-3	11.05.2010	444	75,00%
K&L RUPP	150018-3	11.05.2010	444	75,00%
K&L RUPP	154893-1	11.05.2010	444	75,00%
M&S	40244	16.05.2010	500	75,08%
M&S	40277	18.05.2010	735	75,05%
ECG	8/3809/38	18.05.2010	434	74,94%
M&S	40279	18.05.2010	967	75,02%
M&S	40304	25.05.2010	546	75,05%
ECG	8/3811	30.05.2010	645	75,06%
ECG	8/1519	30.05.2010	283	75,00%
ECG	8/1511	30.05.2010	285	75,10%
ECG	8/1002/10	30.05.2010	500	75,08%
ECG	8/	30.05.2010	500	75,08%
ECG	1516	30.05.2010	265	75,14%
ECG	8/1514	30.05.2010	361	75,07%
			7353	75,04%

Figure B. 13.1.2. Production Report on Monthly Basis (For May)

Müşteri Termin Tarihi by 20

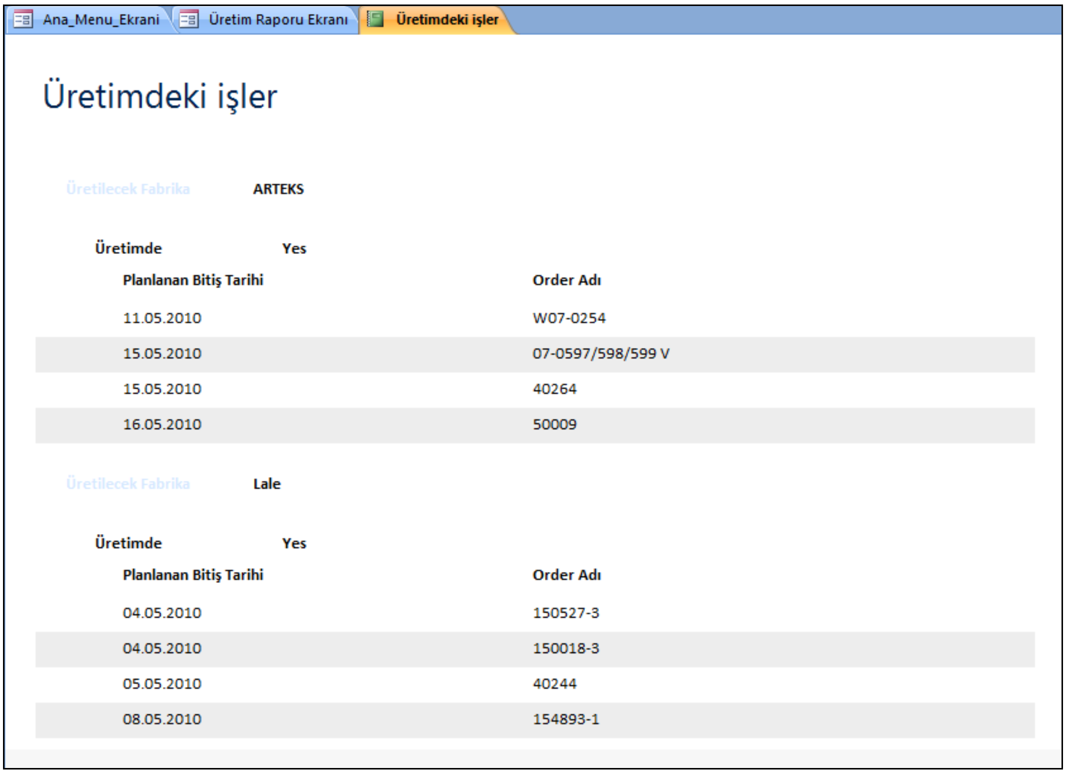
Fabrika Adı Arteks

Müşteri Adı	Order Adı	Müşteri Termin Tarihi	Gerçekleşen Üretim	Gerçekleşen Verimlilik
NED	W07-0254	12.05.2010	466	69,97%
M&S	40264	16.05.2010	478	69,98%
M&S	50009	16.05.2010	643	70,00%
			1587	69,98%

Fabrika Adı Lale

Müşteri Adı	Order Adı	Müşteri Termin Tarihi	Gerçekleşen Üretim	Gerçekleşen Verimlilik
K&L RUPP	150527-3	11.05.2010	444	75,00%
K&L RUPP	150018-3	11.05.2010	444	75,00%
K&L RUPP	154893-1	11.05.2010	444	75,00%
M&S	40244	16.05.2010	500	75,08%
			1832	75,02%

Figure B. 14.1.3. Production Report on Weekly Basis (For 20th week)



Üretimdeki işler

Üretilecek Fabrika ARTEKS

Üretimde Yes

Planlanan Bitiş Tarihi	Order Adı
11.05.2010	W07-0254
15.05.2010	07-0597/598/599 V
15.05.2010	40264
16.05.2010	50009

Üretilecek Fabrika Lale

Üretimde Yes

Planlanan Bitiş Tarihi	Order Adı
04.05.2010	150527-3
04.05.2010	150018-3
05.05.2010	40244
08.05.2010	154893-1

Figure B. 15.1.4. Work-in-Process Orders Report

Üretime Hazır işler

Üretilecek Fabrika	1-BERMUDO
Üretime Hazır	Yes

Order Adı	Planlanan Başlama Tarihi
1800	10.05.2010
07-0653/658CAC	11.05.2010
1805	09.05.2010

Üretilecek Fabrika	ARTEKS
Üretime Hazır	Yes

Order Adı	Planlanan Başlama Tarihi
W07-0254	08.05.2010
07-0597/598/599 V	10.05.2010
50009	11.05.2010
40264	07.05.2010

Üretilecek Fabrika	KL KONF.
Üretime Hazır	Yes

Order Adı	Planlanan Başlama Tarihi
07-0641CAXL	

Üretilecek Fabrika	Lale
Üretime Hazır	Yes

Order Adı	Planlanan Başlama Tarihi
8/3809/3810	
40279	08.05.2010
40244	04.05.2010
40277	04.05.2010
154893-1	03.05.2010
150527-3	03.05.2010

Figure B. 16.1.5. Ready to Production Orders Report

B.4.2. Statistics

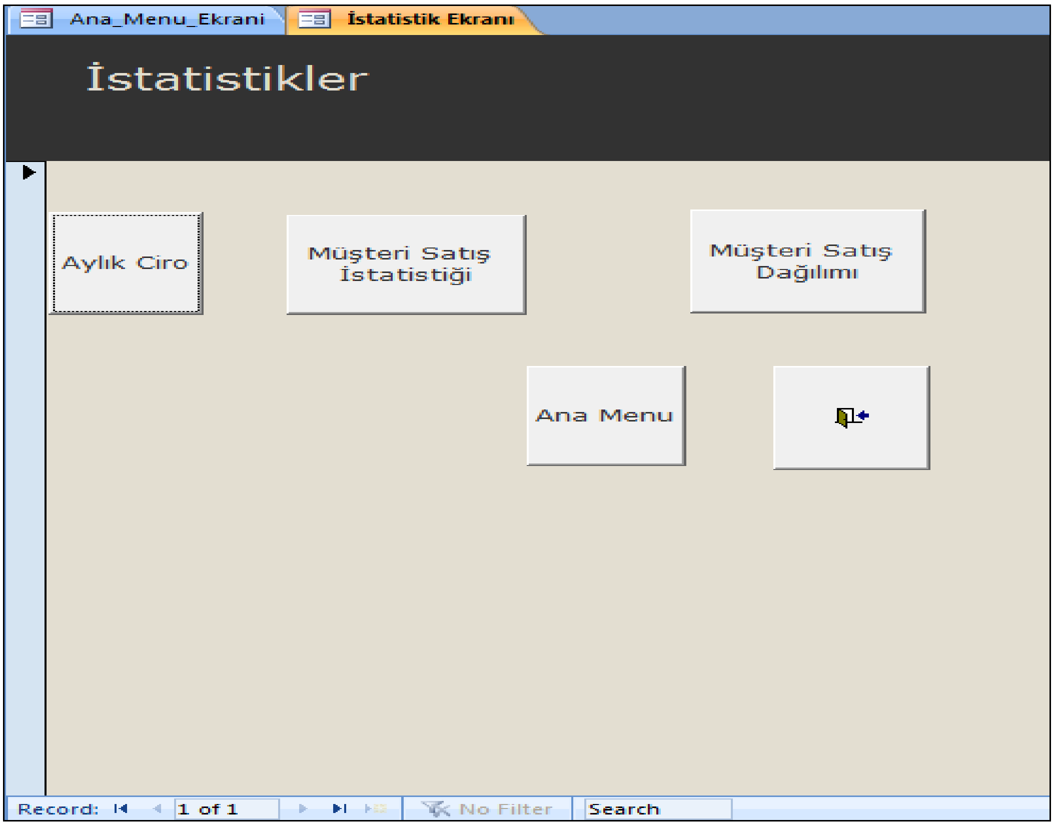


Figure B. 17.2.1. Sub menu for Statistics

B.4.2.1. Turn Over on Monthly Basis

Üretilecek Fabrika 1-BERMUDO

Müşteri Termin Tarihi by Month Mayıs 2010

Müşteri Termin Tarihi	Order Adı	Ciro	Miktar
25-May-10	07-0708ME	18.000,00 €	2500
18-May-10	07-0707/710 ME	27.097,50 €	3613
18-May-10	07-0653/658CAC	24.700,00 €	3800
19-May-10	07-0671 ME	11.700,00 €	1800
18-May-10	1805	6.534,00 €	990
18-May-10	1800	64.810,00 €	12962
		152.841,50 €	

Müşteri Termin Tarihi by Month Haziran 2010

Müşteri Termin Tarihi	Order Adı	Ciro	Miktar
01-Haz-10	07-0605 CAXL	18.744,00 €	3124
01-Haz-10	07-0606 CAXL	14.880,00 €	2480
02-Haz-10	07-0673 MEXL	9.940,00 €	1400
01-Haz-10	W07-0268	3.500,00 €	500
08-Haz-10	07-0819/820 ME	15.000,00 €	2000
02-Haz-10	07-0672 MEXL	14.400,00 €	2000
08-Haz-10	1909	102.200,00 €	14000
		178.664,00 €	

331.505.50 €

Figure B.18.2.1.1. Turn-over Report on Monthly Basis for Factory 1-Bermudo

Üretilecek Fabrika ARTEKS

Müşteri Termin Tarihi by Month	Mayıs 2010		
Müşteri Termin Tarihi	Order Adı	Ciro	Miktar
30-May-10	8/1518	295,20 €	24
17-May-10	07-0597/598/599 V	20.500,00 €	4100
30-May-10	8/1520	192,00 €	24
30-May-10	8/1510	9.552,00 €	796
30-May-10	8/1515	8.568,00 €	1008
30-May-10	8/1512	11.050,00 €	1300
12-May-10	W07-0254	10.290,00 €	1470
25-May-10	40275	52.045,00 €	7435
25-May-10	40273	51.034,80 €	7188
16-May-10	40264	49.543,00 €	7622
16-May-10	50009	33.565,00 €	6713
30-May-10	8/1513	12.048,00 €	1004
		258.683,00 €	

Müşteri Termin Tarihi by Month	Haziran 2010		
Müşteri Termin Tarihi	Order Adı	Ciro	Miktar
15-Haz-10	GEVEWEN	42.000,00 €	7000
15-Haz-10	1801	35.266,00 €	5038
08-Haz-10	07-0729CAXL	27.056,00 €	7120
08-Haz-10	1910	11.360,00 €	1600
01-Haz-10	W07-0267	14.000,00 €	2000
08-Haz-10	50018	32.560,00 €	8800
01-Haz-10	50015	51.750,00 €	10350
		213.992,00 €	
		472.675.00 €	

Figure B.19.2.1.2. Turn-over Report on Monthly Basis for Factory Arteks

Üretilecek Fabrika Lale

Müşteri Termin Tarihi by Month Mayıs 2010

Müşteri Termin Tarihi	Order Adı	Ciro	Miktar
25-May-10	40304	65.052,00 €	10008
18-May-10	40279	46.200,00 €	8400
18-May-10	8/3809/3810	17.510,00 €	2060
18-May-10	40277	50.400,00 €	8400
11-May-10	154893-1	15.400,00 €	2200
16-May-10	40244	3.900,00 €	600
30-May-10	8/	1.620,00 €	200
30-May-10	1516	6.400,00 €	800
11-May-10	150527-3	4.200,00 €	600
30-May-10	8/3811	6.557,00 €	830
30-May-10	8/1002/1003	21.931,20 €	3046
30-May-10	8/1511	11.260,08 €	1404
30-May-10	8/1519	192,00 €	24
30-May-10	8/1514	6.400,00 €	800
		257.022,28 €	

Müşteri Termin Tarihi by Month Haziran 2010

Müşteri Termin Tarihi	Order Adı	Ciro	Miktar
15-Haz-10	150527-4	5.600,00 €	800
08-Haz-10	153074-2	5.600,00 €	800
08-Haz-10	07-0788 ME	9.800,00 €	1400
15-Haz-10	155539-1	5.760,00 €	800
15-Haz-10	155540-1	5.520,00 €	800
04-Haz-10	155115-1	5.840,00 €	800
16-Haz-10	07-0733 CAXL	4.050,00 €	810
16-Haz-10	07-0751 CAXL	16.420,00 €	3284
16-Haz-10	07-0732 CAXL	11.072,00 €	2768
15-Haz-10	155539-2	5.680,00 €	800
08-Haz-10	07-0730CAXL	11.792,00 €	2948
08-Haz-10	07-0731 CAXL	1.558,00 €	380
08-Haz-10	07-0664 MEXL	2.412,00 €	335
01-Haz-10	50011	41.250,00 €	7500
01-Haz-10	40301	48.024,00 €	8004
08-Haz-10	50013	43.200,00 €	7200
15-Haz-10	50038	42.000,00 €	7000

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09-Haz-10	W07-0388	15.540,00 €	2220
09-Haz-10	W07-0389	5.964,00 €	840
09-Haz-10	W07-0390	6.048,00 €	840
08-Haz-10	07-0663 MEXL	13.140,00 €	1800
		306.270,00 €	

Figure B.20.2.1.3. Turn-over Report on Monthly Basis for Factory Lale

B.4.2.2. Sales Statistics

Müşteri satış

Müşteri.[Müşteri Adı K&L RUPP

Müşteri Termin Tarihi by Mont **Mayıs 2010**

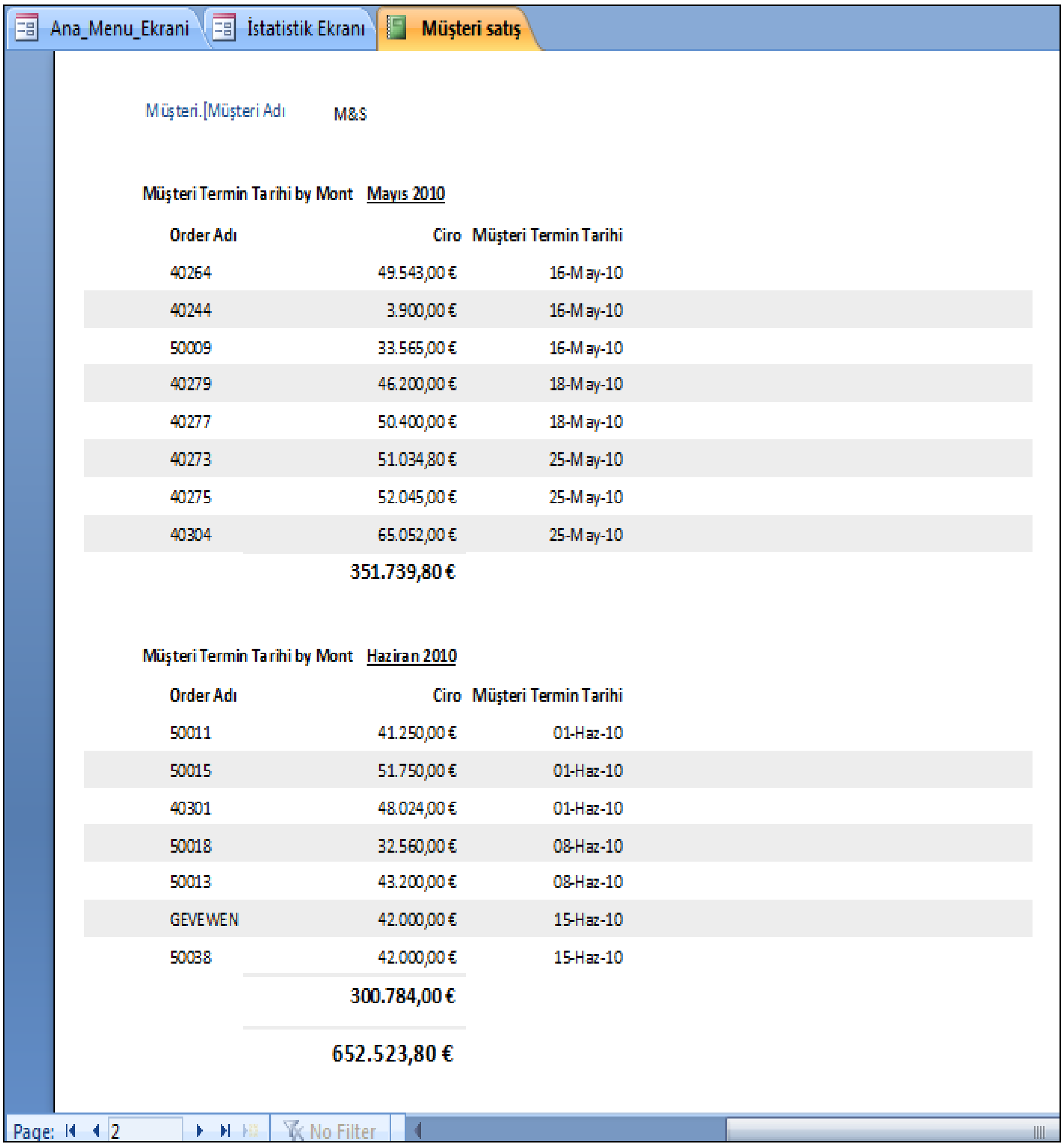
Order Adı	Ciro	Müşteri Termin Tarihi
154893-1	15.400,00 €	11-May-10
150527-3	4.200,00 €	11-May-10
	19.600,00 €	

Müşteri Termin Tarihi by Mont **Haziran 2010**

Order Adı	Ciro	Müşteri Termin Tarihi
155115-1	5.840,00 €	04-Haz-10
153074-2	5.600,00 €	08-Haz-10
150527-4	5.600,00 €	15-Haz-10
155539-2	5.680,00 €	15-Haz-10
155539-1	5.760,00 €	15-Haz-10
155540-1	5.520,00 €	15-Haz-10
	34.000,00 €	

53.600,00 €

Figure B.21.2.2.1. Sales by Customer Statistics – Part 1



Müşteri.[Müşteri Adı M&S

Müşteri Termin Tarihi by Mont Mayıs 2010

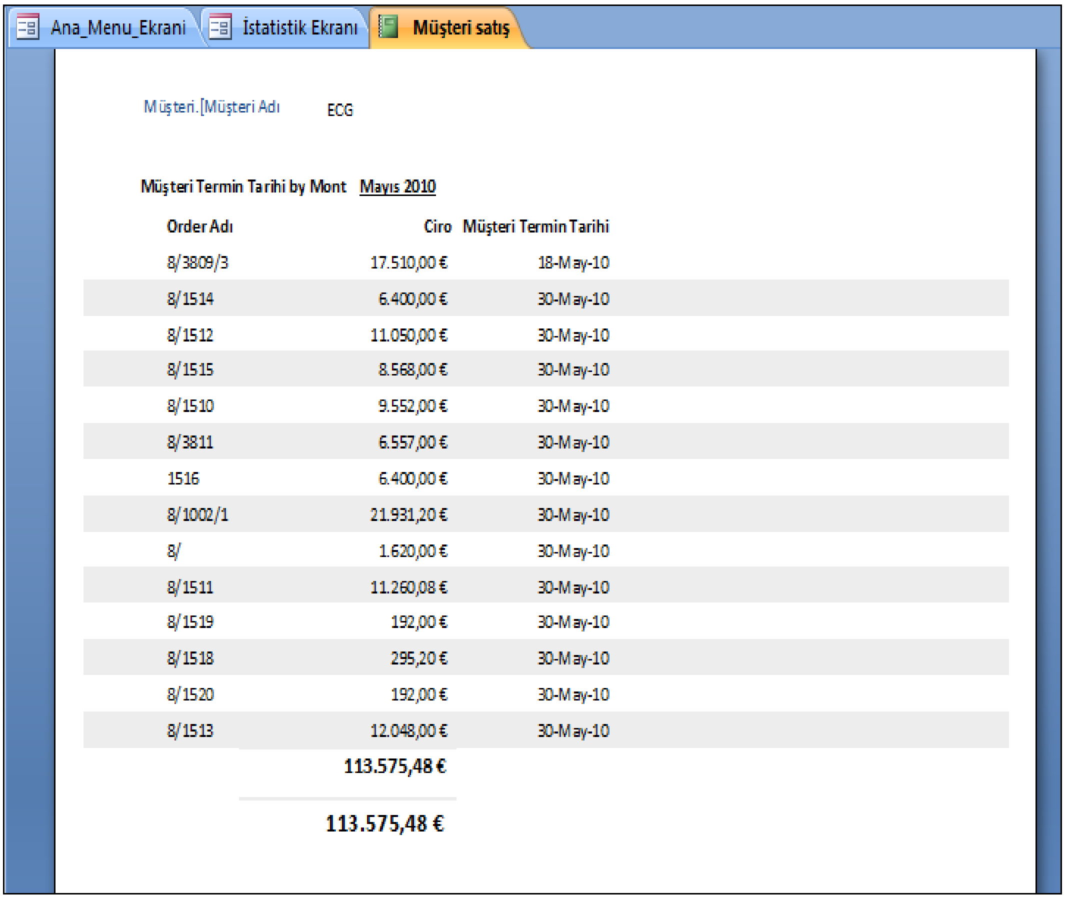
Order Adı	Ciro	Müşteri Termin Tarihi
40264	49.543,00 €	16-May-10
40244	3.900,00 €	16-May-10
50009	33.565,00 €	16-May-10
40279	46.200,00 €	18-May-10
40277	50.400,00 €	18-May-10
40273	51.034,80 €	25-May-10
40275	52.045,00 €	25-May-10
40304	65.052,00 €	25-May-10
	351.739,80 €	

Müşteri Termin Tarihi by Mont Haziran 2010

Order Adı	Ciro	Müşteri Termin Tarihi
50011	41.250,00 €	01-Haz-10
50015	51.750,00 €	01-Haz-10
40301	48.024,00 €	01-Haz-10
50018	32.560,00 €	08-Haz-10
50013	43.200,00 €	08-Haz-10
GEVEWEN	42.000,00 €	15-Haz-10
50038	42.000,00 €	15-Haz-10
	300.784,00 €	

652.523,80 €

Figure B.22.2.2.2 Sales by Customer Report – Part 2



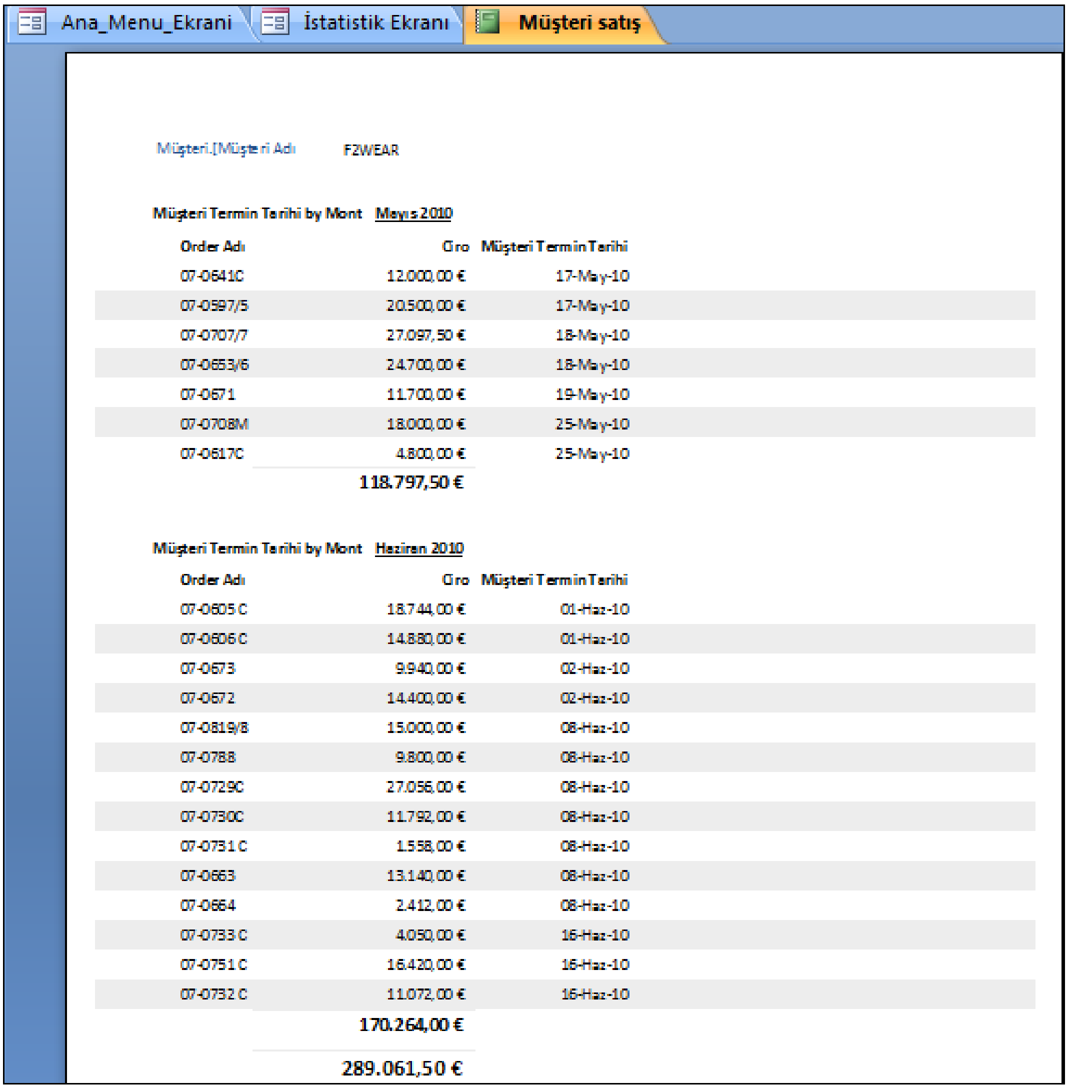
Ana_Menu_Ekrani | İstatistik Ekranı | Müşteri satış

Müşteri.[Müşteri Adı ECG

Müşteri Termin Tarihi by Mont Mayıs 2010

Order Adı	Ciro	Müşteri Termin Tarihi
8/3809/3	17.510,00 €	18-May-10
8/1514	6.400,00 €	30-May-10
8/1512	11.050,00 €	30-May-10
8/1515	8.568,00 €	30-May-10
8/1510	9.552,00 €	30-May-10
8/3811	6.557,00 €	30-May-10
1516	6.400,00 €	30-May-10
8/1002/1	21.931,20 €	30-May-10
8/	1.620,00 €	30-May-10
8/1511	11.260,08 €	30-May-10
8/1519	192,00 €	30-May-10
8/1518	295,20 €	30-May-10
8/1520	192,00 €	30-May-10
8/1513	12.048,00 €	30-May-10
	113.575,48 €	
	113.575,48 €	

Figure B.23.2.2.3. Sales by Customer Report – Part 3


Ana_Menu_Ekrani | İstatistik Ekranı | Müşteri satış

Müşteri.[Müşteri Adı F2WEAR

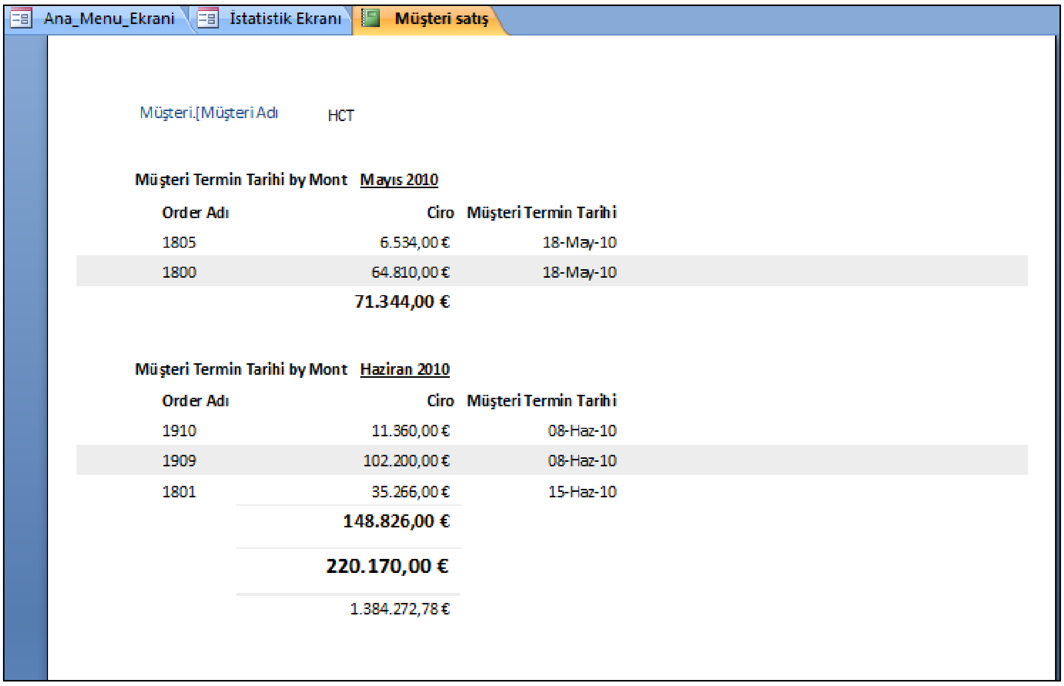
Müşteri Termin Tarihi by Mont Mayıs 2010

Order Adı	Gro	Müşteri Termin Tarihi
07-0641C	12.000,00 €	17-May-10
07-0597/5	20.500,00 €	17-May-10
07-0707/7	27.097,50 €	18-May-10
07-0653/6	24.700,00 €	18-May-10
07-0671	11.700,00 €	19-May-10
07-0708M	18.000,00 €	25-May-10
07-0617C	4.800,00 €	25-May-10
	118.797,50 €	

Müşteri Termin Tarihi by Mont Haziran 2010

Order Adı	Gro	Müşteri Termin Tarihi
07-0605 C	18.744,00 €	01-Haz-10
07-0606 C	14.880,00 €	01-Haz-10
07-0673	9.940,00 €	02-Haz-10
07-0672	14.400,00 €	02-Haz-10
07-0819/8	15.000,00 €	08-Haz-10
07-0788	9.800,00 €	08-Haz-10
07-0729C	27.056,00 €	08-Haz-10
07-0730C	11.792,00 €	08-Haz-10
07-0731 C	1.558,00 €	08-Haz-10
07-0663	13.140,00 €	08-Haz-10
07-0664	2.412,00 €	08-Haz-10
07-0733 C	4.050,00 €	16-Haz-10
07-0751 C	16.420,00 €	16-Haz-10
07-0732 C	11.072,00 €	16-Haz-10
	170.264,00 €	
	289.061,50 €	

Figure B.24.2.2.4. Sales by Customer Report – Part 4



Müşteri Termin Tarihi by Mont Mayıs 2010

Order Adı	Ciro	Müşteri Termin Tarihi
1805	6.534,00 €	18-May-10
1800	64.810,00 €	18-May-10
	71.344,00 €	

Müşteri Termin Tarihi by Mont Haziran 2010

Order Adı	Ciro	Müşteri Termin Tarihi
1910	11.360,00 €	08-Haz-10
1909	102.200,00 €	08-Haz-10
1801	35.266,00 €	15-Haz-10
	148.826,00 €	
	220.170,00 €	
	1.384.272,78 €	

Figure B.25.2.2.5. Sales by Customer Report – Part 4

B.4.2.3 Sales Distribution Statistics

Müşteri satış

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16:47:35

Müşteri.[Müşteri Adı]

ECG

Order Adı	Müşteri Termin Tarihi	Ciro
8/1514	30-May-10	6.400,00 €
8/3809/3810	18-May-10	17.510,00 €
W07-0254	12-May-10	10.290,00 €
8/1512	30-May-10	11.050,00 €
8/1515	30-May-10	8.568,00 €
8/1510	30-May-10	9.552,00 €
1516	30-May-10	6.400,00 €
8/1520	30-May-10	192,00 €
8/1518	30-May-10	295,20 €
8/1519	30-May-10	192,00 €
8/1511	30-May-10	11.260,08 €
8/	30-May-10	1.620,00 €
8/3811	30-May-10	6.557,00 €
8/1002/1003	30-May-10	21.931,20 €
8/1513	30-May-10	12.048,00 €
		8,95%

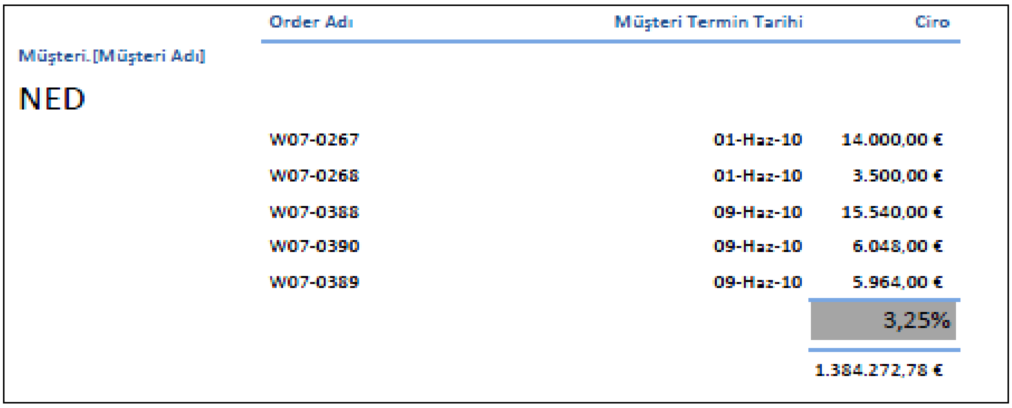
Figure B.26.2.3.1. Sales Distribution Statistics Report – Part 1

Müşteri.[Müşteri Adı]	Order Adı	Müşteri Termin Tarihi	Ciro
F2WEAR			
	07-0597/598/599 V	17-May-10	20.500,00 €
	07-0751 CAXL	16-Haz-10	16.420,00 €
	07-0733 CAXL	16-Haz-10	4.050,00 €
	07-0732 CAXL	16-Haz-10	11.072,00 €
	07-0788 ME	08-Haz-10	9.800,00 €
	07-0819/820 ME	08-Haz-10	15.000,00 €
	07-0729CAXL	08-Haz-10	27.056,00 €
	07-0730CAXL	08-Haz-10	11.792,00 €
	07-0663 MEXL	08-Haz-10	13.140,00 €
	07-0664 MEXL	08-Haz-10	2.412,00 €
	07-0641CAXL	17-May-10	12.000,00 €
	07-0707/710 ME	18-May-10	27.097,50 €
	07-0653/658CAC	18-May-10	24.700,00 €
	07-0671 ME	19-May-10	11.700,00 €
	07-0708ME	25-May-10	18.000,00 €
	07-0617CAXL	25-May-10	4.800,00 €
	07-0605 CAXL	01-Haz-10	18.744,00 €
	07-0606 CAXL	01-Haz-10	14.880,00 €
	07-0673 MEXL	02-Haz-10	9.940,00 €
	07-0672 MEXL	02-Haz-10	14.400,00 €
	07-0731 CAXL	08-Haz-10	1.558,00 €
			20,88%
HCT			
	1909	08-Haz-10	102.200,00 €
	1800	18-May-10	64.810,00 €
	1910	08-Haz-10	11.360,00 €
	1805	18-May-10	6.534,00 €
	1801	15-Haz-10	35.266,00 €
			15,91%

Figure B.27.2.3.2. Sales Distribution Statistics Report – Part 2

Müşteri.[Müşteri Adı]	Order Adı	Müşteri Termin Tarihi	Ciro
K&L RUPP			
	150527-4	15-Haz-10	5.600,00 €
	155539-1	15-Haz-10	5.760,00 €
	153074-2	08-Haz-10	5.600,00 €
	155115-1	04-Haz-10	5.840,00 €
	154893-1	11-May-10	15.400,00 €
	155539-2	15-Haz-10	5.680,00 €
	150527-3	11-May-10	4.200,00 €
	155540-1	15-Haz-10	5.520,00 €
			3,87%
M&S			
	50013	08-Haz-10	43.200,00 €
	40279	18-May-10	46.200,00 €
	40277	18-May-10	50.400,00 €
	40264	16-May-10	49.543,00 €
	50009	16-May-10	33.565,00 €
	40244	16-May-10	3.900,00 €
	40273	25-May-10	51.034,80 €
	40275	25-May-10	52.045,00 €
	40304	25-May-10	65.052,00 €
	40301	01-Haz-10	48.024,00 €
	50015	01-Haz-10	51.750,00 €
	50018	08-Haz-10	32.560,00 €
	GEVEWEN	15-Haz-10	42.000,00 €
	50038	15-Haz-10	42.000,00 €
	50011	01-Haz-10	41.250,00 €
			47,14%

Figure B.28.2.3.3. Sales Distribution Statistics Report – Part 3

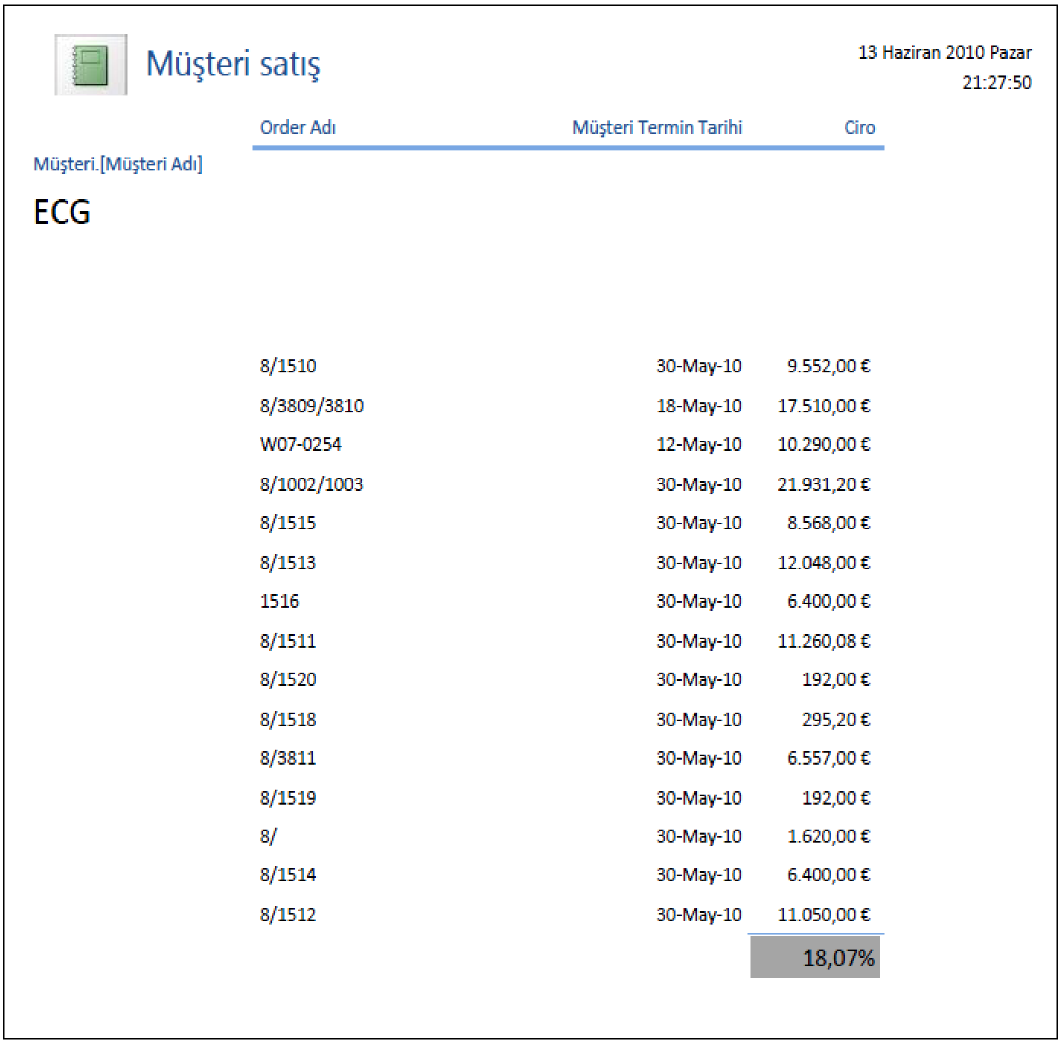


Müşteri.[Müşteri Adı]

NED

Order Adı	Müşteri Termin Tarihi	Ciro
W07-0267	01-Haz-10	14.000,00 €
W07-0268	01-Haz-10	3.500,00 €
W07-0388	09-Haz-10	15.540,00 €
W07-0390	09-Haz-10	6.048,00 €
W07-0389	09-Haz-10	5.964,00 €
		3,25%
		1.384.272,78 €

Figure B.29.2.3.4. Sales Distribution Statistics Report – Part 4



Müşteri satış

13 Haziran 2010 Pazar
21:27:50

Müşteri.[Müşteri Adı]

ECG

Order Adı	Müşteri Termin Tarihi	Ciro
8/1510	30-May-10	9.552,00 €
8/3809/3810	18-May-10	17.510,00 €
W07-0254	12-May-10	10.290,00 €
8/1002/1003	30-May-10	21.931,20 €
8/1515	30-May-10	8.568,00 €
8/1513	30-May-10	12.048,00 €
1516	30-May-10	6.400,00 €
8/1511	30-May-10	11.260,08 €
8/1520	30-May-10	192,00 €
8/1518	30-May-10	295,20 €
8/3811	30-May-10	6.557,00 €
8/1519	30-May-10	192,00 €
8/	30-May-10	1.620,00 €
8/1514	30-May-10	6.400,00 €
8/1512	30-May-10	11.050,00 €
		18,07%

Figure B.30.2.3.5. Sales Distribution Statistics for May- Part 1

Müşteri.[Müşteri Adı]	Order Adı	Müşteri Termin Tarihi	Ciro
F2WEAR			
	07-0671 ME	19-May-10	11.700,00 €
	07-0707/710 ME	18-May-10	27.097,50 €
	07-0641CAXL	17-May-10	12.000,00 €
	07-0597/598/599 V	17-May-10	20.500,00 €
	07-0653/658CAC	18-May-10	24.700,00 €
	07-0708ME	25-May-10	18.000,00 €
	07-0617CAXL	25-May-10	4.800,00 €
			17,33%
HCT			
	1805	18-May-10	6.534,00 €
	1800	18-May-10	64.810,00 €
			10,41%
K&L RUPP			
	150527-3	11-May-10	4.200,00 €
	154893-1	11-May-10	15.400,00 €
			2,86%

Figure B.31.2.3.6. Sales Distribution Statistics Report for May- Part 2

Müşteri.[Müşteri Adı]	Order Adı	Müşteri Termin Tarihi	Ciro
M&S			
	40279	18-May-10	46.200,00 €
	40244	16-May-10	3.900,00 €
	40275	25-May-10	52.045,00 €
	40304	25-May-10	65.052,00 €
	50009	16-May-10	33.565,00 €
	40264	16-May-10	49.543,00 €
	40277	18-May-10	50.400,00 €
	40273	25-May-10	51.034,80 €
			51,32%
			685.346,78 €

Figure B.32.2.3.7. Sales Distribution Statistics Report for May Part-3

Müşteri satış

13 Haziran 2010 Pazar
21:33:11

Müşteri.[Müşteri Adı]

Müşteri.[Müşteri Adı]	Order Adı	Müşteri Termin Tarihi	Ciro
F2WEAR			
	07-0729CAXL	08-Haz-10	27.056,00 €
	07-0606 CAXL	01-Haz-10	14.880,00 €
	07-0673 MEXL	02-Haz-10	9.940,00 €
	07-0672 MEXL	02-Haz-10	14.400,00 €
	07-0664 MEXL	08-Haz-10	2.412,00 €
	07-0663 MEXL	08-Haz-10	13.140,00 €
	07-0605 CAXL	01-Haz-10	18.744,00 €
	07-0730CAXL	08-Haz-10	11.792,00 €
	07-0751 CAXL	16-Haz-10	16.420,00 €
	07-0819/820 ME	08-Haz-10	15.000,00 €
	07-0788 ME	08-Haz-10	9.800,00 €
	07-0733 CAXL	16-Haz-10	4.050,00 €
	07-0732 CAXL	16-Haz-10	11.072,00 €
	07-0731 CAXL	08-Haz-10	1.558,00 €
			24,36%
HCT			
	1801	15-Haz-10	35.266,00 €
	1910	08-Haz-10	11.360,00 €
	1909	08-Haz-10	102.200,00 €
			21,29%

Figure B.33.2.3.8. Sales Distribution Statistics Report for June Part-1

Müşteri.[Müşteri Adı]	Order Adı	Müşteri Termin Tarihi	Ciro
K&L RUPP			
	155539-2	15-Haz-10	5.680,00 €
	155540-1	15-Haz-10	5.520,00 €
	155115-1	04-Haz-10	5.840,00 €
	155539-1	15-Haz-10	5.760,00 €
	150527-4	15-Haz-10	5.600,00 €
	153074-2	08-Haz-10	5.600,00 €
			4,86%
M&S			
	50015	01-Haz-10	51.750,00 €
	50038	15-Haz-10	42.000,00 €
	50013	08-Haz-10	43.200,00 €
	40301	01-Haz-10	48.024,00 €
	50018	08-Haz-10	32.560,00 €
	GEVEWEN	15-Haz-10	42.000,00 €
	50011	01-Haz-10	41.250,00 €
			43,04%

Figure B.34.2.3.9. Sales Distribution Statistics Report for June Part-2

Müşteri.[Müşteri Adı]	Order Adı	Müşteri Termin Tarihi	Ciro
NED			
	W07-0389	09-Haz-10	5.964,00 €
	W07-0390	09-Haz-10	6.048,00 €
	W07-0268	01-Haz-10	3.500,00 €
	W07-0267	01-Haz-10	14.000,00 €
	W07-0388	09-Haz-10	15.540,00 €
			6,45%
			698.926,00 €

Figure B.35.2.3.10. Sales Distribution Statistics Report for June Part-3

APPENDIX C

THE RELATIONSHIP DIAGRAM OF THE DATABASE IN MS ACCESS

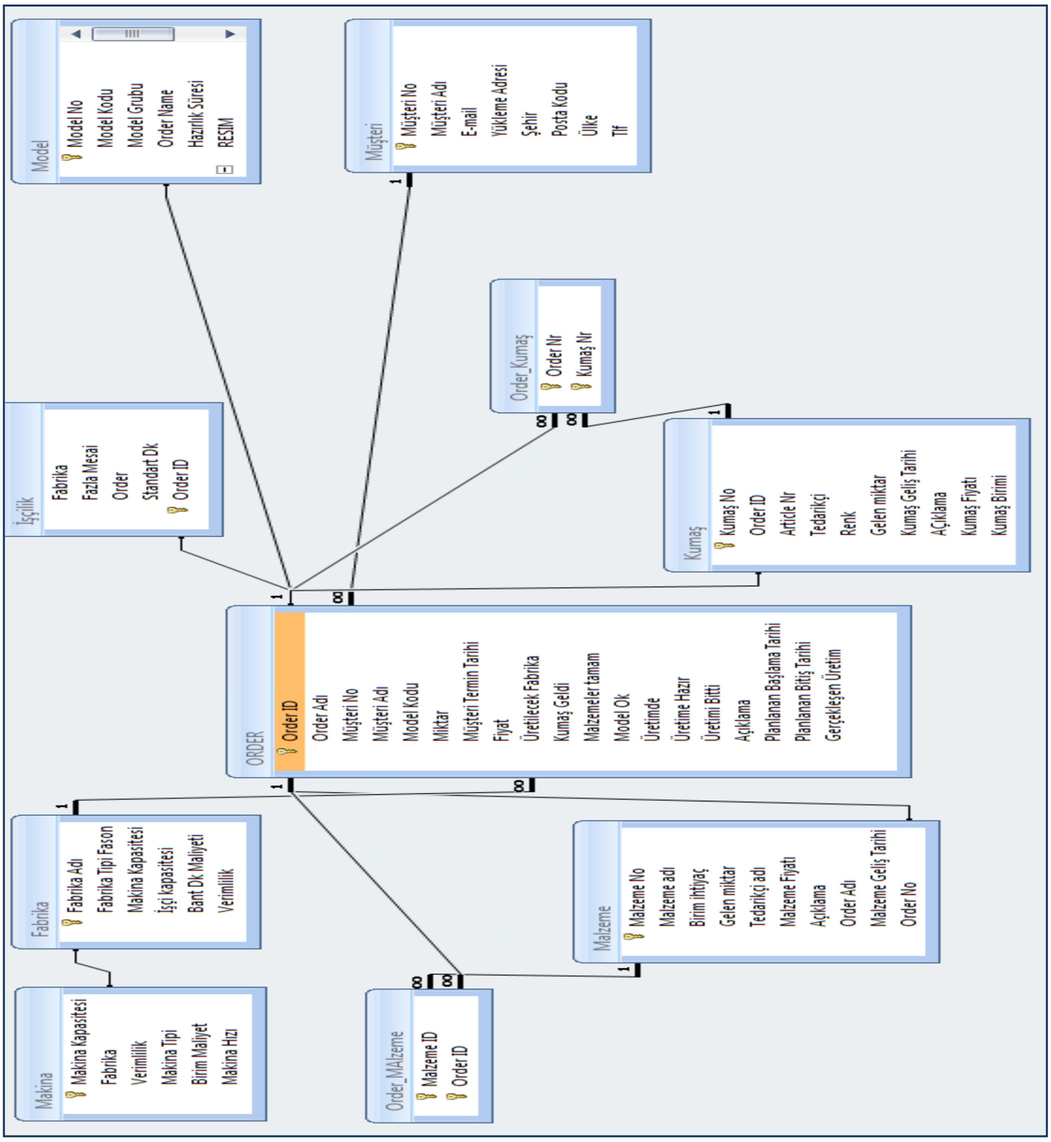


Figure C.36 The relationship diagram of the database in Ms Access

APPENDIX D

ENTITY RELATIONSHIP AND DATA FLOW DIAGRAMS OF THE SYSTEM

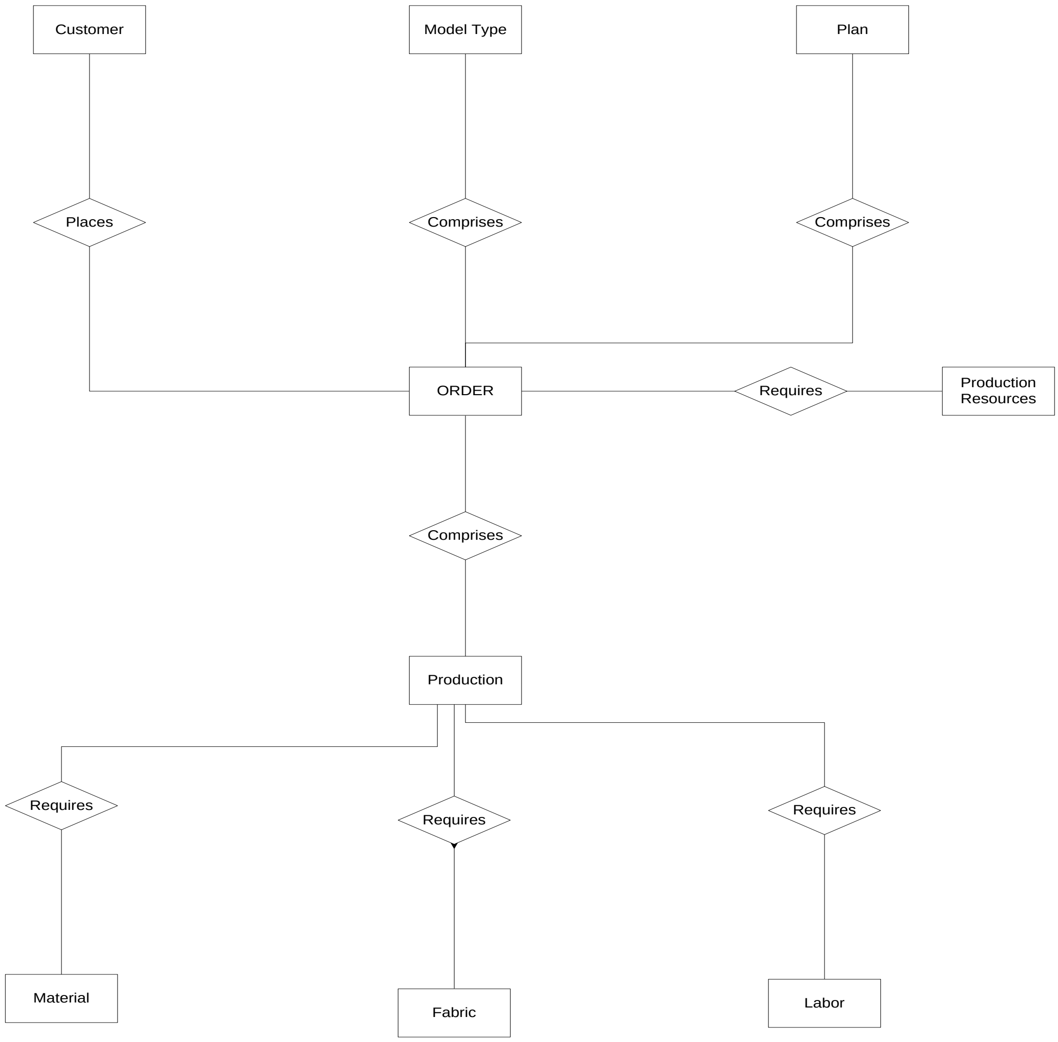


Figure D.37. Entity Relationship Diagram

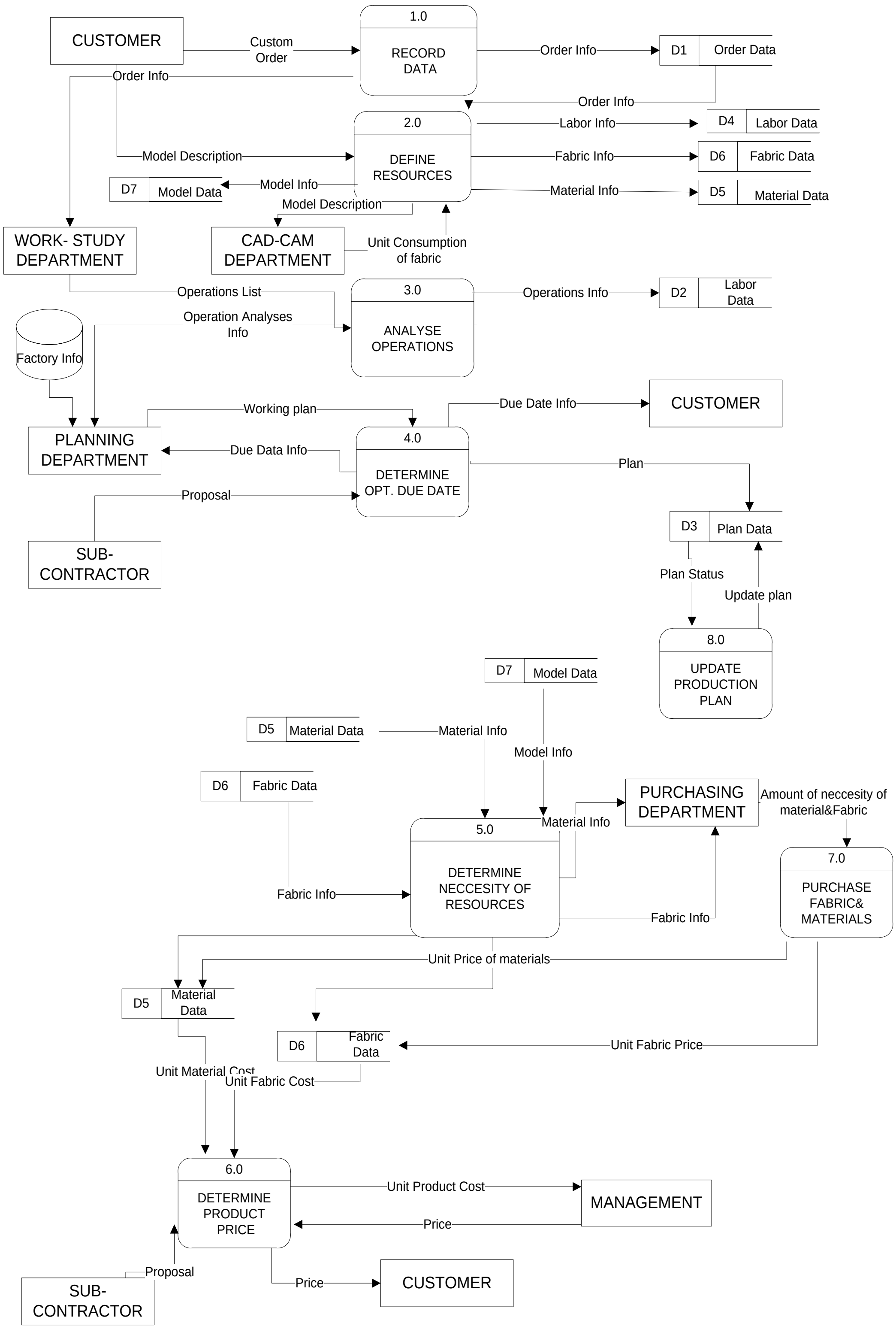


Figure D. 38 Data Flow Diagram (Level 1)

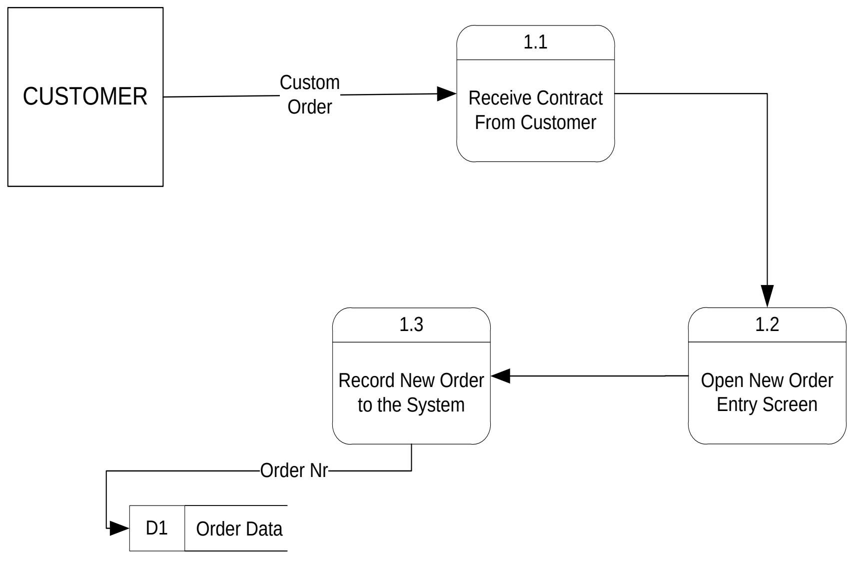


Figure D. 39 Record order data (level 2)

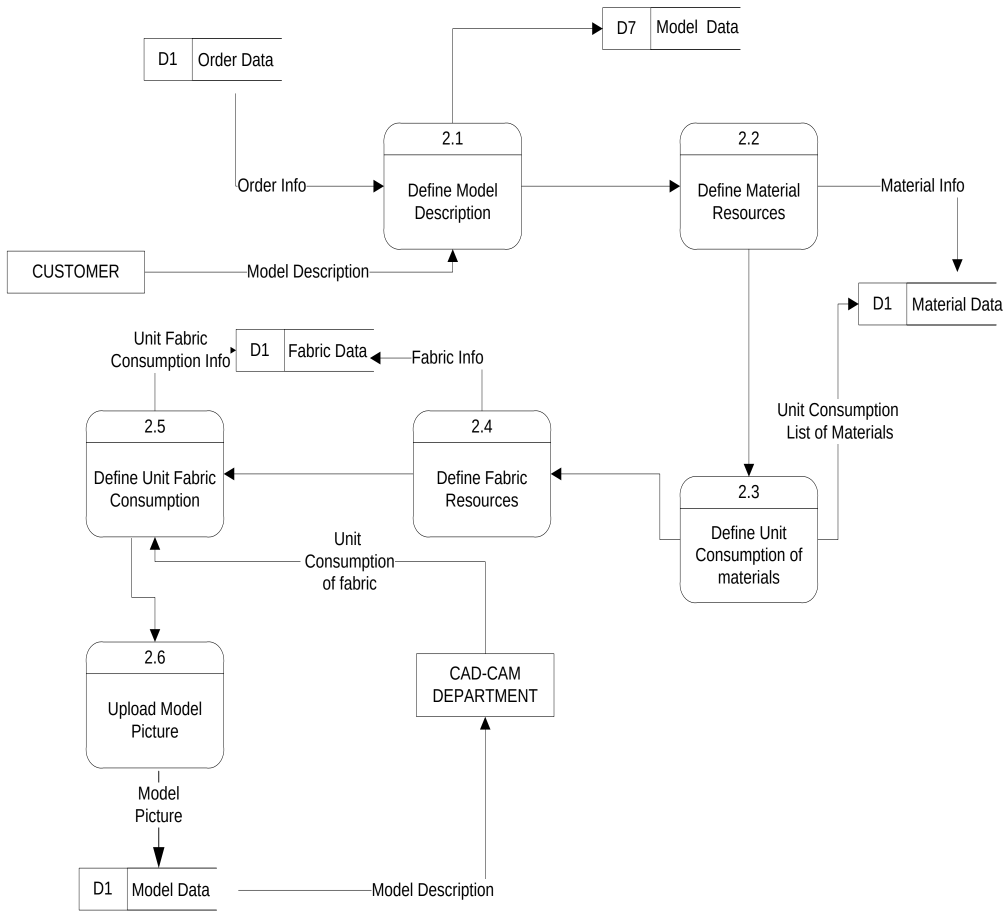


Figure D. 40 Define Resources (Level 2)

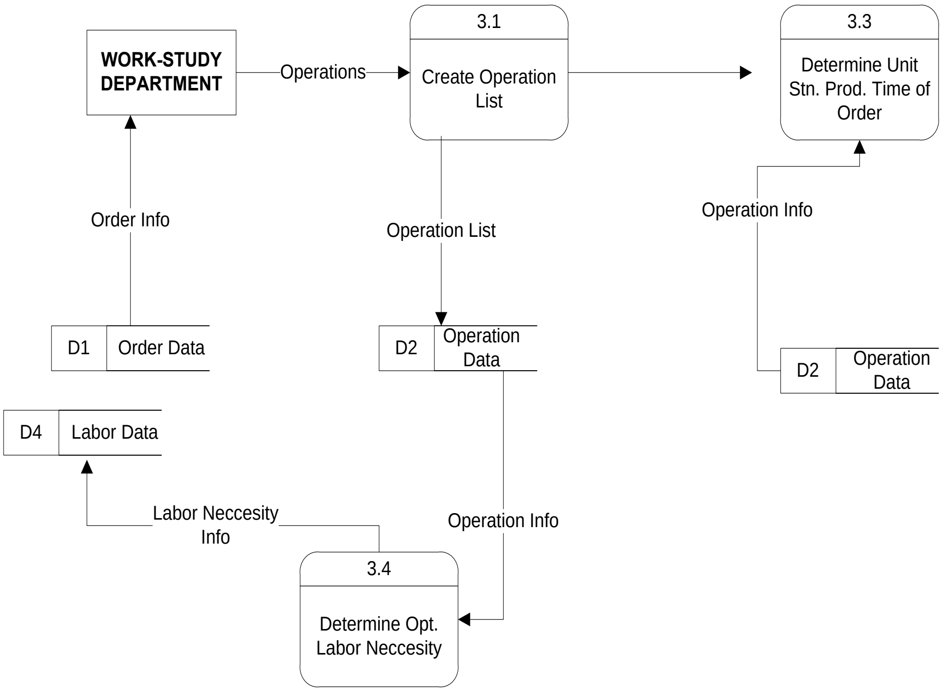


Figure D. 41 Analyze Operations (Level 2)

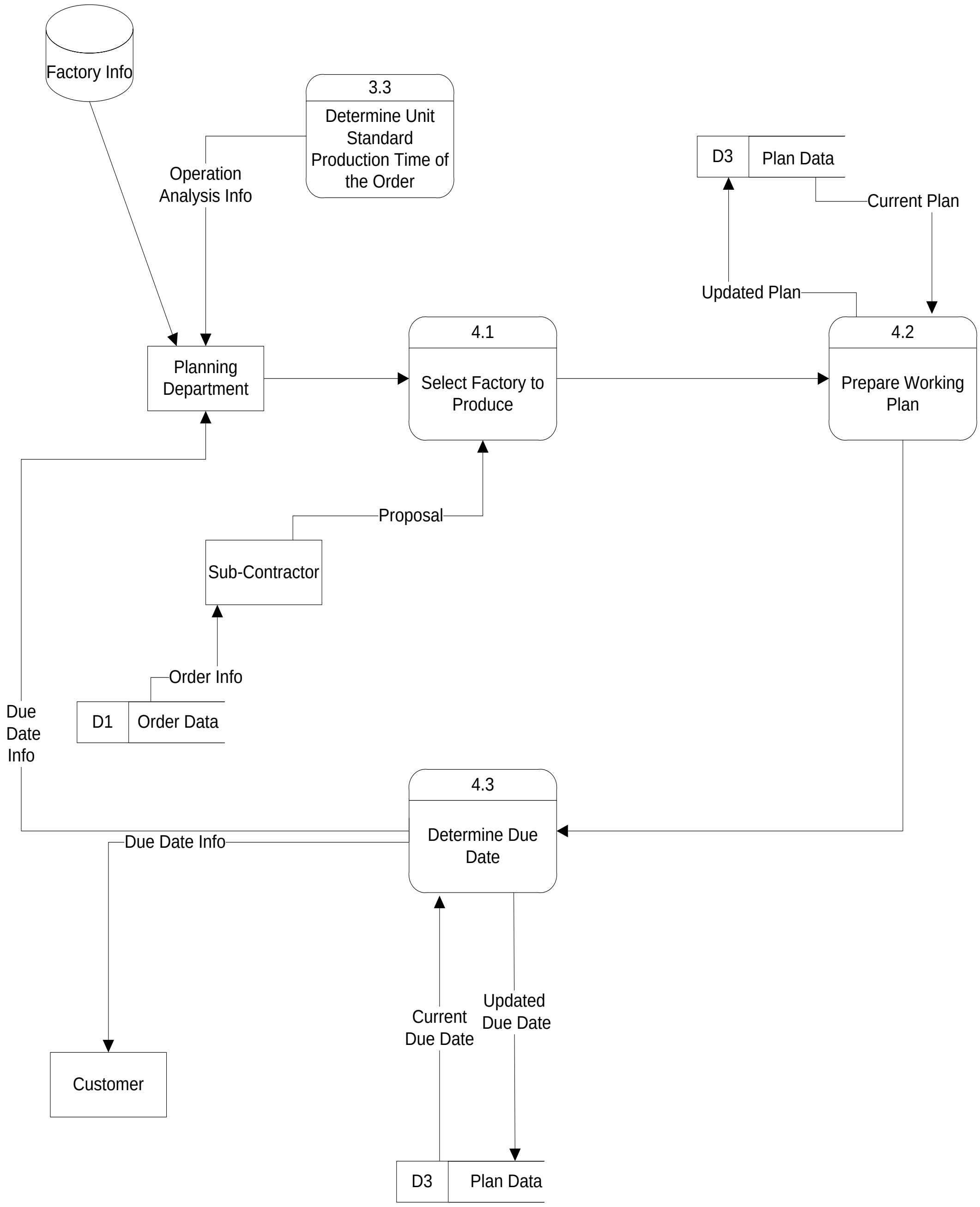


Figure D.42 Determine Due Date (Level 2)

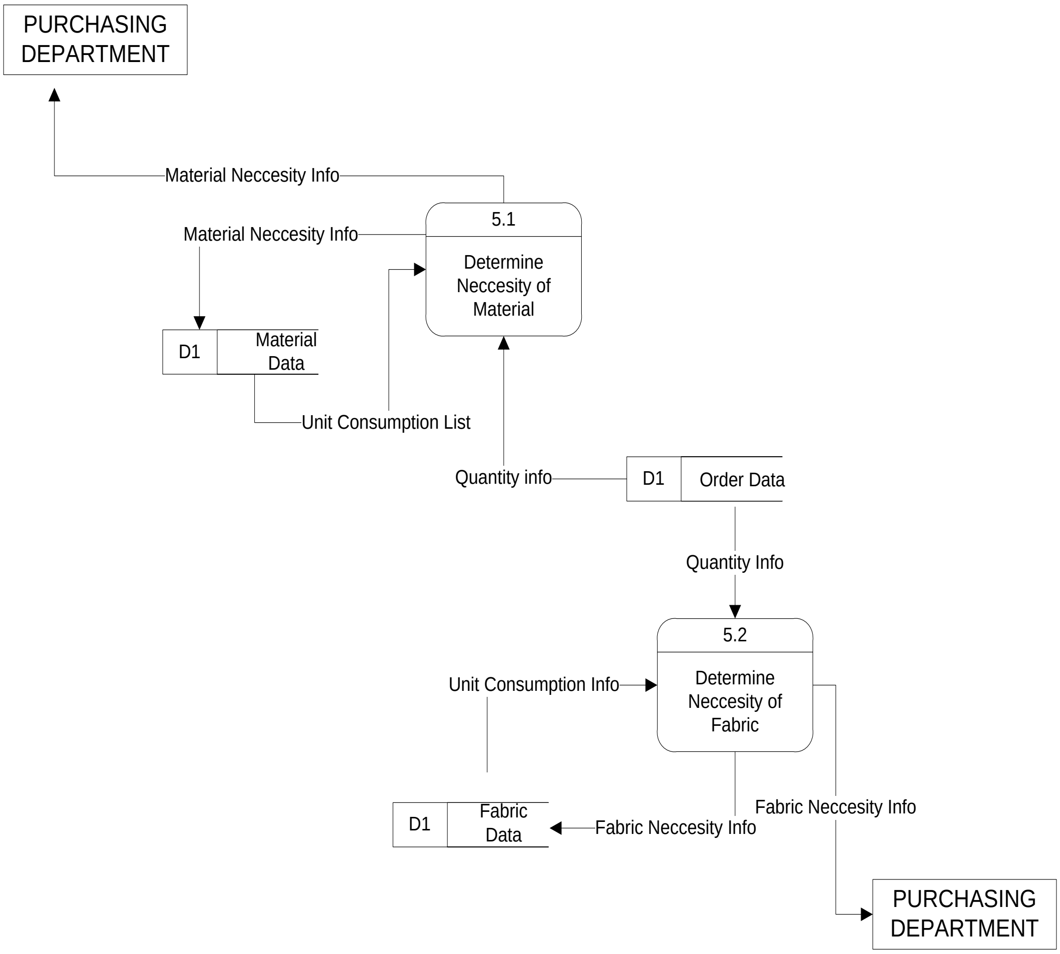


Figure D. 43 Determine Neccesity Of Resources

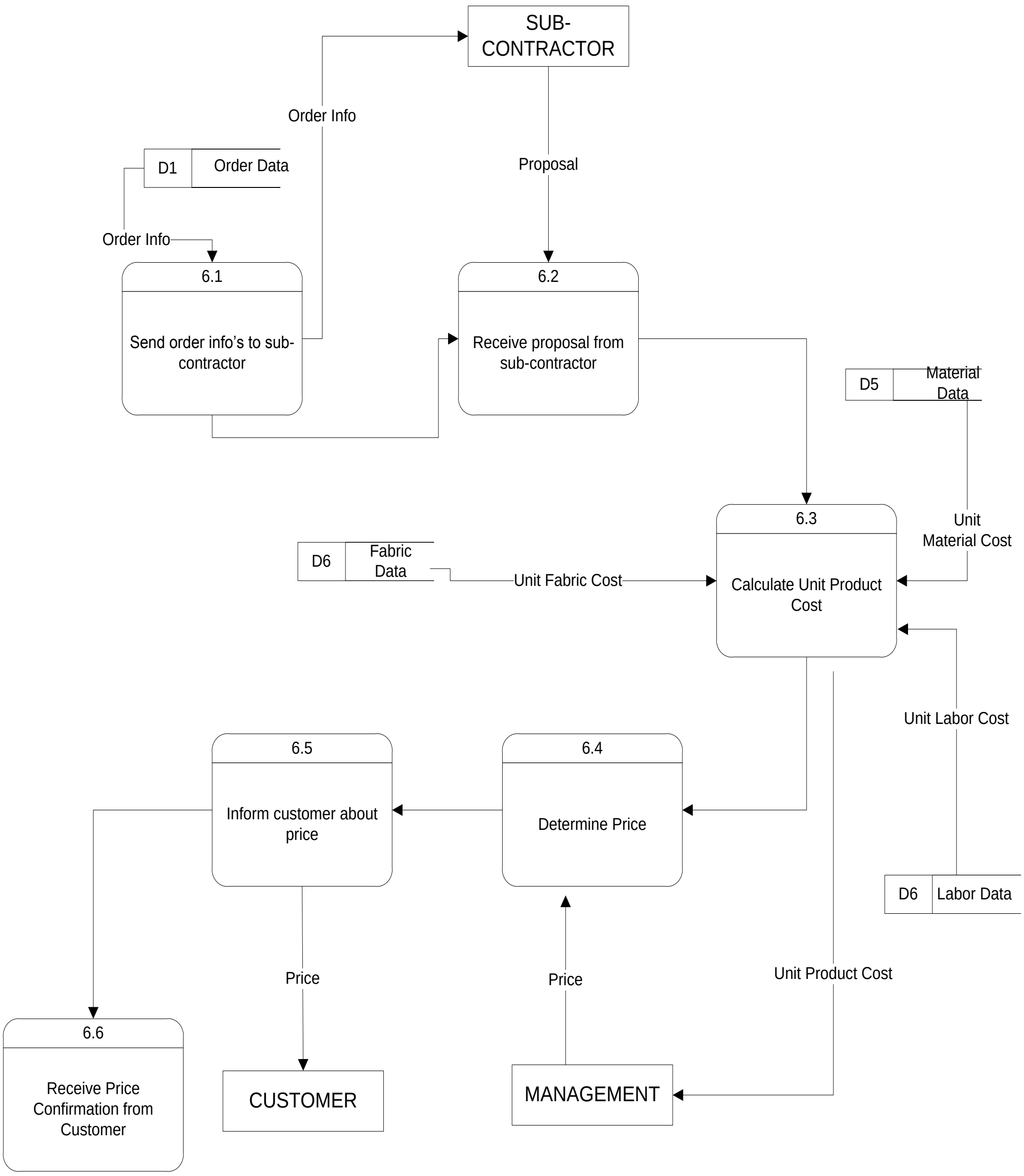


Figure D. 44 Determine Product Price

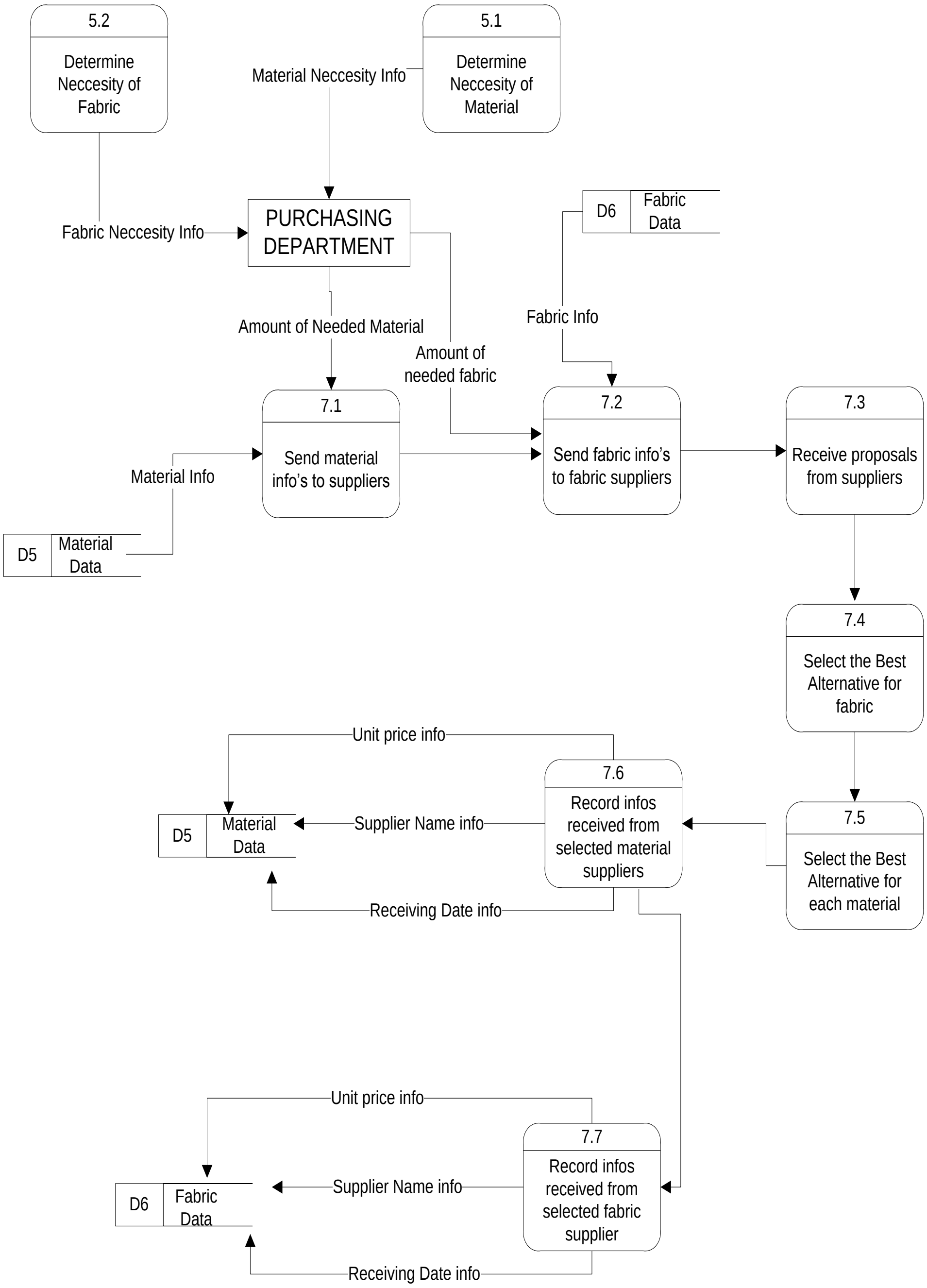


Figure D. 45. Purchase Fabric And Materials

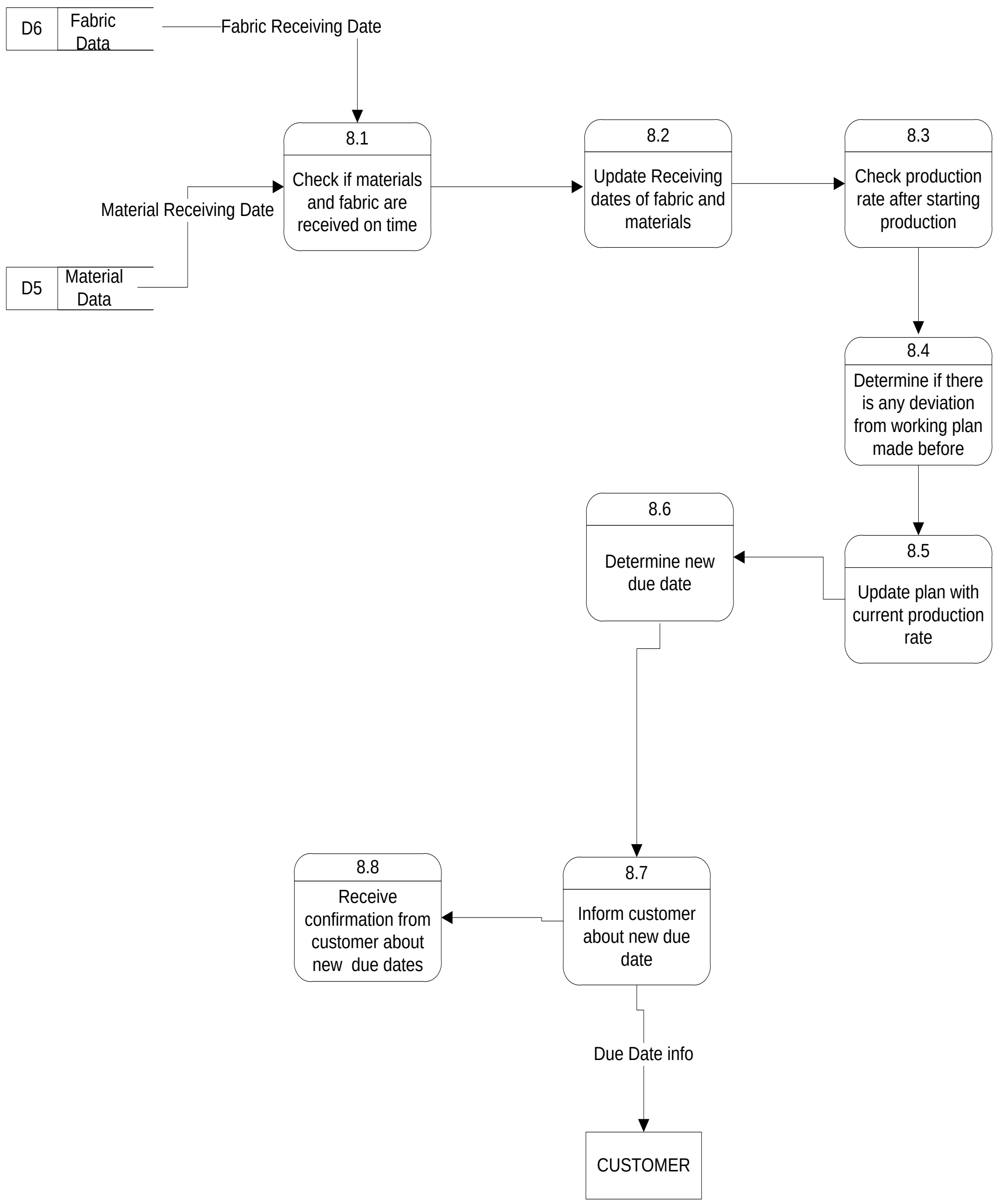


Figure D.46 Update Plan

APPENDIX E

GAMS OUTPUT

```
GAMS Rev 148  x86/MS Windows                    01/25/98 17:08:30 Page 1
G e n e r a l   A l g e b r a i c   M o d e l i n g   S y s t e m
C o m p i l a t i o n


   Sets i orders   /1*15 /
        j line times /1*4/
        t position   /1*8/        ;

 Alias(i,k) ;

Parameters
            D (i) Quantity of order i /1 500, 2 600, 3 2200, 4 8400,5  600,
 6 8400, 7 2060, 8 10008, 9 800, 10 800, 11  24 ,12 1404, 13 200, 14 830,
 15 3046/
            A(i) arriving date of order i /
 1 0
 2 0
 3 0
 4 7
 5 5
 6 5
```

```
7 6
8 6
9 5
10 7
11 7
12 7
13 8
14 8
15 8




 /

         F(i) family of product i        /
1 5
2 7
3 3
4 4
5 5
6 5
7 5
8 4
9 7
10 4
11 3
12 5
13 5
14 7
15 6
```

```

/
  DD(i) Due date of order i        /

1 5
2 5
3 5
4 12
5 10
6 12
7 12
8 19
9 20
10 20
11 20
12 20
13 20
14 20
15 20


/
         S(i) Set up time of family i /


1 0.3
2 0.4
3 0.5
4 0.3
5 0.5
6 0.5
```

```
7 0.5
8 0.3
9 0.4
10 0.5
11 0.5
12 0.5
13 0.5
14 0.5
15 0.5


/



P(i)  capacity of order i /

1 666
2 592
3 592
4 979
5 666
6 1289
7 579
8 727
9 352
10 480
11 377
12 379
13 666
14 859
```

```
15 666
/
;
Positive Variables  C(i,j,t),ST(j,t),U(i,j,t),B(i),Tar(i);
Binary variables   X(i,j,t),Z(j,t);
Variables objctn, Tar(i);
Equations
 amac
Tardiness
line
order
starting
Finishtime
Finishtime2
setuptime
zet1
zet2
comp
demand
amount
Bitis
;
amac..   objctn=e= sum(i,Tar(i))+ 0.1*sum((i,j,t),Z(j,t)*S(i));
```

```
Tardiness(i).. Tar(i)=g=B(i)-DD(i);
line(j,t)..  sum(i,X(i,j,t))=l=1  ;
order(i).. sum((j,t),X(i,j,t))=g=1 ;
Starting(i,j,t).. A(i)*X(i,j,t)=l=C(i,j,t)-(U(i,j,t)/P(i));
Finishtime (i,j,t).. C(i,j,t)=g=sum(k ,C(k,j,t-1))+(U(i,j,t)/P(i))-1000*(1-X(i,j,t))+ST(j,t);
Finishtime2(i,j).. C(i,j,'1')=g=ST(j,'1')+(U(i,j,'1')/P(i))-1000*(1-X(i,j,'1'));
Setuptime(j,t).. ST(j,t)=g=sum(i,S(i)*X(i,j,t))-1000*(1-Z(j,t));
Zet1(j,t).. 1000*Z(j,t)=g=sum(i,F(i)*X(i,j,t))- sum(i,F(i)*X(i,j,t-1)) ;
Zet2(j,t).. 1000*Z(j,t)=g= sum(i,F(i)*X(i,j,t-1))-sum(i,F(i)*X(i,j,t))-1000*(1-(sum(i,X(i,j,t)))) ;
comp(i,j,t).. C(i,j,t+1)=l= 1000*sum(k,X(k,j,t));
demand(i).. D(i) =e= sum((j,t),U(i,j,t));
Amount(i,j,t).. U(i,j,t)=l=10000*X(i,j,t);
Bitis(i,j,t).. B(i)=g=C(i,j,t);


Model Schedule /all/ ;
Solve Schedule using mip minimizing objctn ;
Display X.l,C.l,Z.l,U.l,B.l,tar.l ;
```

```
                 LOWER     LEVEL     UPPER    MARGINAL

---- VAR objctn         -INF      6.700     +INF       .



**** REPORT SUMMARY :        0     NONOPT
                             0 INFEASIBLE
                             0  UNBOUNDED
```

---- 157 VARIABLE X.L

	1	2	3	4	5	6
1 .1	1.000		1.000	1.000		
2 .3	1.000					
3 .4	1.000					
4 .3		1.000				
4 .4			1.000			
5 .2	1.000	1.000			1.000	
6 .1		1.000			1.000	
7 .2			1.000			
8 .3				1.000	1.000	
8 .4		1.000		1.000		
9 .1						1.000
10.3			1.000			1.000
10.4					1.000	1.000
12.2				1.000		
13.2						1.000

+	7	8
7 .2	1.000	
8 .1		1.000
10.4	1.000	
11.3	1.000	
12.2		1.000

14.1	1.000	
15.3		1.000

---- 157 VARIABLE C.L

	1	2	3	4	5	6
1 .1	1.051		5.000	5.000		
2 .3	1.414					
3 .4	4.216					
4 .3		10.580				
4 .4			12.000			
5 .2	5.901	5.901			7.000	
6 .1		5.000			11.517	
7 .2			6.000			
8 .3				14.363	14.363	
8 .4		7.000		17.439		
9 .1						14.189
10.3			10.580			14.363
10.4					19.106	19.106
12.2				7.000		
13.2						8.300

+	7	8
7 .2	11.858	
8 .1		19.000
10.4	19.106	
11.3	14.926	
12.2		15.563

14.1 15.156

15.3 20.000

---- 157 VARIABLE Z.L

	1	2	6	7	8
1	1.000		1.000		1.000
2	1.000				
3	1.000	1.000		1.000	1.000
4	1.000	1.000			

---- 157 VARIABLE U.L

	1	2	3	4	5	6
1 .1	500.000					
2 .3	600.000					
3 .4	2200.000					
4 .3		3505.000				
4 .4			4895.000			
5 .2	600.000					
6 .1					8400.000	
8 .3				2749.937		
8 .4		727.000		3954.318		
9 .1						800.000
10.4					800.000	
13.2						200.000

+ 7 8

7 .2 2060.000
8 .1 2576.745
11.3 24.000
12.2 1404.000
14.1 830.000
15.3 3046.000

---- 157 VARIABLE B.L

1 5.000, 2 5.000, 3 5.000, 4 12.000, 5 10.000, 6 12.000
7 12.000, 8 19.000, 9 20.000, 10 20.000, 11 20.000, 12 20.000
13 20.000, 14 20.000, 15 20.000

---- 157 VARIABLE Tar.L

(ALL 0.000)

EXECUTION TIME = 0.031 SECONDS 3 Mb WIN225-148 May 29, 2007