DEVELOPING AN INTERNET ENABLED SUPPLY CHAIN MANAGEMENT MODEL FOR SMALL AND MEDIUM SIZE ENTERPRISES

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Dedication

To my parents   for your love, encouragement, and support.
To my wife   for her patience and humor
To my daughter   Shahd

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List of Abbreviations

ATF	Attribute For Time Elapsed During Financial Process
BA1	Inventory Level of Product A at Base Stores1
C.I.	Confidence Interval
C/S	Client/Server.
DC	Distribution Center
dd	Daily Demand
dL	Demand During Lead Time
E-Commerce	Electronic Commerce.
EDI	Electronic Data Interchange.
E-Mail	Electronic Mail.
EOQ	Economic Order Quantity
FF	Freight Forwarder
FPT	Financial Process Time
FTP	File Transfer Protocol.
HTML	Hypertext Markup Language.
IL	Inventory Level.
IP	Internet Protocol
IRC	Internet Relay Chat.
IS	Information System
ISP	Internet Service Provider
IV	Inventory Value.
JDs	Jordanian Dinnars
LAN	Local Area Network
LT	Lead Time
MIV	Minimum Inventory Value.
NT	New Technology
OPT	Order Process Time
OS	Operating System
P	Poisson Distribution
Q	Order Quantity (Continuous Review System)
RAF	Royal Air Force
RJAF	Royal Jordanian Air Force
ROP	Reorder Point
RTI	Run Time Interface.
PC	Personal Computer
PM	ProModel Simulation Software
SC	Supply Chain
SCM	Supply Chain Management
SCMIS	Supply Chain Management Information System
SCOR	Supply Chain Operation Reference
SIMRUNNER	ProModel Optimization Software.
SMEs	Small And Medium Size Enterprises
SPT	Shipment Process Time
SQL	Standard Query Language
SS	Safety Stock
STAT: FIT	ProModel Statistical Analysis Software
STD	Standard Deviation.
TC	Total Cost
TOC	Total Operating Cost.
ISCM	Integrated Supply Chain Management
IT	Information Technology
WAN	Wide Area Network.
WWW	World Wide Web.
YAQ	Yearly Average Quantity

Abstract

Developing An Internet Enabled Supply Chain Management Model For Small And Medium Size Enterprises

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In this thesis a supply chain management model was developed based on the Internet technology and on the needs of small and medium sizes enterprises in Jordan. The model describes the supply chain network that consists of suppliers, enterprise, distribution centers, retailers, and end users. To be effective the supply chain management should result in a smooth flow of information and services throughout the network.

The purpose of the model was to improve service level, reduce inventory level, and reduce lead-time in both order processing time and financial processing time. The model incorporates relationships among the chain partners that affect cost and lead-time in order to improve the information system throughout the supply chain.

The model was simulated using PROMODEL software, and was applied to Royal Jordanian Air force in order to test and validate it. Two types of imported products from local and external suppliers were considered in the simulation. The simulation model results showed, cost reduction, service level increase, and a notable reduction in lead-time.

It is recommended that SMEs in Jordan can benefit greatly from Internet usage in their SCM and this will be reflected positively on the enterprise performance and management.

1. Introduction

1.1 Preface

Supply chain consists of the logistical and informational activities between the enterprise and it's partners, where the partners include suppliers, warehouses, distribution centers, retailers, and customers. Information, materials, and money flow between the supply chain partners through distribution channels. In a market economy environment, this flow must be managed effectively so that the enterprise can become competitive. The coordination and integration of the elements of this network are critical to achieving an effective supply chain management.

In recent years, supply chain management has become a tool by which enterprises have increased their profitability. The advancement of computer and information technology combined with e-commerce using the Internet, increasing pressure from customer's responsiveness, and globalization of markets, has forced enterprises to reconsider their supply chain management in their new business strategy.

1.2 Importance of the Study

Competition has forced companies to formulate new supply chain management policies. It was normal for these new policies to explore advantage offered by spread and speed of the Internet. Continuous improvement to all activities of any enterprise are critical in order to provide world class services and meet customer satisfaction, all at competitive prices. The developments of the Jordanian enterprises whether, they perform administrative functions, provide customer services, or manufacture products, relies on building stronger and more effective links with their partners, this in turn, depends greatly on their supply chain management.

Optimizing the supply chain management process requires Jordanian enterprises to share information with their partners, define and put forward correct solution for problems, and finally choose the right tool to execute their work. In order to achieve these objectives, individual enterprises in Jordan should coordinate and integrate their activities with other interrelated companies. The Internet provides the means to increase the effectiveness of communications, and achieve greater interactivity between the enterprise and its partners in the supply chain.

1.3 Problem Definition

Enterprises in Jordan can be divided into two main categories in relation to the policy they follow to achieve their SCM objectives. First, enterprises that focus on service level and customer satisfaction. This is done by increasing the inventory level, thus providing better services and higher fill rates, which adversely affects the cost causing it to increase (Our case study, RJAF, is included in this category). Second enterprises focusing on keeping their inventory level at minimum. But as customer purchasing power increases, there is an increased pressure on these enterprises to make available a high variety of quality products. Since new products have shorter life cycles, and customer demand vary greatly, inventory and back orders levels will fluctuate considerably across the supply chain, again this will result in an increase in order cost or decrease in customer service.

Improved service and inventory levels by the Jordanian enterprises can be achieved now by using the developments in information and communications technologies, together with the better understanding of the supply chain management strategies.

The lead-time is one of the most important factors that should be considered by SMEs management in Jordan. According to RAF directorate of supply, it takes some products or goods more than one year to be delivered compared with the actual "travel" time of no more than forty days when shipped by containers. This results in significant increase of waste, cost, and a reduction in service level.

1.4 Research Objectives

The main objective of this research was to develop an Internet based supply chain management model that can assist small and medium size enterprises in Jordan in improving their customer service level while reducing the relevant costs.

The simulation was used to:

1. Model all processes and activities on the different supply chain locations.
2. Model the order, financial, and shipping processes activities.
3. Model material flow, and [illegible]er flow between the different locations in the RJAF supply chain.
4. Test the validity of the simulation model
5. Highlight the current supply chain management at RJAF, and evaluate several alterations made to the model parameters.

The works aimed at enhancing small and medium size enterprises in Jordan to better manage their supply chain using the Internet. A simulation model was used to assist and improve the existing supply chain used at Royal Jordanian Air Force (RJAF). Through the simulation several conclusions were drawn concerning lead-time, resource utilization, inventory level, and the total cost.

1.5 Methodology

The following methodology was adopted to achieve the research objectives:

1. Literature review into the previous work accomplished by other researchers in the field of supply chain management, modeling, and simulation.
2. Problem identification and formulation. This includes the identification of the system architecture and the building of entities, input resources, locations, and the process and routing logic of all system parameters and variables.
3. Development of the model and formulation of the simulation model using RAF supply chain as a case study.
4. Determination of the performance measures used for assessment purposes in the system.
5. Collection the real system data.
6. Validation and verification of the developed simulation model.
7. Evaluations of the current supply chain management, and output data for RAF supply chain.
8. Interpretation and discussion of the results, conclusions and recommendations.

1.6 Overview of the Thesis

The thesis consists of six chapters; the thesis starts with an introduction and overview of the work. Chapter one includes general information about supply chain management, importance of the study, des ption of the problem, objectives of the thesis, and the methodology used to accomplish the work.

Chapter two presents literature review on the supply chain, supply chain management, SCM in the Internet, SMEs, modeling, and supply chain simulation.

Chapter three discusses the structure of the model; problems facing supply chains in Jordan, the objectives of the model, and implementation of the model through the Internet.

Chapter four presents the simulation of supply chain management model, and includes, the system layout, performance measures used, the input data, system structure, model validation and verification, and the output data. It also includes a description of the RAF supply chain structure.

Chapter five discusses the results drawn from the supply chain management model. These include evaluation of the current supply chain management system and suggestions for several modifications designed to reduce the delay time in orders, financial process, and shipping process. Other improvements air at reducing the inventory levels, costs, and increasing the customer service level were discussed in this chapter.

Finally, chapter six presents conclusion and recommendations.

2. Literature Review

The concept "supply chain management" was introduced in the early 1980s and since then the concept has received increasing attention within the field of logistics. Supply chain management is viewed as a broad logistics concept that focuses on integration of the total material flow, from supplier to the ultimate customer. The main stated objectives are to lower costs and improve customer service (Persson, 1997).

In the last few years, however, it has become clear that many companies have reduced manufacturing costs, as much as, is practically possible. Many of these companies have discovered that effective supply chain management is the next step they need to take in order to increase profit and market share (Levi *et al.*, 2000).

2.1 Supp' Chain and Supply Chain Management

A supply chain can be defined as a worldwide network of business entities, such as suppliers, factories, warehouses, distribution centers, and retailers, through which raw material are acquired from suppliers, transformed, and delivered to customers (Kjenstad, 1998).

Supply chain management seeks to synchronize a firm's functions and those of its suppliers to match the flow of materials, services, and information with customer demand (Krajewski and Ritzman, 1999).

Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements (Levi *et al.*, 2000).

2.2 Supply Chain Management Objectives

A basic purpose of supply chain management is to control inventory by managing the flows of materials (Krajewski and Ritzman, 1998). The aim of the supply chain is to minimize non-value-added activities and their associated structure because this will serve in greater customer responsiveness and flexibility into the supply chain, driving costs down (Stewart, 1995).

The objective of supply chain management is to be efficient and cost effective across the entire system; total system wide costs ‹from transportation and distribution to inventories of raw materials, are to be minimized. Thus, the emphasis is not as simple as minimizing transportation cost or reducing inventories, but rather, on taking a system approach to supply chain management (Levi *et al.*, 2000).

2.3 Small and Medium Size Enterprises

Small- and medium-size enterprises (SMEs) are defined as enterprises with fewer than 500 employees were management is centralized mainly in the hands of the owner-manager, who has a high degree of control over activities, and specifically seeks to improve their performance and efficiency through logistics (Halley and Guilhon, 1997).

It is well documented that SMEs have unique characteristics that differentiate them from conventional marketing in large organizations. These may be determined by the inherent characteristics and behaviors of the entrepreneur or owner/manager; and they may be determined by the inherent size and stage of development of the enterprise. Such limitations can be summarized as limited resources (such as finance, time, marketing knowledge); lack of specialist expertise (owner-managers tend to be generalists rather than specialists); and limited impact in the marketplace. Clearly such limitations will influence, indeed determine, the marketing characteristics of an SME (Gilmore *et al.*, 2001).

There is no clear cut between SMEs and large enterprises. But according to the characteristics of the enterprises in Jordan like limited resources, lack of specialists, and limited impact in the marketplace, it is clear that these characteristics are the same as those of SMEs.

2.4 Information Technology for the Supply Chain.

Information technology (IT) is an important enabler of effective supply chain management. Much of the current interest in supply chain management is motivated by the possibilities that are introduced by the abundance of data and the savings inherent in analysis of these data. The innovative opportunities coming fore with e-commerce, especially through the Internet have also increased the interest in IT (Levi *et al.*, 2000).

Information changes the ways súpply chains can and should be effectively manageu, .hese changes may lead to, among other things, lower inventories. Indeed, the objective is to characterize how information affects the design and operation of the supply chain. They show that by effectively harnessing the information now available, one can design and operate the supply chain much more efficiently and effectively than ever before. Levi *et al.*, (2000) Argue that this abundance of information:

1. Helps reduce variability in the supply chain.
2. Helps suppliers make better forecasts, accounting for promotions and market changes.
3. Enables retailers to react and adapt to supply problems more rapidly.
4. Enables lead time reductions.

The use of the Internet, and especially the World Wide Web (WWW), may go further to actually replacing some of the more traditional forms of activities in the supply chain. There are numerous organizations that now sell and supply directly via the WWW. Some of the companies involved are big players in their markets- and are taking advantage of the lower costs that WWW-based operations can support. One advantage is that the relationship between customer and supplier can be both direct and very fast. This allows an organization to design and build tailored products and get them to customers quickly. (Moore, 1998).

2.5 Internet, Intranet, Extranet

The Internet is a network of computers that are connected together by using telephone or other communication lines. It is a publicly accessible network (Abu Ali, 1999). The Internet offers a number of facilities such as: WWW (World Wide Web), e-mail (electronic mail) telnet (log in), file transfer protocol (FTP) to down load, newsgroups, and Internet relay chat (IRC) for text chatting.

Intranet is a privately accessible network (inside company network) using Internet technology and tools (Abu Ali, 1999). It may consist of many interlinked local area networks and also use leased lines in the wide area network. Intranet is easy to use because all users will use the same interface to access information, easy to maintain because information management is centralized and low on cost because Internet technology is cheap and widely available.

Extranet, which is a semi-private network (between two or more companies- business partners) using Internet technology and tools (Abu Ali, 1999). It is a private network that uses the Internet protocols and public telecommunication system to securely share part of a business's information or operations with suppliers, vendors, customers, or other businesses. It allows exchange of large volumes of data using Electronic Data Interchange (EDI), allowing client to review their account record, and provide or access services provided by one company to a group of other companies such as online banking application.

2.6 Supply Chain Management Modeling

Modeling has been used as a tool within supply chain management for several decades. Early models of supply chain or segments thereof, where evaluated analytically. This method is not powerful enough to understand real-world systems (Swaminathan *et al.*,1996). While Teigen (1997), states that in recent years, simulation as a tool for understanding issues of organizational decision-making has gained considerable attention and momentum. He mentioned the use modeling and simulation on the supply chain with different proposes, including studies of the effects of various supply chain strategies on demand amplification and a study of the effect of sharing supplier available-to-promise information.

A model is defined as an abstract representation of a physical system that is used to perform some kind of off-line analysis of the system. Supply chain models may, for instance, be created as part of a supply chain reengineering process, or as tools to help answer strategic, tactical, or operational aspects of the supply chain. However the computer-based information and communication infrastructure of a physical supply chain may also be viewed as a model in which physical quantities, shipments dates, etc., are represented as numbers A supply chain model, on the other hand, may simply be created to answer a specific question (Kjenstad, 1998).

2.7 Simulation Based Supply Chain Management

A simulation method is a method by which a comprehensive supply chain model can be analyzed, considering both strategic and operational elements. However, as with all simulation models, one can only evaluate the effectiveness of a pre-specified policy rather than develop new one. It is the traditional question of " what if"? Versus "what's best?" (Persson, 1997).

To deal with changes and variations a scenario approach is necessary. Also when optimization algorithms are not used, scenarios are a good way to look for the best practices in supply chain operations. The scenarios approach means the user build different kinds of scenarios, corresponding to alternative supply chains, and compare them according to their accumulated costs and lead times. A scenario means a possible state of the future; for example a possible alternative scenario can be a supply chain with fewer warehouses than at present. Change and variation are studied by building several scenarios (Seppala and Holmstrom, 19[illegible]).

2.8 Comments on the Previous Research

This research was intended to improve the supply chain management for SMEs in Jordan by developing a SCM internet based model to suit SMEs then using a simulation to test and validate the model. RJAF was used as a case study to test the model validity. The research cited the literature concerning attempts to investigate performance of supply chain management systems based upon previous experience and historical data of supply chain management. Most of the relevant works were concerned with design and analysis of the information and supply operations internally, between different functions within the enterprise, and externally between the enterprise and its partners.

The research in this thesis has investigated the performance and efficiency of the supply chain management by developing an Internet model. For this purpose, a simulation-based supply chain management model was developed to solve real life problems. Emphases were placed on building an appropriate model to analyze and solve these problems. The simulation was used to evaluate decisions, and support research for better performance and operational policies.

Two-simulation softwares were evaluated to determine which is more suitable for the work at hand. ARENA (version 3.01) software, and PROMODEL (version 4.2) software, after studying and assessing both, it was found that PROMODEL was easier to use, and debug. Accessories were better for our model, and it is equipped with a good optimizing software (SIM RUNNER) and STAT:FIT for statistical analysis. Also it is equipped with a wide variety of graphics, tracing, libraries, and a direct logic test system that can facilitate discovering logic errors. So PROMODEL found to be more suitable for the model.

3. Supply Chain Management Model

3.1 Introduction

As in any management techniques, information processing is a crucial component for an effective supply chain management (SCM). The SMEs should explore the advantages of advanced information technology for a better management of their supply chains. To explore these issues, we have developed a supply chain management model based on the Internet for small and medium size enterprises (SME) in Jordan using RAF supply chain as case study.

The structure of the work for the next two chapters is divided into two phases each consisting of three areas. The majority of the work has been focused on the design and implementation of the model. The first phase describes the construction of the model and includes SCM in Jordan, objectives of the model, and implementation of the model through the Internet. The second phase describes the simulated implementation of the model and includes the input data, model validation and verification, and simulation model output data.

3.2 Supply Chain Management in Jordan

There are many issues that can assist in development of the SMEs in Jordan. Some of them include: the type of business and partnerships that can reduce cost, improved service level, what performance measures must be used to make the partnerships successful, and how the saved cost can be transformed to the end user.
Many of the problems facing supply chains in Jordan, as in other parts of the world, are new. These problems include, but are not limited to, shorter life cycles of products, for example computers and communication devices have only a life cycle of few months. Since

they are new products and there is no historical data available about the customer demand accompanied with fluctuating (most of the time decline) in prices, the enterprises in Jordan dealing with these types of products have to order only one (or a few) at a time to overcome the reduction in product value during life cycle.

3.2.1 Problems of Supply Chains in Jordan

There are many problems with the existing supply chain in Jordan such as:

1. Long lead-time in both materials and orders flow. It takes some kind of goods more than six months (lead time) compared to the actual travel time, which is no more than four to five days using air carriers to bring the good. This results in an increase in wasted time and effort, and reduction in customer service level.
2. Lack of information and information exchange in the suppliers-enterprise-customer series. This includes the data that should be transferred, and how the data should be analyzed.
3. The variation in the number of suppliers w: :ime. Enterprises must continuously seek suppliers with lower price, higher quality, and minimum delivery time.
4. Inventory level with the concern of limited life cycle, and the payment policy, since most of the Jordanian SMEs still using the traditional method of payment.

3.3 Objectives of the Model

Most of the enterprises in Jordan do not adopt the concept of supply chain management in order to reduce the lead time and hence increase the service level, applying this concept will also result in reducing the associated costs of goods, products, and services. The model provides a framework for the Jordanian enterprise SCM for evaluating and improving the supply chain performance and management, and assists companies in increasing the effectiveness of their SC.

3.4 Model Construction

3.4.1 Definition

The supply chain management (SCM) model is a framework developed for small and medium size enterprises in Jordan for evaluating and improving the entire supply chain performance and management by using the potential and cropping the benefits of the Internet.

3.4.2 Model Elements

Construction of the model includes three main components. First the physical locations. These are the enterprise, suppliers, bank, freight forwarder, distribution centers, retailers, and customers or end users. Second, activities between these locations, which include order process, information process, material flow, distribution process, transportation process, and the financial process. Third, Internet components.

All of these components and their interaction are shown in Figure {3.1}.

3.4.2.1 Locations

1. **Suppliers**: the enterprises, firms, or companies that supply row materi. , goods, finished products, services to the Jordanian enterprise, and they are divided into two main geographic groups:
   - Local suppliers: suppliers that are located in Jordan.
   - External suppliers: suppliers that are located outside Jordan such as suppliers from: USA, France, etc.

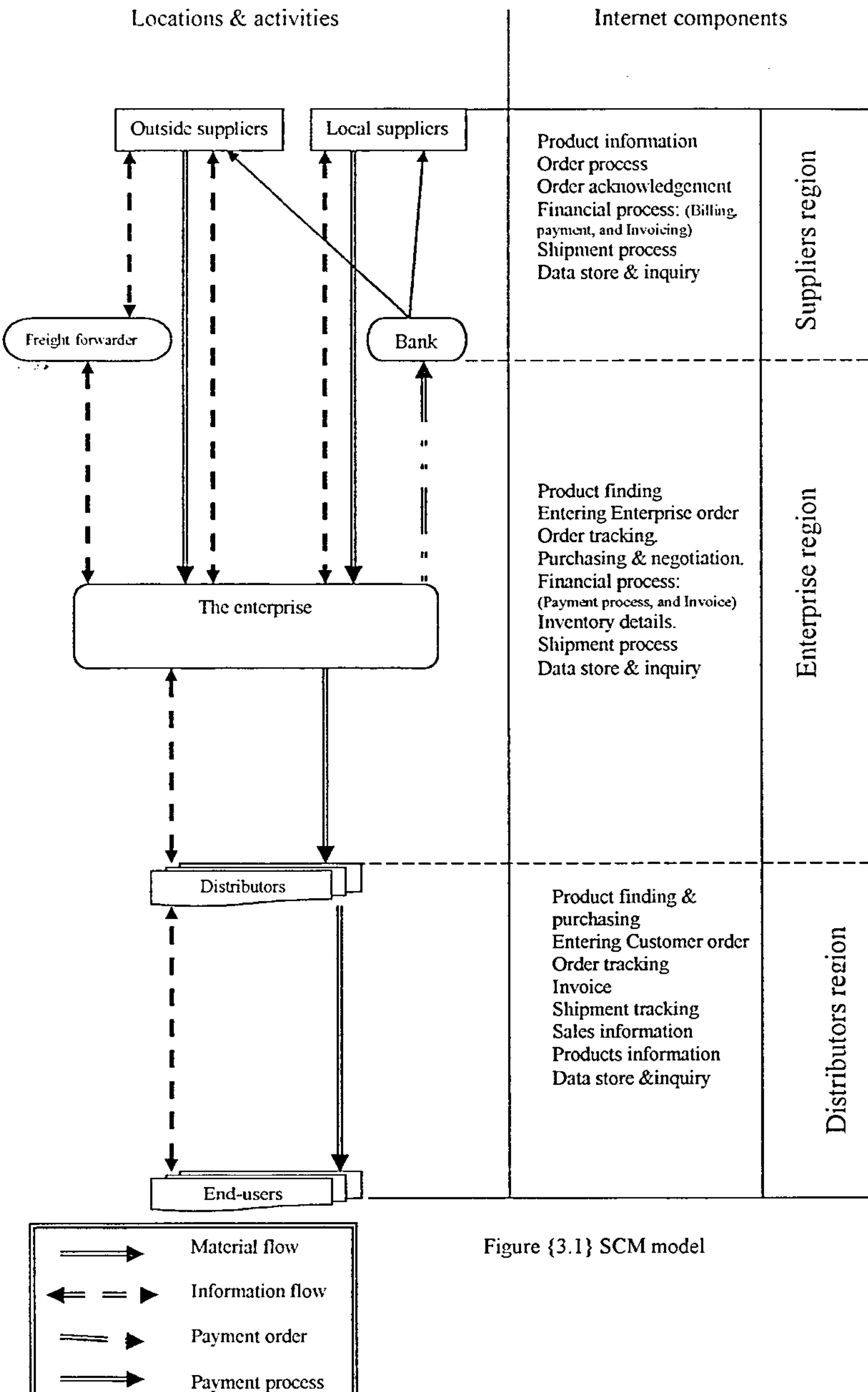

Figure {3.1} SCM model

2. **The enterprise**: Small and medium size enterprises in Jordan offer services or/and manufactured goods. They may consist of management, financial, purchasing, material management, warehouses, sales and stores, and employee sectors.
3. **Distribution centers**: the main warehouses that receive products from the enterprise and distribute them to the retailers.
4. **Retailers**: they receive products from the closest distribution center. They have direct contact with the customer and end users.
5. **End user**: here the term "end user" represents the customers. They receive products and services from retailers where orders are dependent on customer demand.
6. **Bank**: payment process between the enterprise and its supplier will be accomplished through the bank.
7. **Freight forwarder**: when importing products from outside suppliers the shipping process needs to be accomplished by freight forwarder specially when air fright and containers are used for shipping.

3.4.2.2 Activities

1. **Distribution process**: consists of two stages of distributions: first between the enterprise and its distribution and retailers. Second, between the distributors and customers.
2. **Transportation**: Table {3.1} shows the transportation methods used over the entire supply chain in Jordanian enterprises.

Table {3.1} Transportation modes used by SMEs in Jordan

Location	Highway	Rail	Water	Air	Pipeline
External supplier to enterprise	Yes	No	Yes	Yes	No
Local supplier and enterprise	Yes	No	No	No	No
Enterprise to distribution centers	Yes	No	No	No	No
Distribution centers to retailers	Yes	No	No	No	No
Retailers to end users	Yes	No	No	No	No

3. **Order process**: The retailers' transfer the customer demand into orders, which are sent to the distribution centers. The same process is repeated at the enterprise and the local and external suppliers.
4. **Material flow**: The flow of materials begins with the purchase of materials (e.g. spare parts, products, machines, ...etc.), or services (maintenance, software's, ...etc.) from outside or local suppliers after which these products are send to the end users using the distribution and transportation process.
5. **Financial process**: This includes payment process using online payment methods such as on line credit card, and /or electronic checks.
6. **The flow of Information**: Includes all essential information flow to achieve an effective supply chain performance. Also it includes information about, products, prices, orders, shipping, and demands.

3.4.2.3 Internet Components

The Internet components in the model represent the interoperability between locations, the communication, and cooperation components.

For the Jordanian SMEs, the supply chain management structure through the Internet should seek to minimize the non-value-added activities and their associated structures. The Internet components as shown in Figure {3.1} are divided into three major areas:

- Suppliers region, in this area many processes will accomplished using the internet; these processes include, product information, order process, order acknowledgement, financial process which include billing, payment and invoicing, shipping process, the store of the data, and inquiry.

- Enterprise region, in which product finding, entering the enterprise order, order tracking, financial process, which include payment process and invoicing, inventory details, shipment process, data store, and inquiry are the processes to be implemented using the Internet in this area.

- Distribution region, which will include the necessary information to be implemented through the Internet such as: product finding, purchasing, entering the customer order, order tracking, invoice, shipment tracking, sales information, data store, and inquiry.

The availability of the above information on the Internet will increase customer satisfaction, increase flexibility of the supply chain, and greatly decrease the process time, which will drive the cost down.

3.5 Implementation of the Model through the Internet

Following in this section, firstly, a discussion of the SCM model through the Internet, Secondly; the building of the system architecture, and finally implementing the model.

3.5.1 SCM Model Through the Internet

In the model, the supp!, chain locations that constitute the supply chain were linked via a computer network to act in a close and a more coordinated manner. The locations in this network remain separate, but join their information and resources to provide a better management of information exchange, and to support exchange of data between the enterprise and other locations.

Every location must consist of two main components: firstly, the internal network which includes both the company particular management system, and its internal processes and activities. Secondly, the wide networks (Internet, Extranet, and Intranet) which consist of all interoperation between the enterprise and the other locations.

The associated costs when implementing the model through the Internet include system building and data entry, software cost, operation cost, training cost, and operator's cost. Payment and financial processes are achieved using online payment methods such as credit cards. Performing banking transactions and reporting financial information is done also through the Internet.

Security aspects need to be addressed to prevent unauthorized access from outside or within organization, while allowing the access for those who are responsible for the development and maintenance.

3.5.2 The Internet Using Needs

To implement the model by a Jordanian enterprise, a need to connect to the Internet is obvious to be able to transmit and receive information. Other needs include: first, identifying the data, which must be available to individual locations. These data must be put together to allow all members to view information simultaneously. Second, design of the web page: which should satisfy the information representation requirements at various locations. Third, stored data: all data kept in computers at va· .s chain locations. Fourth, information system management: which is required to manage the retrieval, and storage of data. Fifth, personnel: trained employees needed to run the system. Sixth, procedures: instructions describing how to use and operate the system. Seventh, reviewing the data: information should be updated as required.

3.5.3 System Architecture

The system architecture defines the basic system components and the relationships between them. It depends on the nature of the business and the requirements that must be achieved. Figure {3.2} shows the Internet SCM model basic architecture. The five major components that make up the system's architecture are:

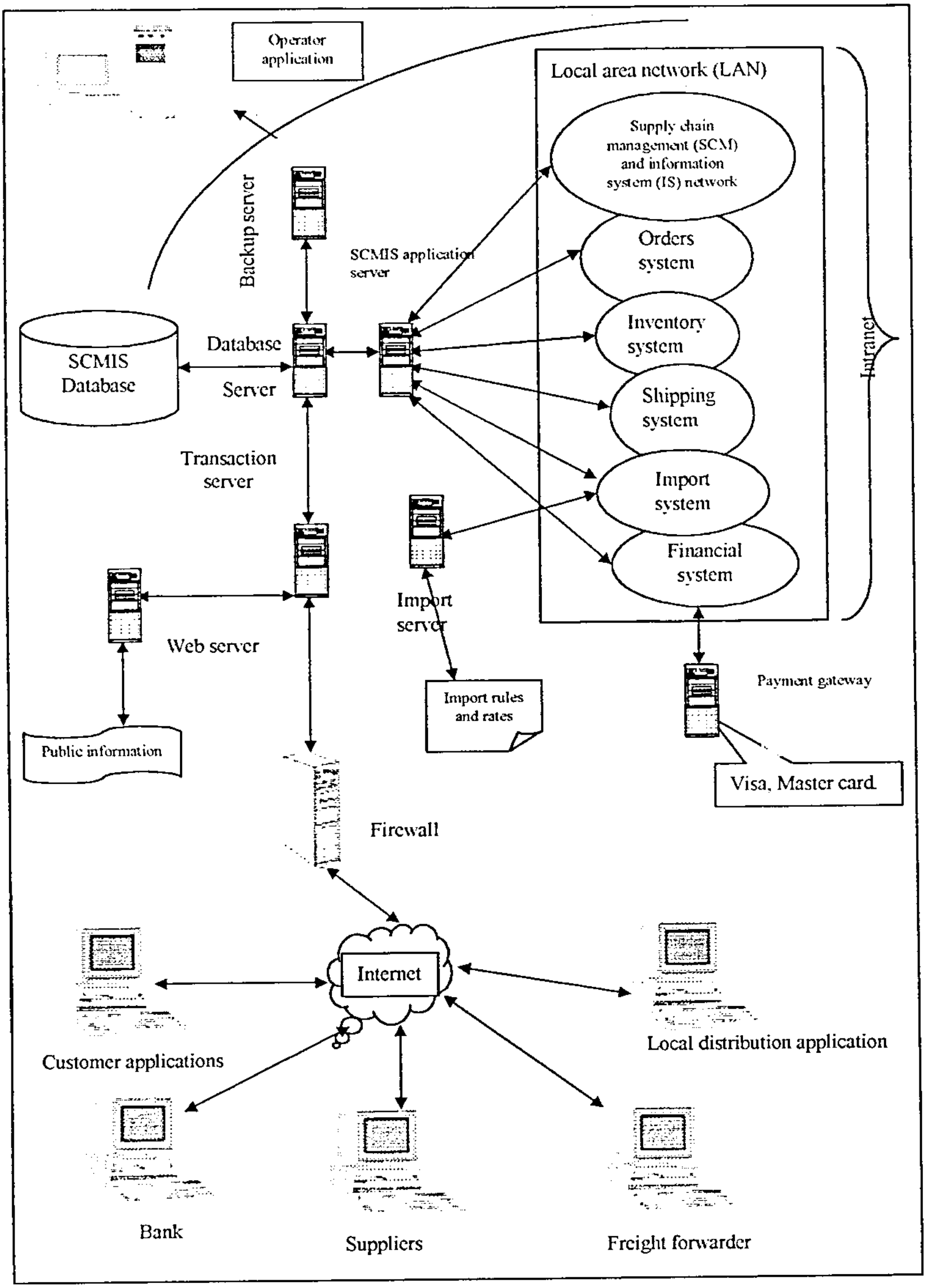

Figure {3.2} System Architecture

- End user components.
- Local distribution components.
- Enterprise components and servers.
- Suppliers components.
- Bank and freight components.

3.5.3.1 Customer (End User) Components

Customers will be able to log on to the system, browse the available products, populate an order form, and submit that order .The order form will provide the customer with the means of editing information, such as shipping address, billing address, and payment method. The system will make it easy for customers to register and track their orders.

3.5.3.2 Local Distribution Components

This category is made separate from the ordinary customers since they will give more authority. They are provided with additional functionalities; therefore, they need special client applications and a distinguished user interface that meets their needs.

3.5.3.3 SME Components and Servers

SME provides the core functionalities of the SCMIS by running and maintaining the following components:

1. Database server: this server will enable the users to access the SCMIS database.
2. Inventory control system: this part is responsible for managing the inventory levels across all the stores and warehouses. The enterprise should decide what items should be placed, and how much should be ordered.

3. Shipping system: The freight forwarder has access to the transaction statements and can mark orders as fulfilled and send the appropriate notification to the enterprise.
4. Financial system and payment gateway: this group will take care of all the payment instruments in the system. For example the enterprise will connect the credit card agencies through the payment gateway in order to authorize the transaction and later to settle the payment.
5. Supply chain management information system SCMIS network and SCMIS application server: this part is responsible for managing the supply chain across all locations. The mangers at the enterprise decides what items should be ordered, stocked, when an order from the supplier should be placed, how much should be ordered, shipment method, and the payment process. SCMIS application server will run the supply chain applications for orders, financial, shipping, inventory, import, and information interchange.
6. Import server and import system: import server to perform import calculations according to the Jordanian trade rules. The import system consists of the import rules, regulation and rates according to the government instructions and laws.
7. Web server and public information: this part is responsible for managing, maintaining, administration, and monitoring the public information and all information available for the users outside enterprise (outside the local area network).
8. Firewall: to protect the resources of private network (LAN) from users from other networks. It is used to screen requests to make sure they come from acceptable (previously defined) user and IP address.

* **Suppliers components**: the connection to the suppliers is performed through the supplier' gateway server. There is a special client/server (C/S) application between the suppliers and the enterprise to interchange special data.

3.5.4 Interfaces

The SCMIS is broken down into these various interfaces in order to ensure that it provides the functionalities that satisfies the requirements of the model:

1. End users interface: used by customers to place and track orders over the Internet.
2. Enterprise interface: used by the enterprise to place and track orders for their warehouses.
3. Suppliers interface: used by the suppliers to track order and track shipping, and billing with the enterprise.
4. Inventory management interface: this will allow the SME to control the inventory levels across all the warehouses.
5. Payment interface: this interface will help to authorize the transaction and to settle the payment.
6. Other interfaces: these include freight forwarder, operator interface and customer service interface.

As mentioned previously the transactional activities include: finding the produc , negotiating, placing order, payment for purchasing, and tracking orders, material shipping, and inventory control.

3.5.5 General Requirements

The requirements for the implementation of the model through the Internet as illustrated in Figure {3.2} will greatly depend on the type of the company work, size, budget, type of products, and the needs of the company, so general requirements will be discussed. The hardware and software requirements are briefly discussed here in general.

1. Hardware: personal computers in all locations of the supply chain members, modems, and the devices needed to connect the PC through the telephone network (telephone lines and cables), and Internet service provider ISP, which provide

access to the Internet. The number of personal computers PCs or terminals will be determined by the number of locations served, size of the duty, and the number of employees.

2. Specifications: preferably the most recent personal computers models since they may serve longer, with higher speed, and with higher capacity.
3. Software: which consists of the instructions that control hardware operation (OS). It also includes special programs for browsing the system and Network operating system: such as Windows NT.
4. Security system: this will include a security system to guarantee privacy and make the information access available only for authorized personnel.

4. Simulation of the Supply Chain Management Model

4.1 Introduction

Supply chain models are used to simulate and study the effect of information sharing, variety in demand, and variety in order process. Simulation does not give the optimum solution but it allows the testing of various parameters and suggested solutions. It also gives important indications on how to improve operation performance. Also simulation uses animation to illustrate various relationships in the model.

In this chapter, simulation is used to model an existing supply chain used in the Royal Air Force (RAF), and therefore suggest modifications. Many benefits (as shown in appendix A) can be gained using simulation as a tool to model the supply chain, as a step in improving the supply chain management system.

A simulation software package called PROMODEL is used to simulate the operation of the RAF supply system in order to evaluate the appropriateness and improving its operational performance, and provide a basis for suggesting improved modes of operation.

4.2 Royal Air Force Supply Chain

As any other Air forces in the world, and to accomplish its' tasks the Royal Jordanian Air force (RAF) requires it's fleet of aircraft and inventory to be in a high state of readiness. This can only be accomplished through a system based on continuously performing all types of maintenance and inspections weather scheduled or otherwise. This system must be responsive and capable of meeting the various demands of the maintenance teams, working around the clock, in the fastest possible way. The system needs to support not only, the aircraft, but also a wide range of ground support equipment, weapons and other mechanical, electrical and electronic systems, not to mention the logistic support for the personnel working which include clothing, stationary, automotive spare parts ...etc.

Like most developing countries Jordan buys it's armament from developed nations, aircraft included. Thus the supply chain required to support such equipment must branch out and deal with external as well as local suppliers. Two of the products that are used daily in preventive and scheduled maintenance are hydraulic and engine oils. Hydraulic oil, product B, is imported from an external supplier based in the USA. It is used in the hydraulic systems of the aircraft, which are the backbone of the flying machine. Engine oil (product A) is used in the vehicles and support equipment engines as a lubricant and it is purchased from local suppliers.

RAF supply chain consists of the company itself (the location in concern) and its' internal supply chain ranging from distributors to end users, who are part of the internal supply chain of the air force. The directorate responsible of running and managing the supply chain is the directorate of Supply. The other elements of the supply chain are the local and external suppliers who supply the products, the banks through which financial processes are performed, and the freight forwarder responsible for accomplishing the shipping process from the external suppliers.

Directorate of supply at RAF is considered as an SME because it complies with the characteristics of the SMEs described by Gilmore *et al* (2001) like limited resources and lack of specialists. The number of employees is less than 500 hence complying with the definition given by Hally and Guilhon (1997).

4.3 System Layout

The supply chain studied in this thesis is a service SC for two types of imported products from two different suppliers. It is then distributed to three bases' warehouses each in turn distributing to three units. Finally the units deal with the end users demand. This system is part of RAF main stores supply chain. Figure {4.1} shows supply chain management model for RAF main stores. Main stores are the location where, all products and orders will pass through, have the following responsibilities:

- Order policy
- Inventory policy
- Financial process (payment billing).
- Shipment policy.
- Distribution policy.

The following transportation modes were used in the simulation model: Ship (container), Truck, Pickup1, Pickup2, and Pickup3. Financial processes between the main stores and the suppliers were done through the bank location. The freight forwarder accomplishes shipping process from the external supplier. Entities used in the simulation model include cans of engine oil, cans of hydraulic oil, orders, checks, and the information signal. Figure {4.2} shows the system lay out as shown in the simulation model.

4.4 Performance Measures

In a simulation, it is essential to define the performance measures for the model under study against which, the performance of the actual system can be assessed. In our model, the performance measures used to evaluate the system are statistical. Five measurements are made to evaluate the system's performance (see Figure {4.3}), these are:

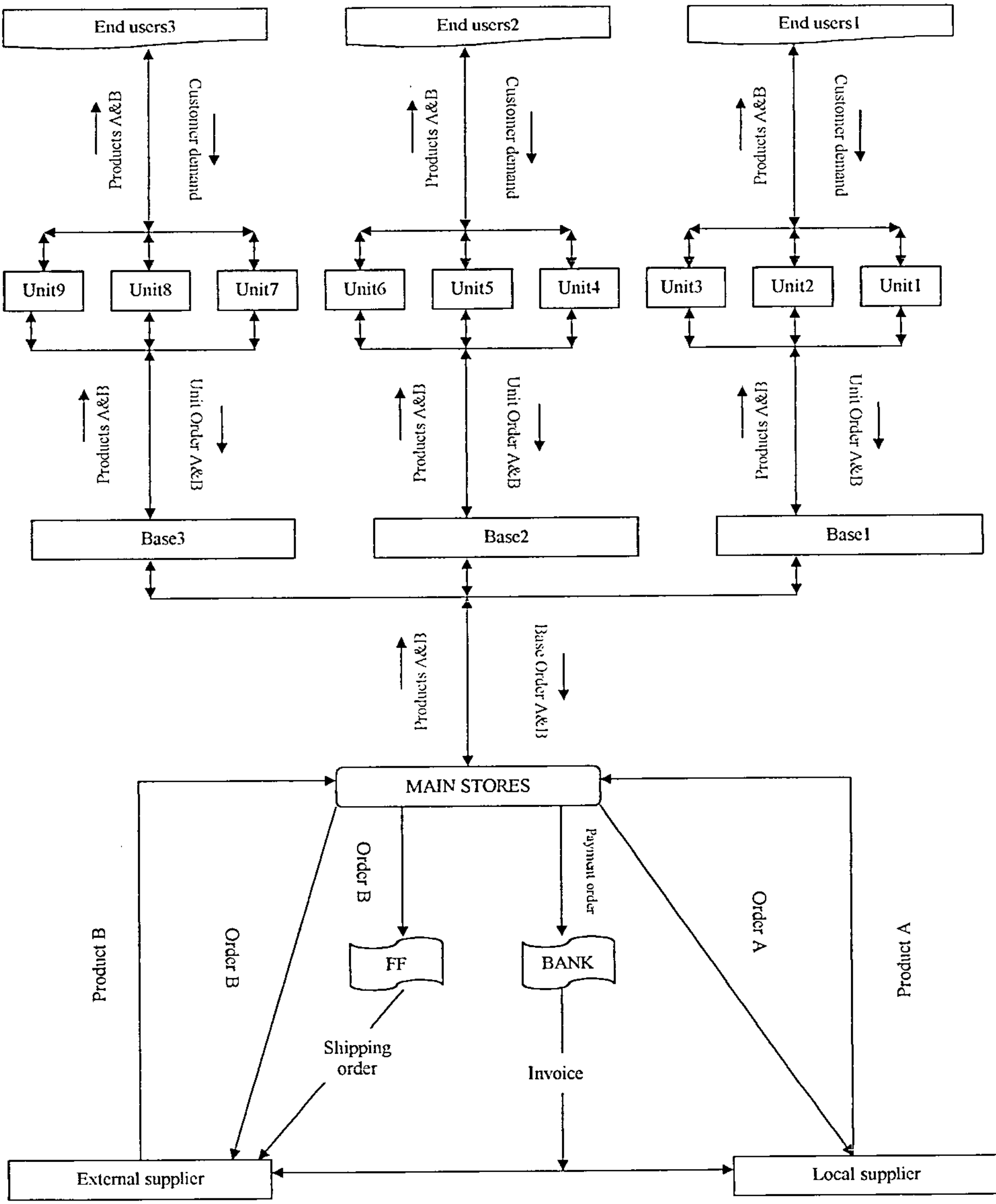

Figure {4.1} SCM model for RAF main stores

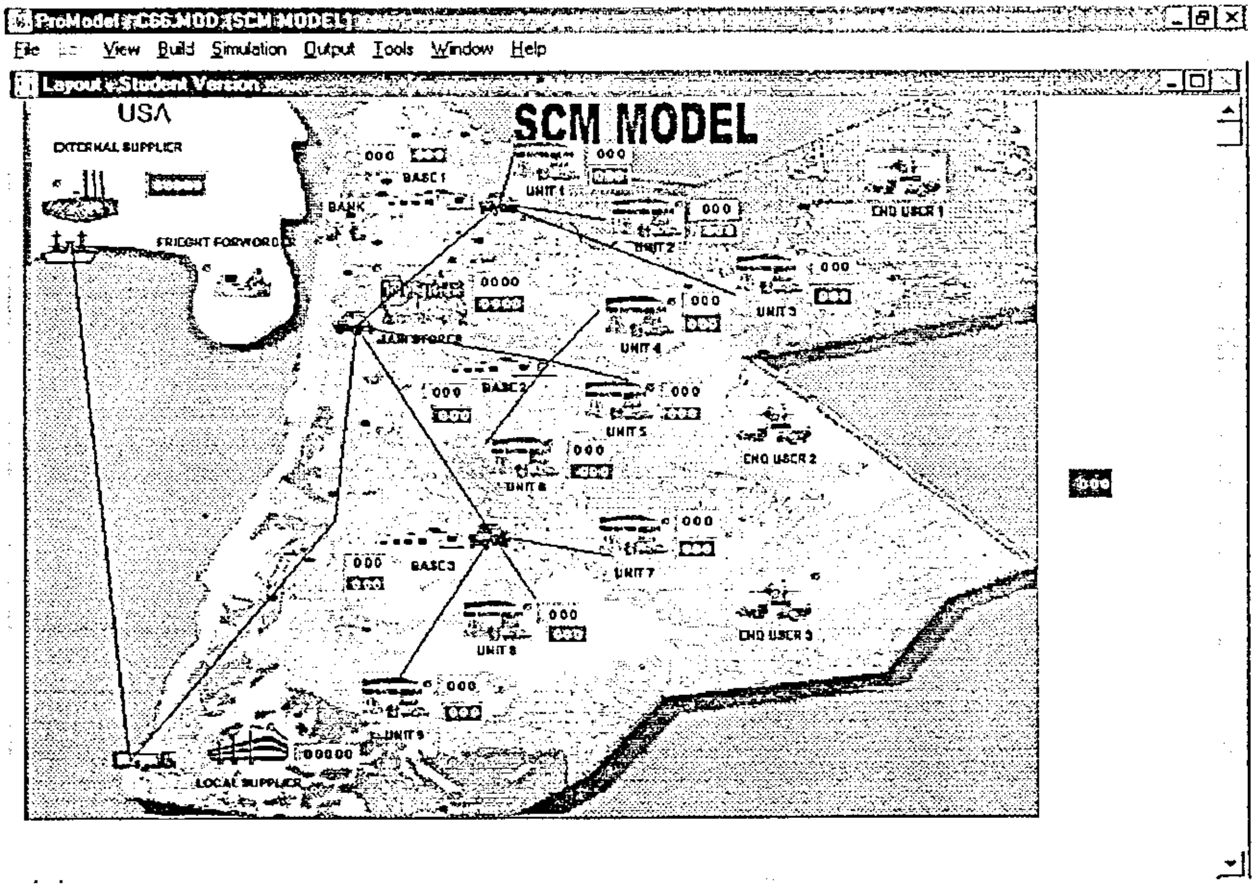

Figure {4.2} System layout

1. Average cost of each entity, location, and resource. The objective is to reduce the associated cost for each location and entity, which include: the inventory cost, order cost, operation cost, and resource cost.
2. Average total cost: total cost of the supply chain is the sum of the costs of all entities, locations, and resources.
3. Average inventory level at the main stores, base stores, and unit stores.
4. Average delay time: including the average lead-time between each location, average order process time, and average financial process time.
5. Customer service level, which is one of the ultimate aims of any supply chain, measure the ability to fulfill orders

(fill rate) within due date or to deliver products when they are expected (on time).

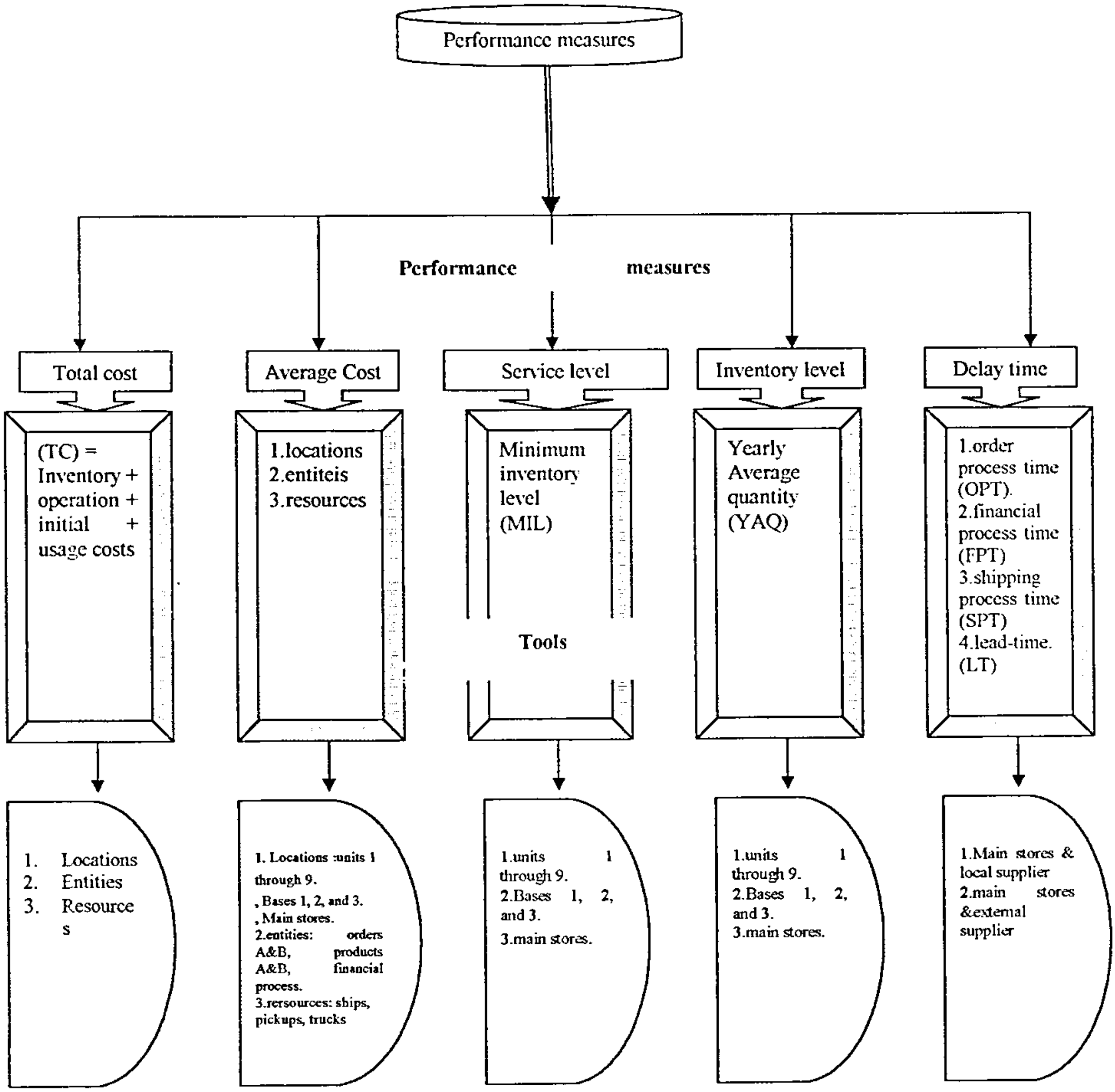

Figure {4.3} Performance measures used in the simulation

4.5 Input Data

4.5.1 Data Analysis

Inputs to the SCM model consist of the entities, resources, locations, distances between locations, speed of the resources, operation and location cost, and cost of the products. Following is a discussion and analysis of the input data.

Resources include the trucks, pickups, and ships. The cost for using each truck and pickup is defined as the regular cost per day, which is relatively small. For the ship, the cost per container is calculated, because the cost depends on several variables such as weight, size of the products, this is called the size weighting method and is calculated as shown in appendix A.

At RAF locations (bases), the operation cost per day is calculated depending on many factors. These include the average daily number of items the store deals with, the cost of the equipment used during [illegible]k, the cost and number of personnel employed to handle and store the products, and cost of the space occupied by the two products. All base stores are considered identical, and all unit stores are considered identical .The results are shown in appendix A.

Order process cost for product A (from local supplier), and for product B (from the external suppliers) and financial process cost are taken from directorate of supply and are as shown in appendix A. The process costs include office expenses (such as paper work, letters, faxes, telephones, etc...), and the cost of personnel handling orders, billing payments and transfer of money .It is obvious that these costs can rise significantly due to repeated mistakes or due to the wrong procedure being followed.

Products cost as they are documented at the directorate of supply at RAF for year 2000 are shown in appendix A.

4.5.2 Data Collection

The collected historical data on customer demand for both product A and B for each unit is taken from the air force quarter reports at the directorate of supply. The data where collected for fourteen quarters from the first quarter in 1996 until the fourth quarter of 2000. The historical data prior to 1996 were not used because they were not properly documented and are not complete. The average daily demand for each quarter was then calculated. {Data detailed are shown in appendix B}.

The maintenance personnel work twenty-four hours a day, all year round. Their demand is dependent on the equipment, vehicles, and airplanes need for preventive, scheduled and corrective maintenance.
As the need for products (A and B) arises, the personnel or maintenance groups send orders t‹ ıeir maintenance section stores (unit stores) which usually very close.

4.5.3 Fitting Probability Distribution

A collection of arbitrary time-oriented occurrences, order quantity arrivals are performed where the number of arrivals during any day (24-hrs interval) is independent with a random nature. The collected data for both products (A and B) were used to find the best probable distribution, which describes the random nature of the daily demand for both products. A Summary of the data is shown in appendix B. For each data summary, Statistical values such as mean, variance, minimum, maximum, and others were calculated. The results are shown in graphical form as a histogram. For <u>Example:</u> Demand for product A at unit 1 stores is taken for twenty quarters. The demand is shown in Table {4.1}.

Table {4.1} Product A demand at unit 1 stores

Year	1996				1997				1998	
Quarter	1	2	3	4	1	2	3	4	1	2
Demand	8	10	9	14	11	16	14	8	15	13
Year	1998		1999				2000			
Quarter	3	4	1	2	3	4	1	2	3	4
Demand	17	17	18	16	12	13	15	14	16	15

The data is then entered to the PROMODEL STAT FIT program, and a histogram is developed as shown in Figure {4.4}. The best distributions were found to be Poisson, binomial, desecrate uniform, or geometric distribution. The output results using PROMODEL STAT FIT are shown in appendix A.

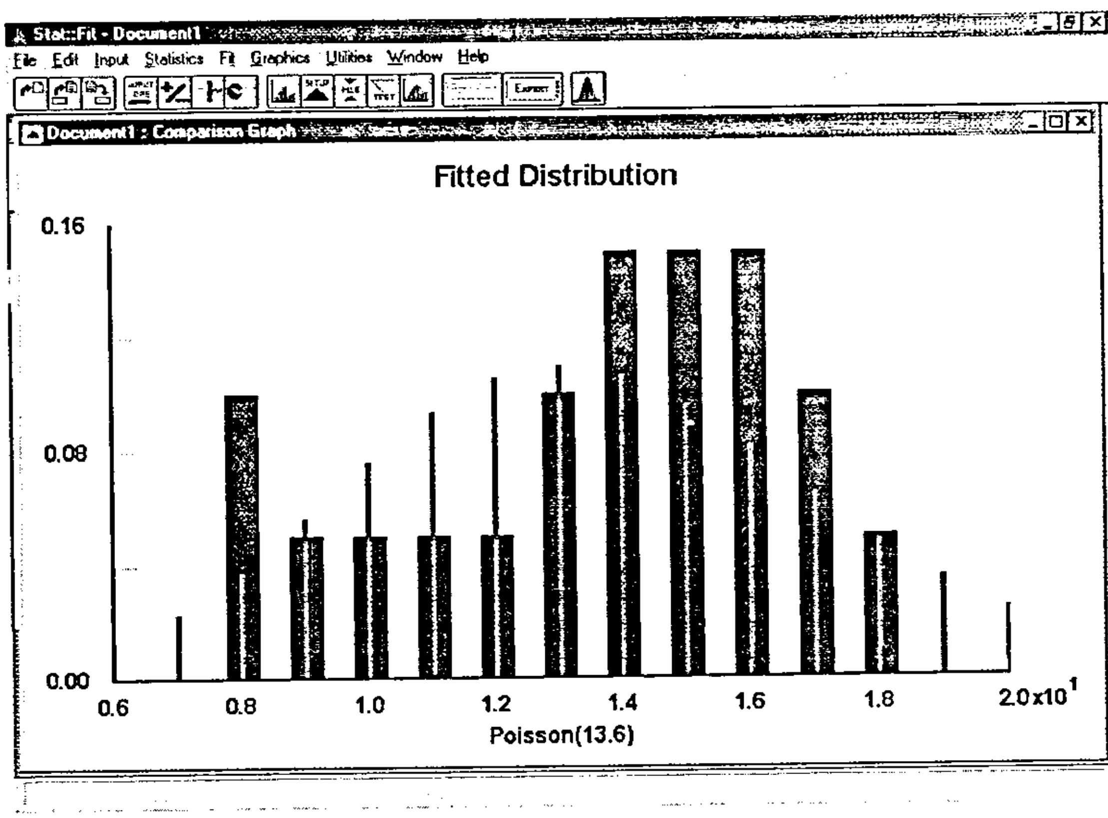

Figure {4.4} The fitted distribution for order arrivals

Similar analysis was carried out for the other set of data at each location. The distribution and parameters for all data are shown in appendix A.

Order arrivals are performed where the number of arrivals during any day (24 hrs) is independent with random nature. The number of order arrivals occurring in any day is independent of the number that occur in any other day. The probability that more than one order will arrive in a short time is negligible. According to these assumptions and the results drawn from STATFIT software, it is clear that Poisson model is appropriate.

4.6 Development of the Simulation Model

The simulation is presented in this section in terms of its assumptions, structure, and initial conditions.

4.6.1 Model Assumptions

Before describing the model, it is important to state the assumption used in the model. The assumptions are as follows:

1. The distance used in the model is measured in meters.
2. The speed is measured in meters per hour for the purpose of this model.
3. The time measurements are made in hours. The system run 24 hours day, 365.25 days (8766 hrs) a year.
4. The orders entering the system are attributed with the quantity of either product A or product B but not both of them. Each order is marked with a different color.
5. The randomness occurs in the system include the arrival of orders quantity and the processing time at each location in the supply chain.
6. Products are assumed to be always available at the suppliers, no shortage of supply from both suppliers is assumed.
7. Resources are assumed to be always available, no stoppage due to lack of resources, or any delay due to unexpected or

unplanned circumstances, and the speed assumed to be constant. The actual number of resources allocated for transporting both products is put (constant). The ships (containers) are available all the time and the freight forwarder is responsible for their availability. The location of each store/base/unit on map (see Figure 4.2) in the model is approximate but the actual distances were used between all locations.

8. The speed of transportation means used (resources) is assumed constant. Two values for speed were used, one when the vehicles assumed unloaded, and one for loaded vehicle case. Appendix A shows the speed of the resources, both speeds are driven from the actual resource speed.

9. Pickup 1 at the main stores is used to carry products from base stores 2 to units 4,5, and 6. This actually what happens in reality as base 2 is located in area covered by main stores and is situated very close to it.

10. Safety stock at each location is limited to meeting the demand of two working days. The daily demand is considered to be the maximum value of daily demand recorded at each location. This limitation is set in accordance with RAF safety instructions.

11. If the lead-time is less than one day (24 hrs), the order quantity is assumed to be a one-day consumption, which equals the maximum daily demand. (From directorate of supply instructions).

12. The initial values are assumed to be half of the order quantity and safety stock. This assumption will not affect the simulation model since the initial value does not affect the process in the simulation.

13. The minimum order quantity from external supplier is 5000 liters of hydraulic oil (product B). This value is set

by the directorate of supply to be consistence with the container capacity with lowest cost.

14. The order quantity from local supplier is not less than one month of consumption. This value is set by the instructions of directorate of supply.

15. According to the instructions of directorate of supply, each unit and base cannot order more than the consumption quantity for 14 days. And since the economic order quantity (EOQ) is higher than this value, the order quantity is assumed to be the 14 days consumption.

According to points 10,11,12, 13, 14, and 15 Table {4.2} shows, the initial quantity, safety stock, demand during lead-time, and the reorder Point.

Table {4.2} Continues review (Q) System data

Location	dd.		SS		dL		ROP		Q		Initial value	
Product	A	B	A	B	A	B	A	B	A	B	A	B
Unit1	18	17	36	34	18	17	54	51	252	238	144	136
Unit2	10	7	20	14	10	7	30	21	140	98	80	56
Unit3	15	14	30	28	15	14	45	42	210	196	120	112
Unit4	15	10	30	20	15	10	45	30	210	140	120	80
Unit5	15	15	30	30	15	15	45	45	210	210	120	120
Unit6	16	10	32	20	16	10	48	30	224	140	128	80
Unit7	11	7	22	14	11	7	33	21	154	98	88	56
Unit8	6	7	12	14	6	7	18	21	84	98	48	56
Unit9	6	6	12	12	6	6	18	18	84	84	48	48
Base1	43	38	86	76	43	38	252	238	602	532	344	304
Base2	46	35	92	70	46	35	224	210	644	490	368	280
Base3	23	20	46	40	23	20	154	98	322	280	184	160
Main stores	112	93	224	186	896	3906	1120	4092	3360	5000	1792	2593

4.6.2 Model Structure

The simulation software package used to build the system is PROMODEL. PROMODEL differs from other simulation software in that it is easier to use, and the commands and logic of the program can be written directly using the built-in commands of the software. One can write a program if needed to perform a special process work. Also it uses animation instead of writing programming codes to perform the requested job. The model consists of twenty locations, three types of resources, and two products.

The system starts at zero hour at the beginning of the year, after that the orders from end users 1, 2, and 3, which represent the customer demand, start to enter the system. Units stores meet the demand of end users and supply their need for either product A or B. If the quantity available at the unit stores is below ROP, an order is initiated and send to the base stores, and at the same time the product is dispensed to the end users. When order reaches the base stores, they send the product requested to the unit. Again if quantity of that product is below the ROP, an order is sent to the main stores. The same procedure is followed at the main stores. If, at the main store and after meeting the demand of the unit, the remaining quantity is below the ROP, then the main stores will initiate and send an order to the local supplier. The local supplier will start processing the order and send an order acknowledgment to the main stores. After main stores receive the information about the order, they will authorize payment order through the bank. The bank, after receiving authorization will transfer money to the local supplier's account. Once the local supplier receives notice of payment being made to his account, the order quantity is send to the main stores. Up· arrival at the main store, the product quantity will be added to the main stores inventory level.

When an order reaches the main stores requesting for product B, the main stores will dispense the quantity required. If the inventory level drops below the ROP, the main store will initiate and send an order to the external supplier for a quantity equivalent to that required reaching the Q value. When the external supplier receives the order, order processing will start and an order acknowledgment will be sent to the main stores. Once the acknowledgment is received, main stores will authorize the bank to make payment to the supplier (product cost) and to the freight forwarder (shipping cost). The freight forwarder will send the shipping order to the external supplier and the shipping process will be accomplished by sending product B to the main stores.
Products A and B are exit the system at the end users where the orders are met and products dispensed.

Figure {4.5} shows the general system flow chart.

Six screens are used to build the simulation model. These are:

- Main screen
- General information
- Location
- Path networks
- Resources
- Entities
- Processing
- Cost
- Back ground graphics
- More elements:
    - Attributes
    - Variables

Following is a brief discussion of each screen

4.6.2.1 Main Screen and General Information

The main screen is used to open the model Run, Simrunner, and Statfit. It was used to build the new model. The characteristics of the main screen (short cut panel) are shown in appendix A.

The general information screen is the screen through which the units for time and distance are selected. Hours and meters were used to measure time and distance respectively. This screen is also used to set a title for the model. Graphic library, and model notes are also controlled from this screen.

4.6.2.2 Locations and Background

As discussed previously in section 4.3; Figure {4.2} shows the screen of the entire system layout. This consists of three end users representing maintenance personnel. Every end user is served by one of

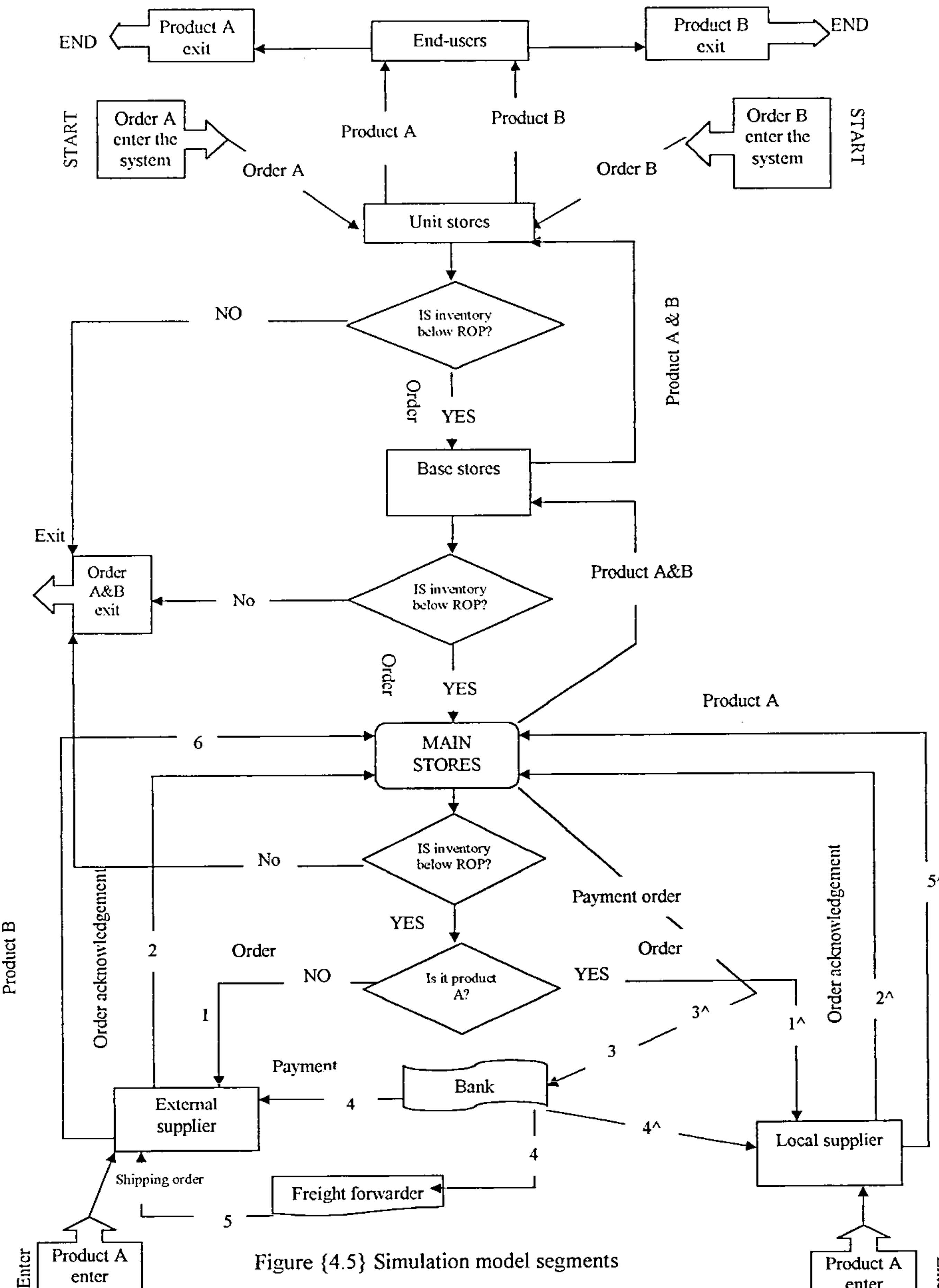

Figure {4.5} Simulation model segments

the three units responsible for it's logistic support. Each unit has its daily demand for products, on a daily base each enter the system to order its consumption of both products. The nine units serving the end-users are represented by their actual location in the system. Every three units are served by one of the three bases (base 1 serves units 1, 2, and 3 and so on). The three bases are served by the main stores. The locations are shown in Appendix A, which also includes the local supplier, external supplier, bank, and freight forwarder.

The background used is the Jordan map, and a yellow colored region was used to represents the external supplier

4.6.2.3 Path Networks

The path network screen consists of two passing networks (passing: allowing the resources to move in the two directions and pass each other's), 14 paths were defined between locations, and the distances between locations were fed to the system. Interface between nodes and each location are defined as shown in appendix A.

4.6.2.4 Arrivals

This screen shows the arrival of orders for both products to each end user. It also shows the frequency of occurrence, and the logic of arrivals.

4.6.2.5 Processing

This screen enables the control of two main functions. Firstly, through the process screen, the process at a given location for a specified entity can be defined. Operation pop up screen represents the logic used at that location for the specified entity. Secondly, through the routing screen, the output from the process side can be determined, the destination to which this output is destined, and the rule of routing is set. The moving logic for the entity between locations is also defined through the routing screen as shown in Figure {4.6}

4.6.2.6 Resources and Entities

Resource screen was used to define the resources used, their numbers, and the path network to be used by each resource.

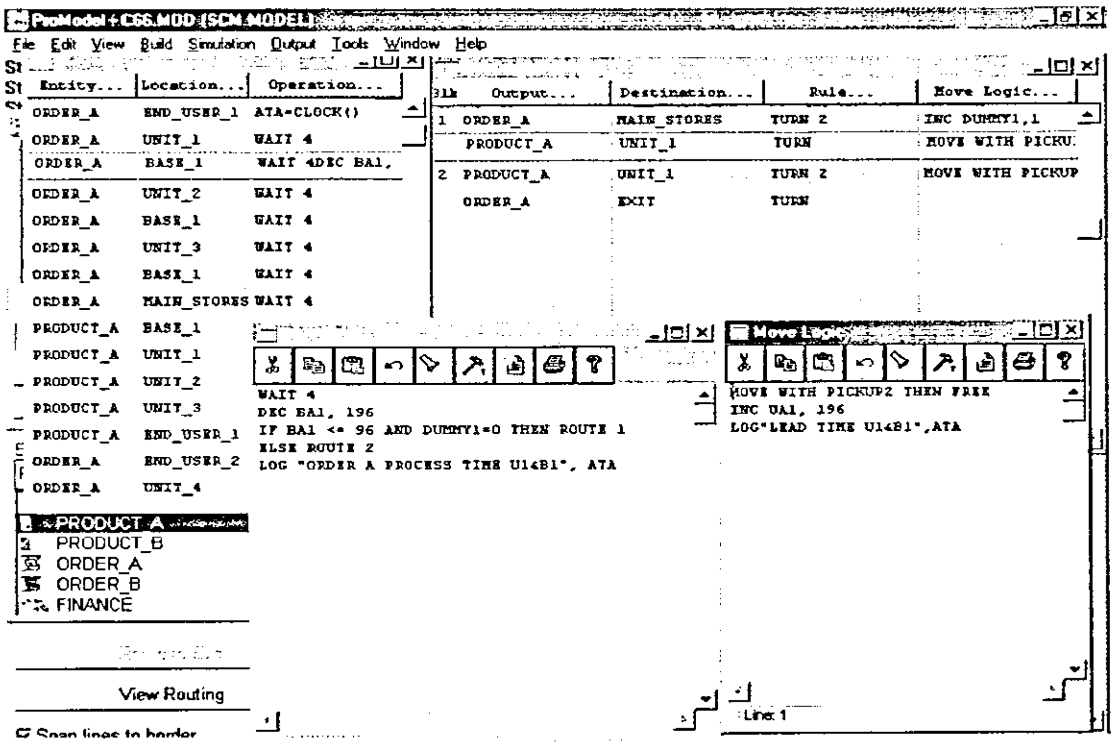

Figure {4.6} Processing screen

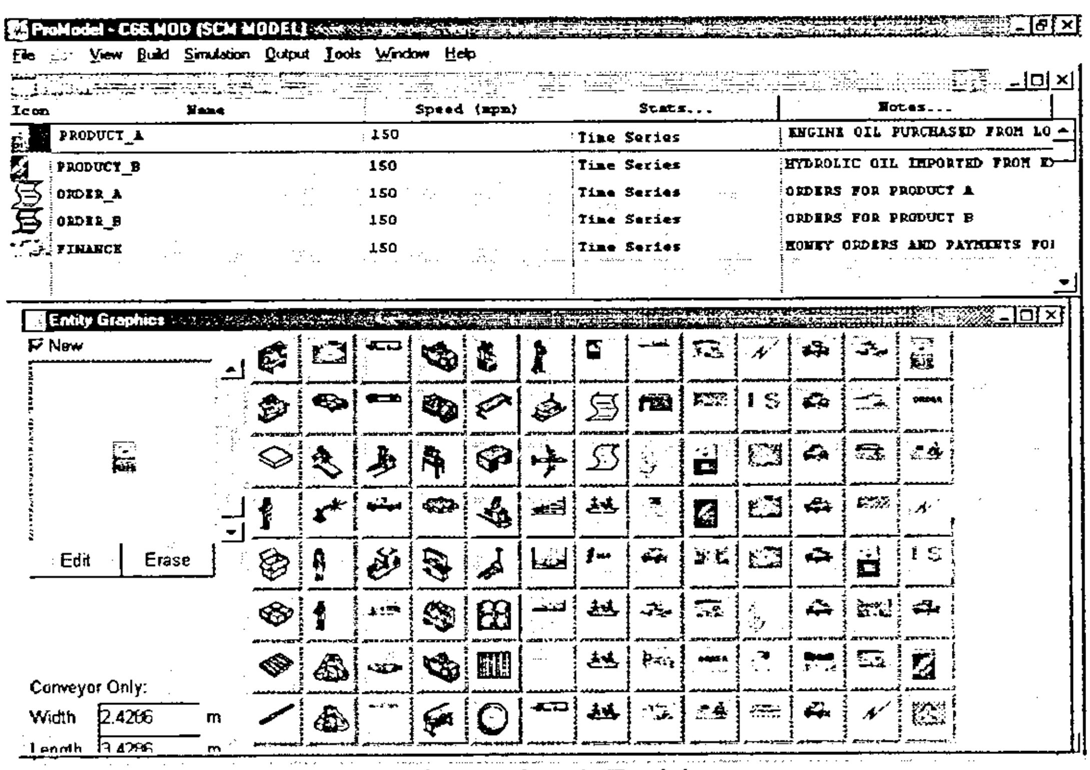

Figure {4.7} Entities screen

Entity screen was used to define and describe each entity used in the system; the speed used in this screen (150 mpm) is the default set by the PROMODEL software. The speed of the entity movement between locations is determined by the speed of the mean of transportation used. The entities and the graphics used are shown in Figure {4.7}.

4.6.2.7 More Elements

This screen contains three main input screens. The attribute screen as shown in appendix A. Several attributes were used to accomplish the model logic. For example, ATF refers to the attribute used for time elapsed during the financial process. Each attribute is described briefly to clarify its work in the program logic.

In the Variable screen, the variety of variables used can be seen. They are divided into two main categories: the first category includes the inventory counters, For example, BA1 represents the inventory level of product A at the base stores1. The second category includes dummy variables. These were used to ensure certain processes are accomplished as requ: .1. For example DUMMY_B is used to ensure that no other orders are send to the external supplier requiring product B while there is an order under process.

Macros were used to accomplish what if Questions?, For example RTI represents run –time interface. Details of these screens are shown in appendix A.

4.6.2.8 Costs

The entry cost for each location, resource and entity which is the initial or usage cost plus operation cost are shown in appendix A.

4.6.2.9 An Internet Based Simulation Model

The internet screen model as shown in Figure {4.8}, the supply chain locations that constitute the supply chain (suppliers, enterprise, distributors, end users, bank, and freight forwarder), were linked via computer network to act in a close and more coordinated fashion. The location in this network remains separate, but join their information and resources to provide a better management of information exchange, and to support exchange of data between the enterprise and other locations.

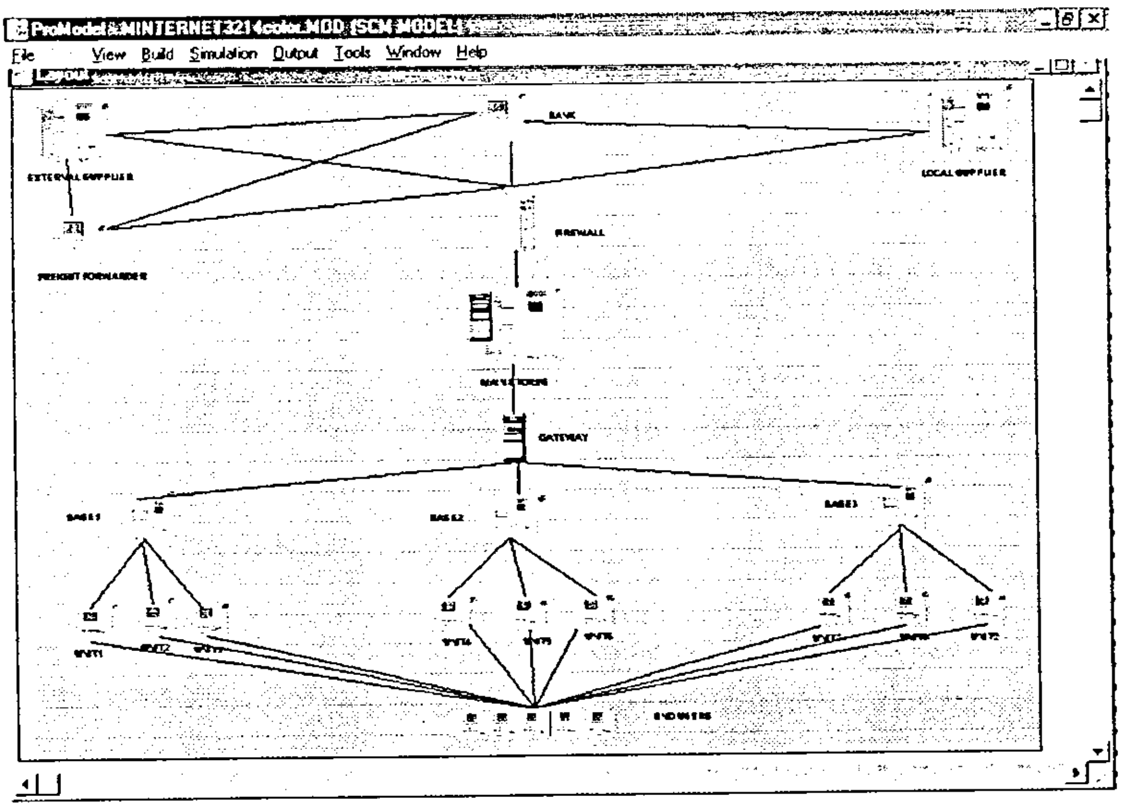

Figure {4.8} Simulation system layout

The Internet simulation of the model shows that the cooperation aspects of the enterprise and other members in the SC should include information exchange, information management, and automatic update of information. Benefit can be made through the use of the Internet. These benefits are mainly in the area of information processing activities such as: entering the end user orders, keeping track of orders between all members, paying bills, payment process, keeping track inventory, keeping track material shipment, and purchasing.

4.7 Initial Conditions

One of the important decisions to be taken before running simulation model was to determine the initial starting conditions such as: initial inventory, running time, and the number of runs. Real systems start with an initial inventory and in-process products. The initial inventory levels in the system are as shown in Table {4.2} with the assumption shown in section 4.6.1. In fact any initial inventory level value can be assumed without having any effect on the process accomplished by the simulation.

Running time for the simulation was set at 8766 hours (one year); this was chosen to imitate the real system, which also runs 24 hours a day, seven days a week all year round. While the simulation is running, random orders for both products A and B, initiated by the end users, start to enter into the system representing the daily demand for both products.

When using most simulation packages, setting the time back to zero and rerunning the model will set an exact repetition of the pervious run. This is because simulation packages use pseudo random numbers, which are generated mathematically and simply appear to be random. Each time the {model is rerun}, the same random numbers are restarted, and the same sequence of numbers will be generated. This can be overcome by changing the seed that initiates the random number generation.

As one hundred runs will ' used throughout the model, point estimation does not provide enough information about parameters. Therefore it is preferable and more meaningful to construct a confidence interval on the point estimator of the parameters. Simulation model data and logic are shown in appendix C.

4.8 Model Validation and Verification

Before performing any output analysis, the validity of the model must be tested, i.e. to check if the model is running in a satisfactory fashion and is executing the required tasks.

Model verification is different from model validation. Verification is to determine that a simulation model performs as intended, i.e., debugging the computer program. While, on the other hand, validation is concerned with determining whether the conceptual logic of the model is accurately representing the investigated system. The simulation model is approved and the results are accepted when the validation model gives the right results.

To determine whether the model is working as required, the following tools were used:

4.8.1 Animation and Counters

* ***Animation***

As mentioned previously, by using PROMODEL simulation, it is easy to determine and assess whether the model is running properly or not through animation of the resources, and entities between the different locations. Model validation ascertained by letting the resources and entities in the model move from one location to another on the preset path. The movement of all resources (ship, truck, pickups) from one location to another according to the preset path was tested several times and found to be working properly

* ***Entry arrivals***

By monitoring the arrival of orders from the end users to the units every twenty-four hours, separate orders for both products A and B will enter the system. This can be seen as an order from end users to the units, each product order is given a different colors, different speed, and different arrival time to monitor the arrivals accurately. The test was performed for several times for each unit individually, and in each run, the orders entered the system separately and were monitored for each product.

Combination test of all items at all units was then performed. The system proved to work as desired, and all the routing rules and priorities were performed as needed.

* *Counters*

Every location is provided with two counters to monitor (count) the inventory level for both products. Each counter was designated a different color (the same color as the order and entity of the product) to easily distinguish and relate the level monitored to the product. Every counter was monitored individually for several times and was found that when the location met an end user demand for a given quantity, the counter decreased by same quantity, and vise versa when an ordered quantity was delivered to that location. This test was performed for several times on every · nter and they were all found to operate correctly by subtracting and adding the dispensed/ received quantity.

4.8.2 Elimination of Randomness

When the source of randomness is eliminated and replaced with a predetermined value, the model can be mathematically studied either manually, or through the use of mathematical software. This is a powerful mean of validation, and can facilitate the monitoring of a model in which all parameters are fixed. The randomness in the model are the enter arrival quantities of both products. This validation was performed using two methods.

1. The system was run using the predetermined values for the order quantities from the end users to the nine units and the same values was used in the unit stores as an inventory (initial value). These

values were shown as a default values in counters at each unit when starting the system. Table {4.3} shows the fixed values used in one of the iterations. When running the system for 8760 hours. The simple calculation, must results in a zero inventory at that each location. Actually this was what happened. This test was repeated for, one day, one week, one month, and one year. For several times, the results were always as expected. i.e. zero

Table {4.3} Deterministic parameters for units

Location	Order quantity enter the location/day		Inventory (counter reading)	
	Product A	Product B	Product A	Product B
Unit1	18	5	6570	1825
Unit2	15	25	5475	9125
Unit3	20	35	7300	12775
Unit4	25	40	9125	14600
Unit5	10	7	3650	3650
Unit6	14	27	5110	9855
Unit7	30	88	10950	32120
Unit8	100	1000	36500	365000
Unit9	500	700	182500	255500

2. To test that the whole system was working and the operations were running as required, the following test was performed. The simu... on was run and a fixed daily demand, with counter values equal to the ROP value, was administered at every location. The predetermined values are shown in Table {4.4}. The fixed values include safety stock, ROP, order quantity, initial value at every location. The processing time and distance between locations are assumed to be zero for the purpose of test.

Table {4.4} Fixed values at the entire system

Location	dd		Ss		ROP		Q		Initial value	
Product	A	B	A	B	A	B	A	B	A	B
Unit1	18	17	36	34	54	51	18	17	54	51
Unit2	10	7	20	14	30	21	10	7	30	21
Unit3	15	14	30	28	45	42	15	14	45	42
Unit4	15	10	30	20	45	30	15	10	45	30
Unit5	15	15	30	30	45	45	15	15	45	45
Unit6	16	10	32	20	48	30	16	10	48	30
Unit7	11	7	22	14	33	21	11	7	33	21
Unit8	6	7	12	14	18	21	6	7	18	21
Unit9	6	6	12	12	18	18	6	6	18	18
Base1	43	38	86	76	129	114	43	38	129	114
Base2	46	35	92	70	138	105	46	35	138	105
Base3	23	20	46	40	69	60	23	20	69	60
Main stores	112	93	224	186	560	465	336	279	560	465

As shown in Table {4.4} ROP value equals the initial quantity and the order quantity is equal to the ROP minus the safety stock. The safety stock is equal to daily demand times two (dd*2). For example, at unit1 product A ROP=54= initial quantity, and Q(18)=ROP(54)-SS(36). These values mean that the counter quantity (inventory level) will fluctuate between the safety stock value and the ROP or the initial value. This also, means that the minimum value will be equal to the safety stock and the maximum value will equal to the ROP. In our example minimum value=36, and the maximum value=54.

When running the system for any period of time, it can be seen by directly monitoring and observing the counters that the system performed as expected. When the system was run at low speed, to facilitate monitoring, it was verified that all counter readings fluctuated between the minimum and maximum values (safety stock and ROP).

The pervious results can be verified in another way. Output report results, after running the system for any period of time, must show that the minimum and maximum values (inventory level) registered by every counter at each location during the simulation, fluctuates between Safety stock value (SS) and the reorder point value (ROP).
The test was performed for 100 runs each for 8760 hours. The output report show results were found to be as expected.

4.8.3 Constant Process Time and Equal Distances Parameters.

This test is performed under the following conditions

1. A constant processing time at each location and for both products. A fixed value of processing is defined at each location.
2. Constant speed for all resources 60 mph.
3. Constant and equal distances between all locations (600m).

Simple calculation shows that lead-time LT is equal to the processing time plus the travel time for all units and bases. Because they have the same process. Example: lead-time at base 1=order process time + travel time, where travel time =distance /speed.

LT= 6 + (600/60) = 16 hours.

Location	Processing time	Expected lead time
Units	4	24
Bases1	6	16
Main stores A	6	29
Main stores B	6	34

Different calculations are performed at main stores for both products according to figure {4.5}, which is accomplished as follows:

Lead-time at main stores for product A is equal to the main stores order process time (6) + local supplier order process time (6) + main stores order acknowledgement process time (6) + financial process time at the bank (5) + the payment process time at the local supplier (6) + travel time (10) = 39 hours = LT.

The same calculation are performed for product B at the external supplier which is equal to the main stores process time (6) + external supplier process time (6) + main stores order acknowledgement process time (6) + financial process time at the bank (5) + freight forwarder (shipping process time) payment process time at external supplier (6) + travel time (10) = 44 hours = LT.

After 100 runs of simulation, each of 8760 hours, the results are shown in the final report (this result is for all locations) were as follows:

Minimum lead-time = maximum lead-time = Average lead-time = expected time. These results comply with the simulation computer output through the monitor screen and final reports, and therefore, the model is valid. Several output data for the performance measures are shown in appendix A.

5. Results and Discussion

5.1 Introduction

Simulation is the right tool to study complex and dynamic systems and is usually applied to evaluate decisions, operation polices, and to support decision-making used by the managers to assess the system's performance. Assuming that a simulation model for a given system is valid, running a simulation of that system in different scenarios and studying their effects is cheaper and less time consuming than experimenting with the actual system and studying the corresponding results. The simulation model will give results within a certain confidence level in which several decisions on various possible improvements can be made.

The purpose of this research was to develop a SCM model then provide a simulation of the supply chain management system for two types of products at Royal Jordanian Air Force. The simulation model was proved to be valid. This model will be used to study different scenarios of improvements in order to help mangers at the Directorate of Supply take reliable decisions concerning improvements to the supply chain management.

As was stated previously, the supply chain management simulation model was designed for two types of products, product A, hydraulic oil, and product B, engines oil. Product A is purchased from a local supplier, while product B is imported from external supplier. The developed model will be used to assess how to effectively perform activities in the supply chain. However, before suggesting any modifications, the existing supply chain management will be evaluated using the developed simulation model.

5.2 The Current Supply Chain Management System

In this section, the supply chain management for both products during year 2001 were evaluated using the developed simulation model, therefore the enter arrival quantities into the model were changed to match the demand capacity during year 2001.Moreover, the following alteration were made to the model to imitate the actual conditions:

- The number of available resources for transporting products between different locations is the same as those used actually.
- The lead-time, order process time, and financial process time used in the system is the same as those given by experts at the directorate of supply.
- Operation, initial, and usage Costs for all entities, resources, and products were taken from the procurement section at directorate of supply.
- Order, shipping, and financial processes and their work sequence (ordinary process) used are the same as those used by the employees when performing routine daily tasks.
- All locations, inventory systems, and locations' capacity with their associated costs are not changed (the same).
- Each product was ordered separately (as in the actual system)
- Quantities from the external supplier were ordered at the beginning of each year or when the current quantity at the main stores is below 1000 unit.
- Order quar...y from local supplier is performed at the beginning of each year or when the available quantity is below 1000 unit.
- The same order quantity, order process, costing, and parameters used in 2000 were applied in 2001.

The simulation model was run for a period of one-year (8766 hrs). The trial was repeated 100 times and the performance measures are evaluated as follows:

- Delay time: delay time for the order process time (OPT), financial process time (FPT), shipping process time (SPT), and the total lead time (LT) between main stores and local and external suppliers are given in Table {5.1} as {average, STD}:

Table {5.1} Delay time in the current system

Delay time	Locations		Average (Hrs)	STD
	FROM	TO		
OPT	Main stores	Local supplier	240.1	34.2
FPT	Main stores	Local supplier	50.1	16.4
LT	Main stores	Local supplier	368.23	41.7
OPT	Main stores	External supplier	410.26	71.4
FPT	Main stores	External supplier	49.91	10.5
SPT	Main stores	External supplier	120.6	23.2
LT	Main stores	External supplier	1667	77.4

- Inventory level: the average amount of inventory in units, bases, and the main stores. See Table {5.2}

Table {5.2} Average IL for the current system

	Product A		Product B	
Location	Average (Lt.)	STD.	Average (Lt.)	STD
Unit 1	259.18	12.3	250.18	13.6
Unit2	147.66	7.35	104.53	5.43
Unit3	179.93	6.64	207.53	10.45
Unit4	221.3	10.86	146.64	7.02
Unit5	222.9	10.82	225.63	14.19
Unit6	243.51	13.07	150.87	7.42
Unit7	163.06	7.96	104.73	4.61
Unit8	87.66	4.44	105.64	6 [illegible]
Unit9	92.38	3.77	93.35	5.43
Base1	631.57	53.6	550.96	46.53
Base2	675.51	55.84	564.08	43.92
Base3	344.1	32.35	330.62	32.25
Main stores	5130.19	248.55	4243.31	220.7

- Minimum level: minimum level is an indicator for the customer service level. A negative value means that there

Table {5.6} Current entities costs

Entity	Average (JDs)	STD
Product A	29176.36	619.5
Product B	44037.31	2532.3
Order A	2173.19	256.1
Order B	1787.69	443.3
Finance	308.25	39.6

- Total cost: total cost includes the resource plus operation plus entities cost. Table {5.7}

Table {5.7} Total current costs

Entity	Average (JDs)	STD
Operation	12182.02	664.9
Resources	7924.19	232.76
Entities	77482.82	2864.7

Therefore, in order to improve the current SC activities, the following modifications are suggested:

- Decrease the delay time in all supply chain processes.
- Changing the number of resources.
- Reduce the inventory by performing new order technique.

Each of the above points will be covered in details in the following sections; also we will see their effect on cost.

5.3 Decrease the Delay Time

Reducing time delays in the supply chain process is the most important factor; since this affected the order schedule, inventory level, and the total cost. Using the international network (Internet) instead of the ordinary channels (including fax, telephone, paper work) to perform orders, financial processes, and shipping processes meant: decreased process time, personal errors, and order cost. This resulted in a reduction in inventory level, order process, financial process, and shipping process time. All of these resulted in reduction in total costs and increase in service level.

By using the model and since lead-time causes, errors and unexpected delays were minimized; the quantity that will minimize the inventory and increase the service level can be ordered. Also, orders and shipments can be tracked so errors can be corrected, and problems can be solved as they occur with minimum effort, cost and least delay time. Table {5.8} shows different scenarios for performing the process in the model and using the ordinary procedures.

Table {5.8} Executing the process using the developed model

Scenarios (Process executed through the developed model)	Average lead time (LT) between Main stores&local supplier (Hrs)	Average lead time (LT) between Main stores &external supplier (Hrs)
All processes	27.05	997.72
Order process only	137.66	1270.88
Financial process only	423.95	1628.36
Shipping process	308.64	1702.3
Both order and financial process	44.73	1223.41

From Table {5.8} it's clearly shown that when managing the supply chain through the developed model, a significant reduction in the total lead-time between different locations was ..ied. This was reflected on the cost and service level in a positive manner.

5.4 Changing the Number of Resources

Transportation and resources allocated to perform the task of moving products and goods between locations are to be studied if improvements and time saving aspects are to be suggested. Three important factors must be taken into consideration when scheduling the transportation. These are:

- Capacity of the transportation
- Speed of the transportation
- Cost which depends on the type of transportation mode (such as air, water...etc.), the place where it is to be used, distance traveled, and the usage rates.

In the RAF supply chain three types of transportation were used, ships or containers, since in this case the assumption was made that containers are available all the time with constant cost (according to the FF rates), this mode will not be considered. The second type is truck; these are used to carry products from local supplier and from Aqaba harbor to the main stores. The third type is the pickups, which are used to distribute products across the internal supply chain.

Table {5.9} shows different scenarios of changing the number of resources and their effect on resource utilization and cost. Where the utilization is calculated as average usage time (Hrs) divided by the total yearly hrs (8766hrs). Since each resource serve only one location, the number allocated for that resource could be varied independently.

Table {5.9} Utilization and costs of variable resources

Resource	Number of resources used	Utilization %	Average total resource cost (JDs)
"" uck	3	5.2	709.57
	2	7.8	673.05
	1	15.6	636.52
Pickup1	5	8.8	3321.76
	3	14.6	3248.71
	2	29.1	3212.19
	1	33.9	3175.64
Pickup2	3	4.2	1981.57
	2	6.3	1945.05
	1	12.6	1908.52
Pickup3	3	5.4	1571.17
	2	8.1	1534.65
	1	16.3	1498.12

Fron- ¨able {5.9} it's clearly shown that cost and utilization rates are best when using a single resource from each type. However, and for practical reasons, it not conceivable for a military or a civilian system to rely only on one resource as a standby must be available to replace any broken down or out service vehicles. Consequently, the preferable number of resources used from each type is two. When running the simulation model for on year, 100 times using two resources from each type it was found that the total cost for all resources including the containers was reduced compared with the output values when using all the current available resources as shown in appendix A.

5.5 Modifying the Order Policy

The current order policy is based on placing a single order once a year for a large quantity of either product A or B. This quantity is based on individual experience and the Figures of the consumption in the previous year. In the last three years a shortage had occurred prompting a second order to be placed, and indicating that the assessment of the officer in chargé was not correct. This order policy has many disadvantages that include high inventory level, low customer satisfaction, and high inventory cost. From a personal point of view this is due to the order policy which is affected greatly by the long process time performed between main stores and both external and internal suppliers. Details were discussed and results were showed in section (5.2).

The order policy is one of the most important factors that can, when executed properly, reduce the inventory level, costs, and increase the customer service level. According to the RAF safety instructions, Directorate of Maintenance instructions, and other assumptions made in section (4.6.1), Table {4.2} was developed to determine the values of: safety stock, demand during the lead time, reorder point, and the order quantity at every location. Since in our model the lead-time in all processes is reduced to the minimum as a result of performing the model through the Internet, the order policy can be changed and tested in order to achieve the expected benefits of the supply chain management.

As the main bulk of inventory is kept at the main stores, any problem in main stores inventory level or order policy will affect other locations directly. Also since the lead time between the bases and main stores, and units and bases is relatively very small compared with that between the main stores and both external and internal suppliers (due to the long process time), shortages of products at the main stores means shortages at the other local locations. For all the above reasons, different scenarios of the order policy at the main stores for both products A and B will be studied. Developed data in Table {4.2} will be the bases of these scenarios.

Table {5.10}. Results of different scenarios of the order policy.

Scenario no.	Order policy scenario	Product A inventory (Lt.)		Product B inventory (Lt.)		Average TOC (JDs)
		Min	Average	Min	Average	
1	Decrease Q and ROP by 10%	397.6	2537.37	989	3671029	14991.4
2	Decrease Q and ROP by 20%	89.6	2191.2	695	3076.59	15187.33
3	Decrease Q and ROP by 30%	-112	1866.45	560	2509.51	15183.7
4	Increase Q by 10% and decrease ROP by 10%.	476	2856.49	989	3883.75	14467.16
5	Decrease Q by 10% and increase ROP by 10%.	621.6	2696.64	891	4273.69	15071.75
6	The same developed order policy.	870.8	3106.08	891	4162.13	14572.72

In Table {5.10} three parameters are used to evaluate the change in order policy. The first one is the average minimum value, which is a good indicator for the fill rate (or service level), and safety stock. From the different scenarios and according to this parameter the second scenario (minimum value =89.6) is not appropriate since the minimum value drop too far below the safety stock value (SS=224). The third scenario (minimum value =-112) is rejected as it means that the main stores cannot fill the orders from the bases. (No inventory to meet demand). The second parameter is the average inventory value, which is a good indicator of the inventory level at the main stores but since the values are very close to each other we will consider it later on when the final comparison is performed. The third parameter is the average total operation cost (TOC); TOC includes the inventory, resources, and orders costs. According to this parameter, the first scenario (decrease Q and ROP by 10%), and fifth scenario (decrease Q by 10% and increase ROP By 10%) are not appropriate since the associated costs are high.

Thus the comparison is reduced to between the developed order policy (scenario six), and scenario four (increasing Q by 10% and decreasing ROP by 10%). The costs are very similar, but when comparing the average inventory level between the two cases, it is clear that the sixth scenario has higher average inventory level with a higher average minimum value.

It is clear according to the parameters used in Table {5.10} and the associated expenses, that the best scenario is when reducing ROP by 10% and increasing Q by 10%, (scenario number four). This result makes sense because when increasing order quantity and reducing the reorder points, the number of orders, average inventory value, and the number of times the resources used will all decrease.

5.6 Cost Analysis

The ultimate target in any business is the cost, as the costs are reduced, the marketing of the products, and the profit margins will be better. A combination of the performance measures results in the previous sections (5.3, 5.4, and 5.5) will be used to investigate the total cost of the supply chain (for the parts in concern, refer to the control of RAF supply chain). The average inventory cost while using the developed model is compared with the current costs for the year 2001. Table {5.11} shows the average inventory cost at each location

Table {5.11} Average inventory cost comparison

Location	Developed system (JDs)	Current system (JDs)
Main stores	485.23	2891.03
Base1	296.28	1058.19
Base2	234.49	845.79
Base3	226.68	829.04
Unit 1	182.96	729.71
Unit 2	182.32	728.01
Unit 3	182.6	728.14
Unit 4	182.28	729.33
Unit 5	185.14	729.45
Unit 6	182.66	728.22
Unit 7	182.54	729.09
Unit 8	182.3	727.91
Unit 9	182.3	728.04

From Table {5.11} it is clear that there is a significant reduction in inventory cost when implementing the developed model especially at the main stores.

Table {5.12} shows the costs of the resources comparison between the current and developed systems.

Table {5.12} The resources costs comparison

Resource	Developed system (JDs)	Current system (JDs)
Ship	2108.09	1073.22
Truck	613.05	319
Pickup1	3208.59	2841.67
Pickup2	1955.85	2052.66
Picup3	1516.65	1637.58

From Table {5.12} it can be seen that the current expenses of resource usage are lower than of the developed system, this is expected because the number of times the transportation carried loads increases due to the change in order policy.

Table {5.13} shows the entities costs and their percentages.

Table {5.13} Entities costs and percentages

Entity	Developed system		Current system	
	Total Cost (JDs)	Percentage 100%	Total Cost (JDs)	Percentage 100%
Product A	27476.9	37.82	29176.36	37.66
Product B	43055.36	59.26	44037.31	56.83
Order A	921.89	1.27	2173.19	2.8
Order B	926.48	1.28	1787.69	2.31
FP	270.09	0.37	308.25	0.4

It is clear from Table {5.13} that the orders costs (as a percentage of the total cost) decreased from 2.8% to 1.27% for product A. and from 2.31% to 1.28% for product B. The financial process costs decrease from 0.4 to 0.37 when using the developed system. But the question is why does the order costs decrease when using the developed system while the number of orders increase, noting that in the current system two or three orders were performed each year. The answer is simply because the order and financial process times and costs are reduced greatly since these processes were performed through the Internet.

Table {5.14} shows the total costs comparisons.

Table {5.14} Comparison between the total costs.

Activity Costs	Developed system (JDs)	Current system (JDs)
Locations costs	2887.84	12182.02
Resources costs	9402.23	7924.19
Entities costs	72650.75	77482.82
Total costs	84940.82	97589.03

As shown in the table the location costs decrease when using the developed model by

Reduction =((12182.02-2887.84)/12182.02)*100%= 76.3%

This reduction is due to the decrease in the inventory level since more orders are performed and this will result in hidden cost reductions due to the item short time cycles, which will reduce the waste.

The resource costs are increased when using the developed model by:

Increase =((9402.23-7924.19)/9402.23)*100%=15.72%

As discussed previously this increase is due to the increased number of orders, which will result in an increase in the number of transportation usage.

Also when comparing the reduction in total costs to the products purchasing values we find:

Total cost difference = 97589.03-84940.82=12648.21 JDs

Total products purchasing costs = 70532 JDs

Percentage of the reduced costs = 12648.21/70532=17.93%

This is a significant reduction and can be explained by the following three factors: firstly, decrease in orders, finance, and shipping process time, secondly, decrease of the costs of these process due to the use of the internet, and thirdly, the reduction in inventory level due to the order policy implemented.

With minor modifications the developed simulation model can be used for different organizations, and different types of goods and services. Different scenarios with simple alteration can be used to determine best solution for the supply chain management and assist in reducing lead-time, reduce cost, and increase the service level. Also it can provide help to managers in their decision making process concerning the management of their supply chain.

6. Conclusion and Recommendations

6.1 Introduction

This search has dealt with supply chain management in small and medium size enterprises using RAF as a case study. This was chosen, as the supply chain management term is relatively new in Jordan and with the government drive to kick-start the economy through incentives building of new industrial zones and exploring new markets for Jordanian products. Enterprises need to improve their performance and competitiveness to crop these opportunities. One way to do so is to explore the advantages of an Internet based supply chain management system to improve in areas such as cost reduction, increased service level, and reduced delay time.

In this thesis a supply chain management model for enterprises based on the use of the Internet with the aim of accelerating processes and reducing costs was introduced. The elements and activities used in the model were the same as those used by actual enterprises in Jordan. The model aimed at enhancing Jordanian enterprises' competitiveness through achieving a tangible reduction in the lead-time and the associated costs. This will surely be reflected in the form of improved services and higher profit margins.

6.2 Conclusions

1. Applying the developed model resulted in reducing the delay times associated with the long processes of ordering, purchase, shipping, and payment when using the traditional (current) method. Such a reduction in delay time, as shown previously, resulted in a decrease in the inventory level, and in the order

cost. This also resulted in a notable reduction in the total costs, and increase in the service level.

2. When assessing the supply chain management for the year 2001 at RAF, it was found that when comparing between the current system before and after several modifications were made, the followings were realized:

- When reducing the delay time in the supply chain process, through the use of the developed model, it was found that the lead-time between local supplier and the main stores was reduced from 240 to 27 hrs. In the case of external supplier, the lead-time was reduced from 1667 to 997 hours, of the 997 hrs, 960 are shipping time, meaning the lead-time was reduced from 707 to 37 hours.

- The number of resources used is higher than it needs to be. From the results of the scenarios modeled, it was found that the most probable number of transportation used is two of each type. Altering the number to two resulted in an increase in the resources utilization.

- When changing the order policy to meet the "speed" required by directorate of supplies instructions and to comply with the RAF safety precautions, it was found that there was a reduction in the inventory level. This resulted in a decrease in the inventory costs and an improvement in the service level.

3. When implementing the system with the best solutions found in each scenario according to the performance measures the following findings were observed:

   a. The lead-time was decreased because the process delay is eliminated, and errors are minimized.
   b. The resource costs were increased because the number of usage (utilization rate) of these resources was increased.
   c. The number of performed orders was increased but since the orders process time is minimized and the order costs were reduced, the total order costs were reduced.

4. Cost analysis showed that: the average inventory costs have decreased, the average entities costs have decrease, while, and on the other hand, the resource cost has increased. It was found that when using the developed model instead of the current system the reduction in the total cost was 17.93%. This reduction is tangible and should make managing the supply chain attractive and profitable to the enterprises.

5. With minor modifications the developed simulation model can be used for different organizations, and different types of goods and services. Different scenarios with simple alteration can be used to determine the best solution for the supply chain management and assist in reducing lead-time, reduce cost, and increase the service level. Also it can provide help to managers in their decision making process concerning the management of their supply chain.

6.2 Recommendations

Following are some of the recommendations based on this research:

1. RAF should benefit from the achieved reductions in lead-time and implement an Internet based supply chain management system across its' entire range of imported products.
2. RAF main stores should revise their order policy more frequently and take into consideration the short life cycle of products and changes in users' demand.
3. The model is applicable to different enterprises, and different types of goods and services. SMEs can benefit form the simulation to assess and improve their supply chains.
4. Enterprises in Jordan should follow the continuous and increasingly changing world, and benefit from the Internet and use it to its' advantage to compete in an increasingly aggressive market.
5. The order, payment and shipping processes should be performed through the Internet, as this will reduce the processing time. It's strongly recommended that enterprises should use some form of electronic or online payment to perform financial processes.
6. Recommendations for further research:
   Further work suggested to study the effect of adding more supply chain attribute to the model. These may include more enterprises, distributors, suppliers' selection and relation, and more products. It is also suggested that a detailed study be conducted to discover and strengthen weak links between the Jordanian SMEs and the external suppliers from different countries.

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Simulation Model construction

PROMODEL a simulation software package is used to simulate the operation of the RAF supply system in order to evaluate the appropriateness and improving its operational performance. and provide a basis for suggesting improved modes of operation.

I. System Layout

The supply chain studied in this thesis is a service SC for two types of imported products from two different suppliers. It is then distributed to three bases' warehouses each in turn distributing to three units. Finally the units deal with the end users demand. This system is part of RAF main stores supply chain.

The main stores imports two types of products:

- Product A: Engine oil.
- Product B: Hydraulic oil.

Two different suppliers supply the products:

- Local supplier: supply product (engine oil).
- External supplier: supply product B (hydraulic oil).

Main stores is the location where. all products and orders will pass through, have the following responsibilities:

- Order policy
- Inventory policy
- Financial process (payment billing).
- Shipment policy.
- Distribution policy.

The following transportation modes were used in the simulation model:

- Ship (container): shipping product B from the external supplier.
- Truck: shipment of product A from the local supplier.
- Pickup1: carrying products from main stores to the bases and from base number 2 to units, 4,5, and 6.
- Pickup2: carrying products from base 1 to units1, two, and three.
- Pickup3; carrying both products from base3 to units 7, 8, and 9.

Financial processes between the main stores and the suppliers were done through the bank location.
The freight forwarder accomplishes shipping process from the external supplier.
Entities used in the simulation mode are shown in figure (A-1) and include:

- Can of engine oil to represent engine oil product.
- Can of hydraulic oil to represent the hydraulic oil product.
- Order A: white color order paper to represent order of product A.
- Order B: red color order paper to represent order of product B.
- A check to represent the payment process.
- Electronic signal (information signal) with red and blue colors to represent information about: order acknowledgement, shipping order, and payment order.

Figure (A-1) shows the entities and resources used in the simulation model.

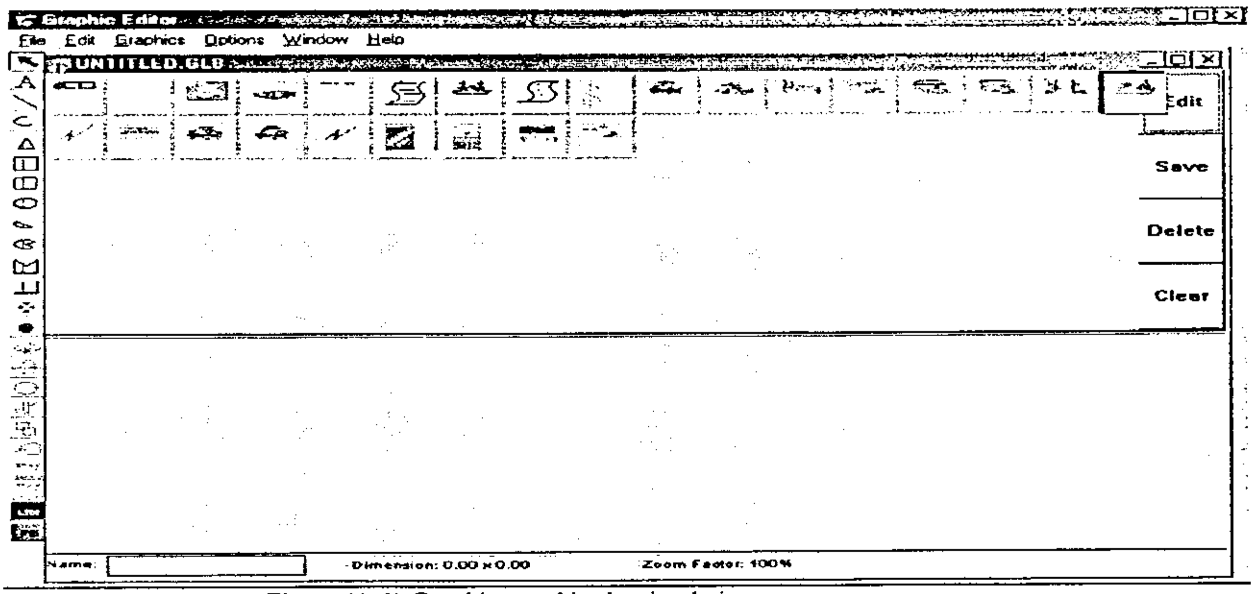


Figure (A-1) Graphics used in the simulation

The locations used in the simulation model are arranged in two region areas:

- Yellow region: represent USA from which product B imported. It has two locations:
  - External supplier.
  - Freight forwarder
- The Jordanian chart in which the location are allocated to include the following:
  - Local supplier.
  - Main stores.
  - Bank
  - Bases1, 2,and3.
  - Units1, 2,3,4,5,6,7 8 and 9.
  - End users1,2,3; to represent the maintenance sections personnel for bases 1,2, and 3.

Figure (A-2) shows the system lay out as shown in the simulation model.

II. Data Analysis

Inputs to the SCM model consist of the entities, resources, locations, distances between locations, speed of the resources, operation and location cost, and cost of the products. Following is a discussion and analysis of the input data.

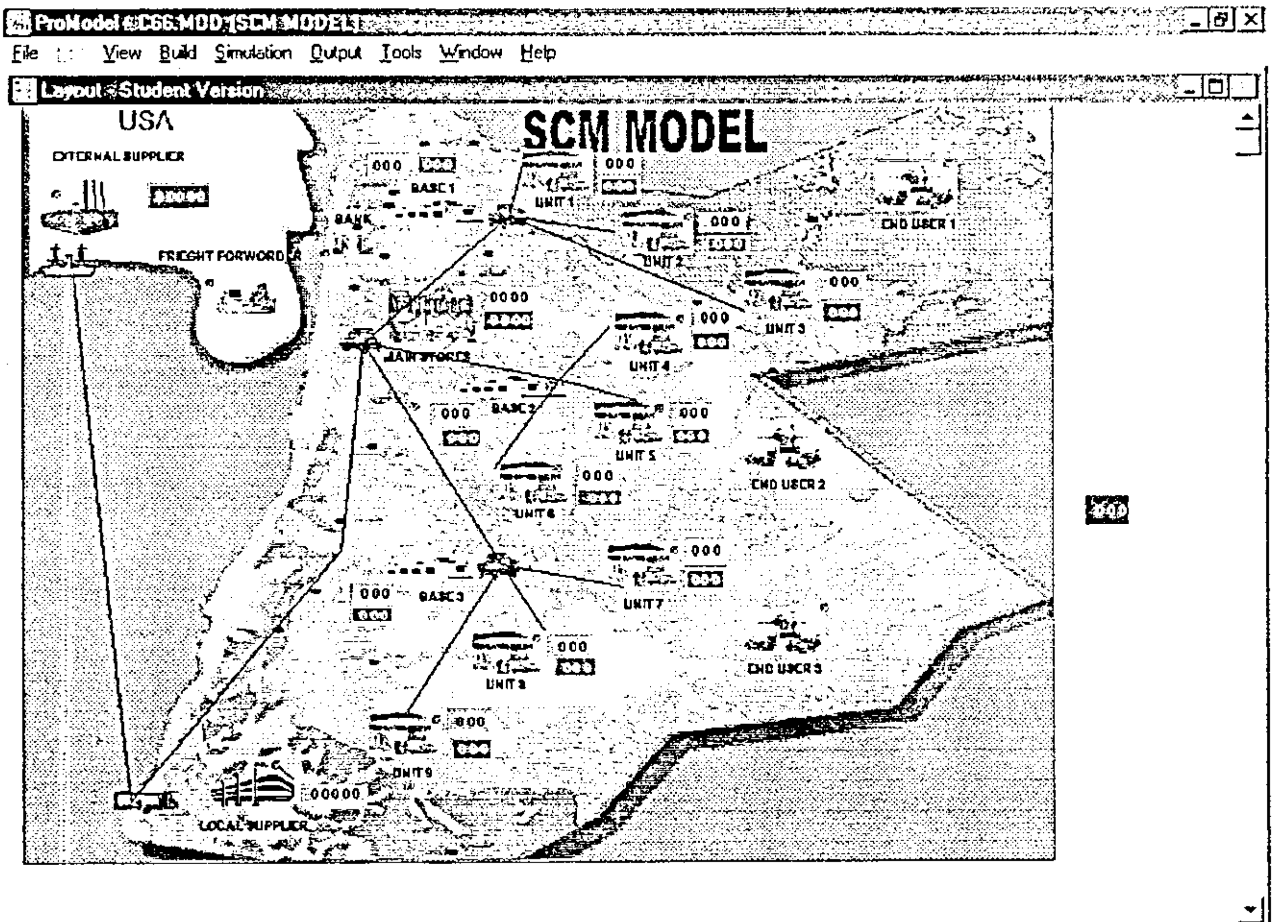


Figure (A-2) System layout

Resources include the trucks, pickups, and ships. The cost for each truck and pickup is defined as the regular cost per day, which is relatively small. For the ship the cost per container is calculated, because the cost depends on several variables such as weight, size of the products, this is called the size weighting method and is calculated as follows:

CFT/35.3 * Miles* Rate /Mile – (35%) (1)

Weight (Lbs.) * $0.1 (2)

Number Of Items * Line Item Cost (0.44 $) (3)

8 $ Per Shipping Order (4)

Total Cost ($) = (1) + (2) + (3) + (4).

Costs in JD's are shown in table (4.1).

Table (A-1) The available resources costs

Resource	Quantity	Cost /usage (JDs)
Truck	2	50
Pickup1	7	18
Pickup2	4	18
Pickup3	4	18
Container	Depend on demand	500

At RAF locations (bases), the operation cost per day is calculated depending on many factors. These include the average daily number of item the store deals with, the cost of the equipment used during work, the cost and number of personnel employed to handle and store the products, and cost of the space occupied by the two products. All base stores are considered identical, and all unit stores are considered identical .The results are shown in table (A-2)

Table (A-2) Locations operation rate

Location	Average operation cost/day (JD's)
Main stores	15
Base stores	5
Unit stores	3

Order process cost for product A (from local supplier), and for product B (from the external suppliers) and financial process cost are taken from directorate of supply and are as shown in table (A-3).

Table (A-3) Process cost

Entity	Cost (JD's)
Order A	21
Order B	34
Financial process	25

The above process costs include office expenses (such as paper work, letters, faxes, telephones, etc...), and the cost of personnel handling orders, billing payments and transfer of money .It is obvious that these costs can rise significantly due to repeated mistakes or due to the wrong procedure being followed.

Products cost as they are documented at the directorate of supply at RAF for year 2000 are as shown in table (A-4).

Table (A-4) Products

Product	Cost/liter (JD's)
Product A	1
Product B	2

III. Data Collection

The collected historical data on customer demand for both product A and B for each unit is taken from the air force quarter reports at the directorate of supply. The data where collected for fourteen quarters from the first quarter in 1996 until the fourth quarter 2000. The historical data prior to 1996 were not used because they were not properly documented and are not complete. The average daily demand for each quarter was then calculated.

The maintenance personnel work twenty-four hours a d-- -ll year round. Their demand is dependent on the equipment, vehicles, and airplanes need for preventive, scheduled and corrective maintenance. As the need for products (A and B) arises, the personnel or maintenance groups send orders to their maintenance section stores (unit stores) which usually very close.

IV. Fitting Probability Distribution

A collection of arbitrary time-oriented occurrences, order arrivals is performed where the number of arrivals during any day (24-hrs interval) is independent with a random nature. The collected data for both products (A and B) were used to find the best probable distribution, which describes the random nature of the daily demand for both products. For each data summary, Statistical values such as mean, variance, minimum, maximum, and others were calculated. The results are shown in graphical form as a histogram.

Goodness of fit test is a method to assess whether the observations are independent samples from a particular distribution with cumulative distribution function. Poisson distribution was found to be the best fit that could model the random nature of the data.

Similar analysis was carried out for the other set of data. The distribution and parameter for all data are shown in table (A-4). Where the mean arrivals of orders λ which is equal to the standard deviation of the distribution.

Table (A-4) Distribution for orders arrival (customer demand)

Location/Arrival orders	**Product A distribution Poisson (lambda)**	**Product B distribution Poisson (lambda)**
Unit1	13.6	9.8
Unit2	5.75	3.5
Unit3	11.55	8.3
Unit4	8.55	6.55
Unit5	8.4	5.95
Unit6	7.15	4.95
Unit7	6.75	4.3
Unit8	3.95	2.6
Unit9	2.85	2

Order arrivals are performed where the number of arrivals during any day (24 hrs) is independent with random nature. The number of order arrivals occurring in any day is independent of the number that occur in any other day (no memory). The probability that more than one order will arrive in a short time is negligible. According to these assumptions and the results drawn from STATFIT software, it is clear that Poisson model is appropriate. Therefore the best distribution to be used is the Poisson distribution.

V. Development of the Simulation Model

The simulation is presented in this section in terms of its assumptions, structure, and initial conditions.

a. Model Assumptions

Before describing the model, it is important to state the assumption used in the model. The assumptions are as follows:

1. The distance used in the model is measured in meters.
2. The speed is measured in meters per hour for the purpose of this model.
3. The time measurements are made in hours. The system run 24 hours day, 365.25 days (8766 hrs) a year.

4. The orders entering the system are attributed with the quantity of either product A or product B but not both of them. Each order is marked with a different color.

5. The randomness occurs in the system include the arrival of orders and the processing time at each location in the supply chain.

6. Products are assumed to be always available at the suppliers, no shortage of supply from both suppliers is assumed.

7. Resources are assumed to be always available, and no stoppage due to lack of resources, or any delay due to unexpected or unplanned circumstances. The actual number of resources allocated for transporting both products is put (constant). The ships (containers) are available all the time and the freight forwarder is responsible for their availability.

8. The location of each store/base/unit on map (figure A-2) in the model is approximate but the actual distances were used between all locations. Table (A-5) shows the distances between the locations.

Table (A-5) Distance between locations

From	To	Distance (M)
Unit1	Base1	23000
Unit2	Base1	38000
Unit3	Base1	44000
Unit4	Base2	23000
Unit5	Base2	38000
Unit6	Base2	40000
Unit7	Base3	15000
Unit8	Base3	90000
Unit9	Base3	21000
Base1	Main stores	130000
Base2	Main stores	13000
Base3	Main stores	11000
Main stores	External supplier	5000000
Main stores	Local supplier	375000

9. The speeds of transportation means used (resources) are assumed constant. Two values for speed were used, one when the vehicles assumed unloaded, and one for loaded vehicle case. Table (A-6) shows the speed of the resources, both speed are driven from the actual resource speed.

Table (A-6) Resources speed

Resource	Speed (unloaded)	Speed (loaded)
Pickup1, 2,3	1160	1060
Truck	1150	105

10. Pickup 1 at the main stores is used to carry products from base stores 2 to units 4,5, and 6, This actually what happens in reality as base 2 is located in area covered by main stores and is situated very close to it.

11. Safety stock at each location is limited to meeting the demand of two working days. The daily demand is considered to be the maximum value of daily demand recorded at each location. This limitation is set in accordance with RAF safety instructions.
12. If the lead-time is less than one day (24 hrs), the order quantity is assumed to be a one-day consumption, which equals the maximum daily demand. (From directorate of supply instructions).
13. The initial values are assumed to be half of the order quantity and safety stock. This assumption will not affect the simulation model since the initial value does not affect the process in the simulation.
14. The minimum order quantity from external supplier is 5000 liters of hydraulic oil (product B). This value is set by the directorate of supply to be consistence with the container capacity with lowest cost.
15. The order quantity from local supplier is not less than one month of consumption. This value is set by the instructions of directorate of supply.
16. According to the instructions of directorate of supply, each unit and base cannot order more than the consumption quantity for 14 days. And since the economic order quantity (EOQ) is higher than this value, the order quantity is assumed to be the 14 days consumption.

According to points 11,12, 13, 14, 15, and 16 table (A-7) shows, the initial quantity, safety stock, demand during lead-time, and the reorder
Point.

Table (A-7) Continues review (Q) System data

Location	**dd.**		**SS**		**dL**		**ROP**		**Q**		**Initial value**	
Product	A	B	A	B	A	B	A	B	A	B	A	B
Unit1	18	17	36	34	18	17	54	51	252	238	144	136
Unit2	10	7	20	14	10	7	30	21	140	98	80	56
Unit3	15	14	30	28	15	14	45	42	210	196	120	112
Unit4	15	10	30	20	15	10	45	30	210	140	120	80
Unit5	15	15	30	30	15	15	45	45	210	210	120	120
Unit6	16	10	32	20	16	10	48	30	224	140	128	80
Unit7	11	7	22	14	11	7	33	21	154	98	88	56
Unit8	6	7	12	14	6	7	18	21	84	98	48	56
Unit9	6	6	12	12	6	6	18	18	84	84	48	48
Base1	43	38	86	76	43	38	252	238	602	532	344	304
Base2	46	35	92	70	46	35	224	210	644	490	368	280
Base3	23	20	46	40	23	20	154	98	322	280	184	160
Main stores	112	93	224	186	896	3906	1120	4092	3360	5000	1792	2593

b. Model Structure

The simulation software package used to build the system is PROMODEL. PROMODEL differs from other simulation software in that it is easier to use, the commands and logic of the program can be written directly using the built-in commands of the software. One can write his own program if needed to perform a special process work; also it uses animation instead of writing programming codes to perform the requested job. The model consists of twenty locations, three types of resources, and two products.

The system starts at zero hour at the beginning of the year, after that the orders from end users 1, 2, and 3, which represent the customer demand, start to enter the system. Units stores meet the demand of end users and supply their need for either product A or B. If the quantity available at the unit stores is below ROP, an order is initiated and sends to the base stores, and at the same time the product is dispensed to the end users. When orders reach the base stores, they send the product requested to the unit. Again if quantity of that product is below the ROP, an order is send to the main stores, the same procedure is followed at the main stores. If, at the main store and after meeting the demand of the unit, the quantity remaining is below the ROP, then the main stores will initiate and send an order to the local supplier. The local supplier will start processing the order and send an order acknowledgment to the main stores. After main stores receive the information about the order, they will authorize payment order through the bank. The bank, after receiving authorization will transfer money to the local supplier's account. Once the local supplier receives notice of payment being made to his account, the order quantity is send to the main stores. At arrival at the main store, the product quantity will be added to the main stores inventory level.

When an order reaches the main stores requesting for product B, the main stores will dispense the quantity required. If the inventory level drops below the ROP, the main store will initiate and send an order to the external supplier for a quantity equivalent to that required reaching the ROP again. When the external supplier receives the order, order processing will start and an order acknowledgment will be send to the main stores. Once the acknowledgment is received, main stores will authorize the bank to make payment to the supplier (product cost) and to the freight forwarder (shipping cost). The freight forwarder will send the shipping order to the external supplier and the shipping process will be accomplished by sending product B to the main stores.

Products A and B will exit the system at the end users where the orders are met and products dispensed. Six main screens are used to build the simulation model. These are:

- Main screen
- General information
- Location
- Path networks
- Resources
- Entities
- Processing
- Cost
- Back ground graphics
- More elements:
    - Attributes
    - Variables

Following is a brief discussion of each screen

c. Main Screen and General Information

The main screen is used to open the model Run, Simrunner, and Statfit. It was used to build the new model. The characteristics of the main screen (short cut panel) are shown figure (A-3).

The general information screen is the screen through which the units for time and distance are selected. Hours and meters were used to measure time and distance respectively. This screen is also used to set a title for the model. Graphic library, and model notes are also controlled from this screen. Figure (A-4) shows the general information screen.

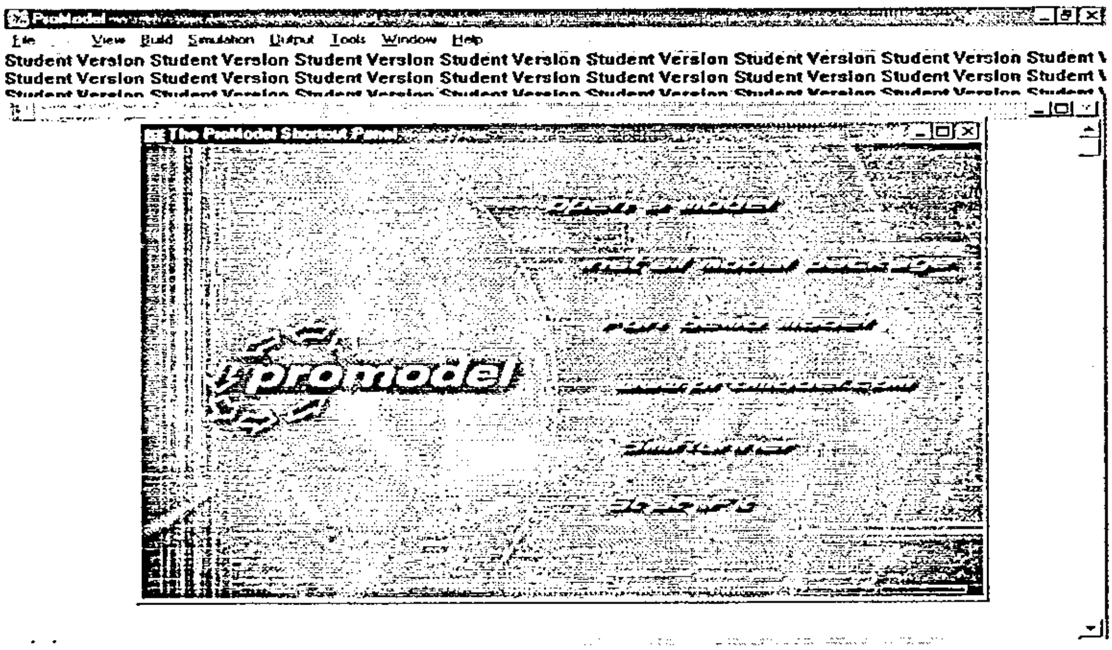


Figure (A-3) Short cut panel

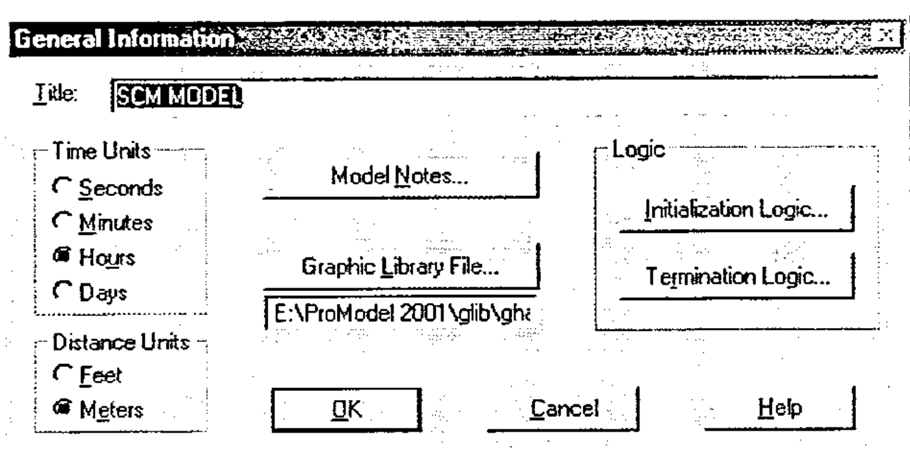
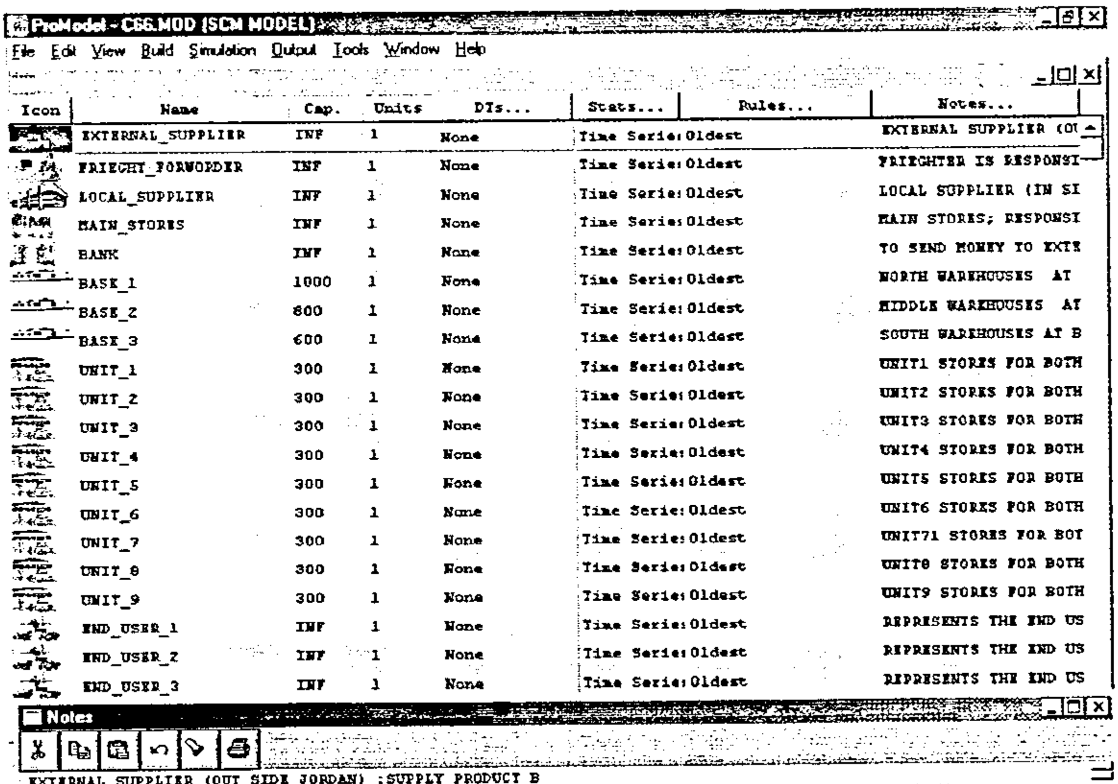


Figure (A-4) General information screen

d. Locations and Background

As discussed previously in section 4.3; Figure (A-2) shows the screen of the entire system layout. This consists of three end users representing maintenance personnel. Every end user is served by one of the three units responsible for it's logistic support. Each unit has its daily demand for products, on a daily base, each enter the system to order its consumption of both products. The nine units serving the end-users are represented by their actual location in the system. Every three units are served by one of the three bases (base 1 serves units 1, 2, and 3 and so on). The three bases are served by the main stores. The locations are shown in figure (A-5), which also includes the local supplier, external supplier, bank, and freight forwarder.


ProModel - C66.MOD (SCM MODEL)

File Edit View Build Simulation Output Tools Window Help

Icon	Name	Cap.	Units	DTs...	Stats...	Rules...	Notes...
	EXTERNAL_SUPPLIER	INF	1	None	Time Serie:	Oldest	EXTERNAL SUPPLIER (OU
	FRIEGHT_FORWORDER	INF	1	None	Time Serie:	Oldest	FREIGHTER IS RESPONSI
	LOCAL_SUPPLIER	INF	1	None	Time Serie:	Oldest	LOCAL SUPPLIER (IN SI
	MAIN_STORES	INF	1	None	Time Serie:	Oldest	MAIN STORES; RESPONSI
	BANK	INF	1	None	Time Serie:	Oldest	TO SEND MONEY TO EXTE
	BASE_1	1000	1	None	Time Serie:	Oldest	NORTH WAREHOUSES AT
	BASE_2	800	1	None	Time Serie:	Oldest	MIDDLE WAREHOUSES AT
	BASE_3	600	1	None	Time Serie:	Oldest	SOUTH WAREHOUSES AT B
	UNIT_1	300	1	None	Time Serie:	Oldest	UNIT1 STORES FOR BOTH
	UNIT_2	300	1	None	Time Serie:	Oldest	UNIT2 STORES FOR BOTH
	UNIT_3	300	1	None	Time Serie:	Oldest	UNIT3 STORES FOR BOTH
	UNIT_4	300	1	None	Time Serie:	Oldest	UNIT4 STORES FOR BOTH
	UNIT_5	300	1	None	Time Serie:	Oldest	UNIT5 STORES FOR BOTH
	UNIT_6	300	1	None	Time Serie:	Oldest	UNIT6 STORES FOR BOTH
	UNIT_7	300	1	None	Time Serie:	Oldest	UNIT71 STORES FOR BOT
	UNIT_8	300	1	None	Time Serie:	Oldest	UNIT8 STORES FOR BOTH
	UNIT_9	300	1	None	Time Serie:	Oldest	UNIT9 STORES FOR BOTH
	END_USER_1	INF	1	None	Time Serie:	Oldest	REPRESENTS THE END US
	END_USER_2	INF	1	None	Time Serie:	Oldest	REPRESENTS THE END US
	END_USER_3	INF	1	None	Time Serie:	Oldest	REPRESENTS THE END US

Notes

EXTERNAL SUPPLIER (OUT SIDE JORDAN) :SUPPLY PRODUCT B

Figure (A-5) Location screen in the simulation

The background used is the Jordan map, and a yellow colored region was used to represents the external supplier

e. Path Networks

As shown in figure (A-6), the path network screen consists of one passing network (passing: allowing the resources to move in the two directions and pass each other's), 14 paths were defined between locations, and the distances between locations were fed to the system. Interface between nodes and each location is defined as shown in the below figure

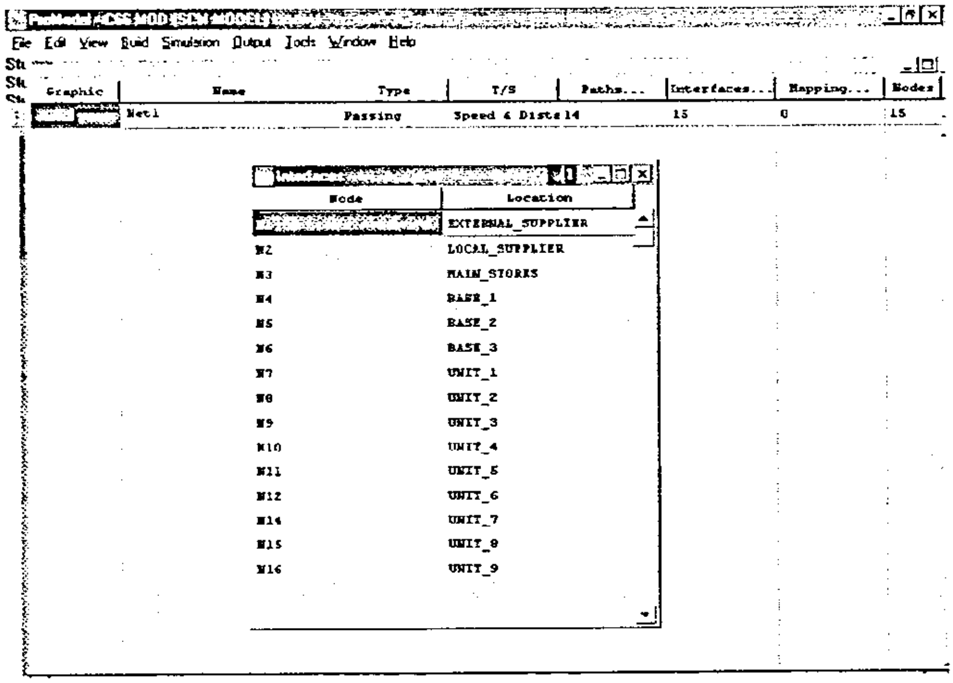


Figure (A-6) Path networks screen

f. Arrivals

This screen shows the arrival of orders for both products to each end user. It also shows the frequency of occurrence. and the logic of arrivals. Figure (A-7) shows the arrival screen.

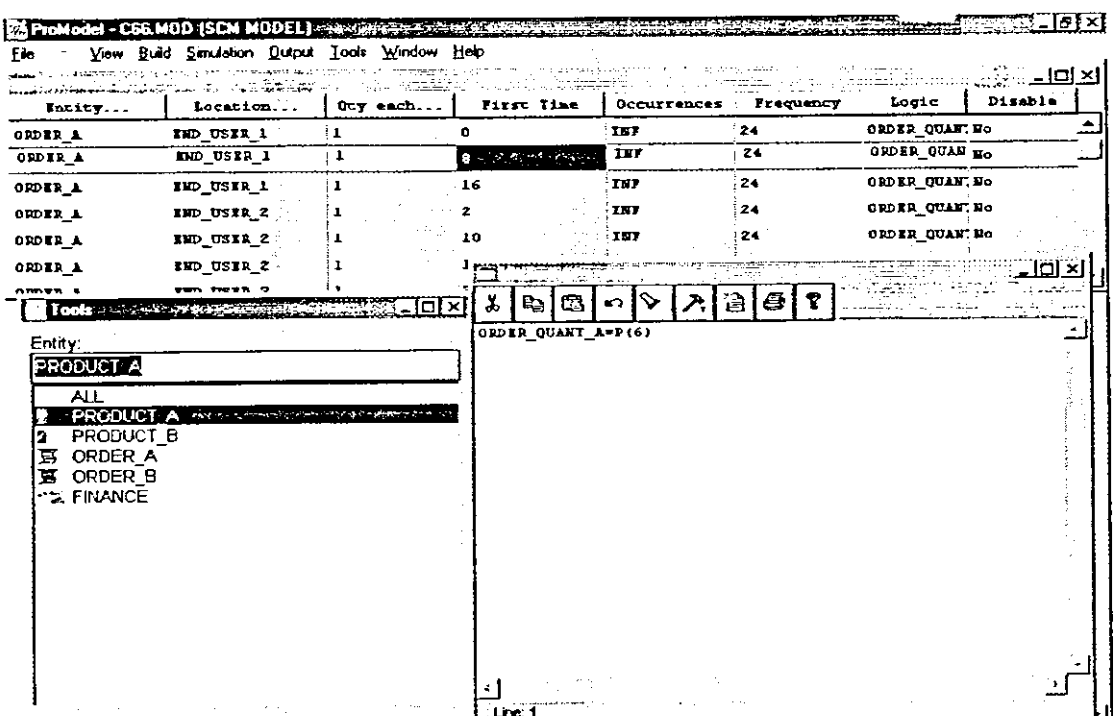


Figure (A-7) Arrival screen

g. Processing

This screen enables the control of two main functions. Firstly, thorough the process screen, the process at a given location for a specified entity can be defined. Operation pop up screen represents the logic used at that location for the specified entity. Secondly, through the routing screen, the output from the process side can be determined, the destination to which this output is destined, and the rule of routing. The moving logic for the entity between locations is also defined through the routing screen as shown in figure (A-8)

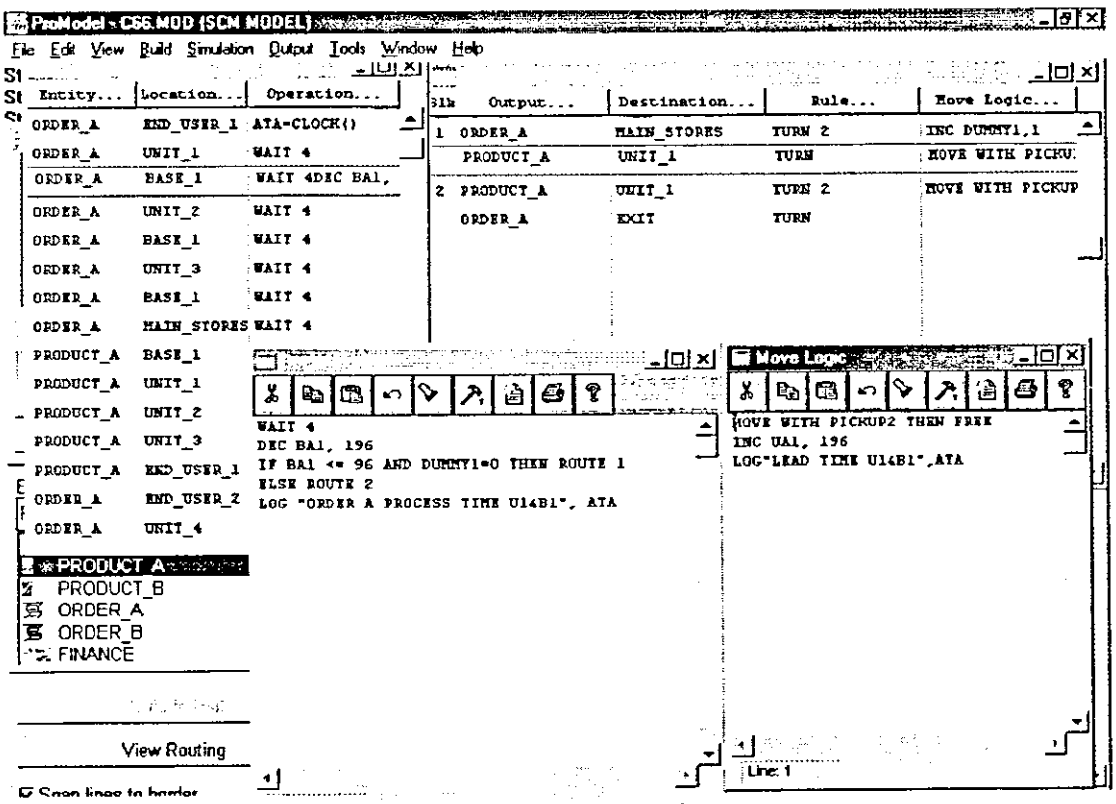


Figure (A-8) Processing screen

h. Resources and Entities

Resource screen was used to define the resources used, their number, and the path network to be used by each resource. Figure (A-9) shows the resources screen.

Entity screen was used to define and describe each entity used in the system; the speed used in this screen (150 mpm) is the default set by the PROMODEL software. The speed of the entity movement between locations is determined by the speed of the mean of transportation used. The entities and the graphic library used are shown in figure (A-10).

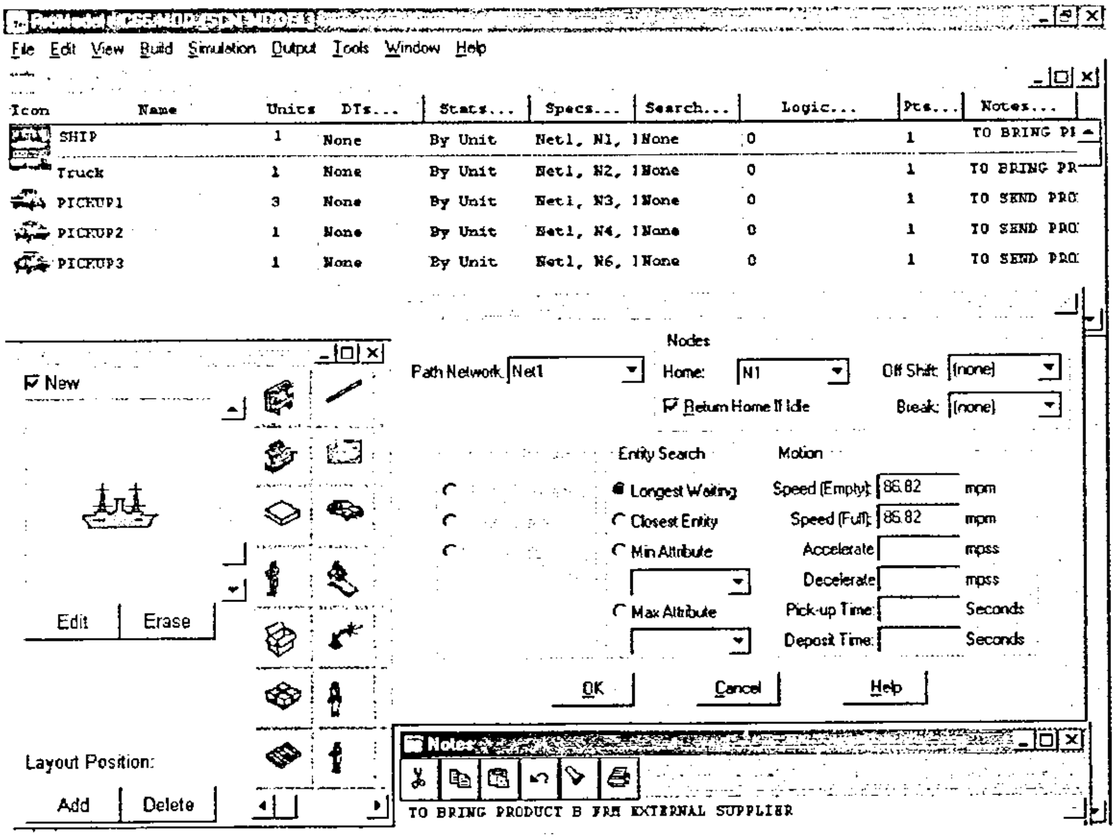


Figure (A-9) Resource screen

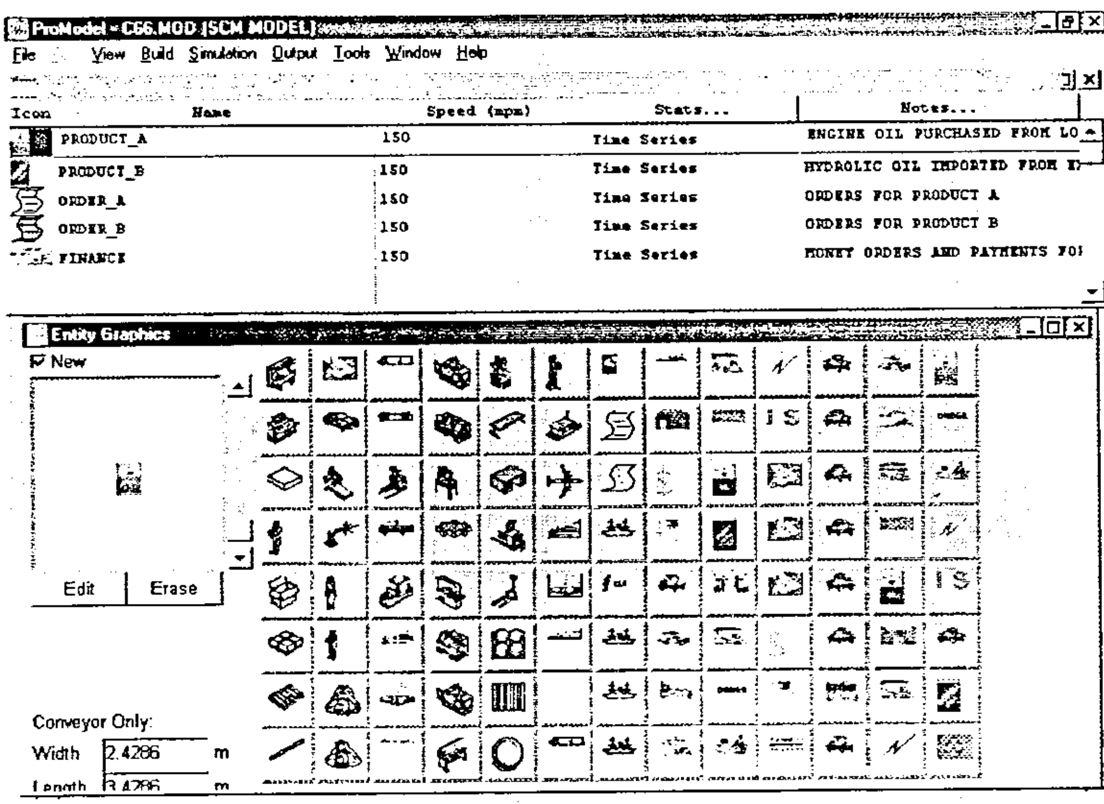


Figure (A-10) Entities screen

i. More Elements

This screen contains three main input screens. The attributes are shown in figure (A-11), several attributes were used to accomplish the model logic. For example ATF: refers to the attribute used for time elapsed during the financial process. Each attribute is described briefly to clarify its work in the program logic.

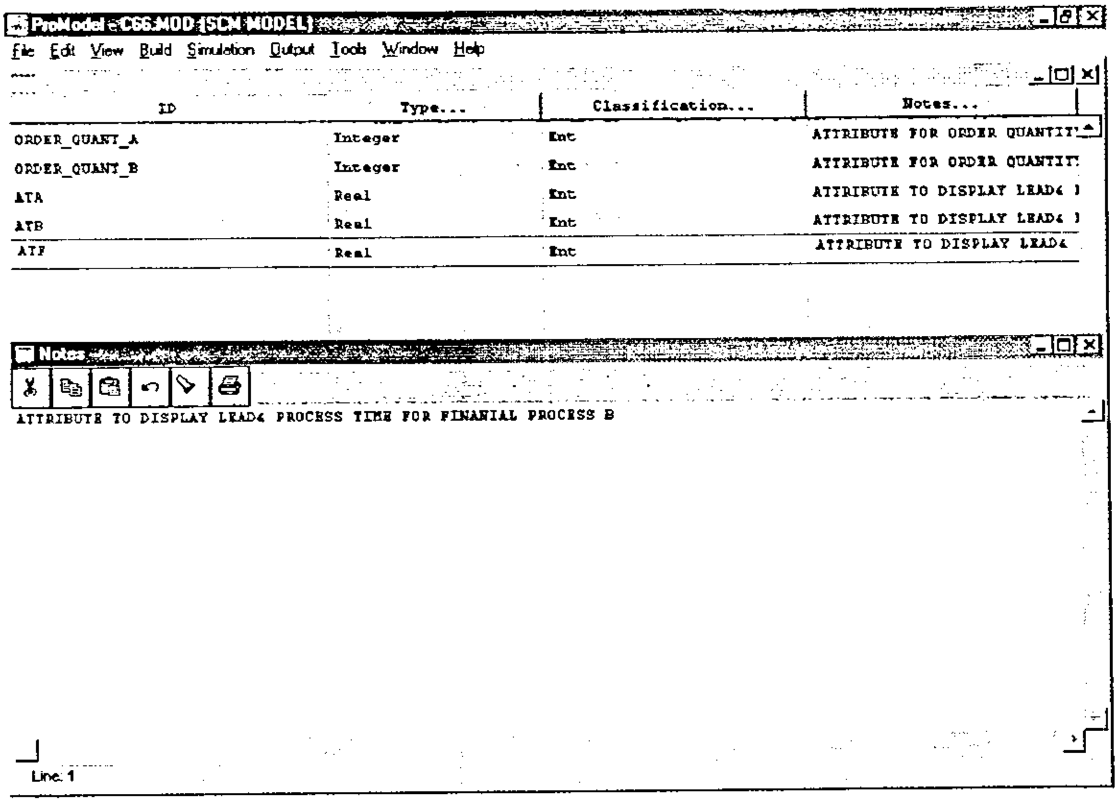


Figure (A-11) Attribute screen

In the Variable screen, the variety of variables used can be seen. They are divided into two main categories: the first category includes the inventory counters, for example BA1; represent the inventory level of product A at the base stores1. The second category includes dummy variables. These were used to ensure certain processes are accomplished as required. For example DUMMY_B: is used to ensure that no other orders are send to the external supplier requiring product B while there is an order under process. Figure (A-15) shows the variable screen.

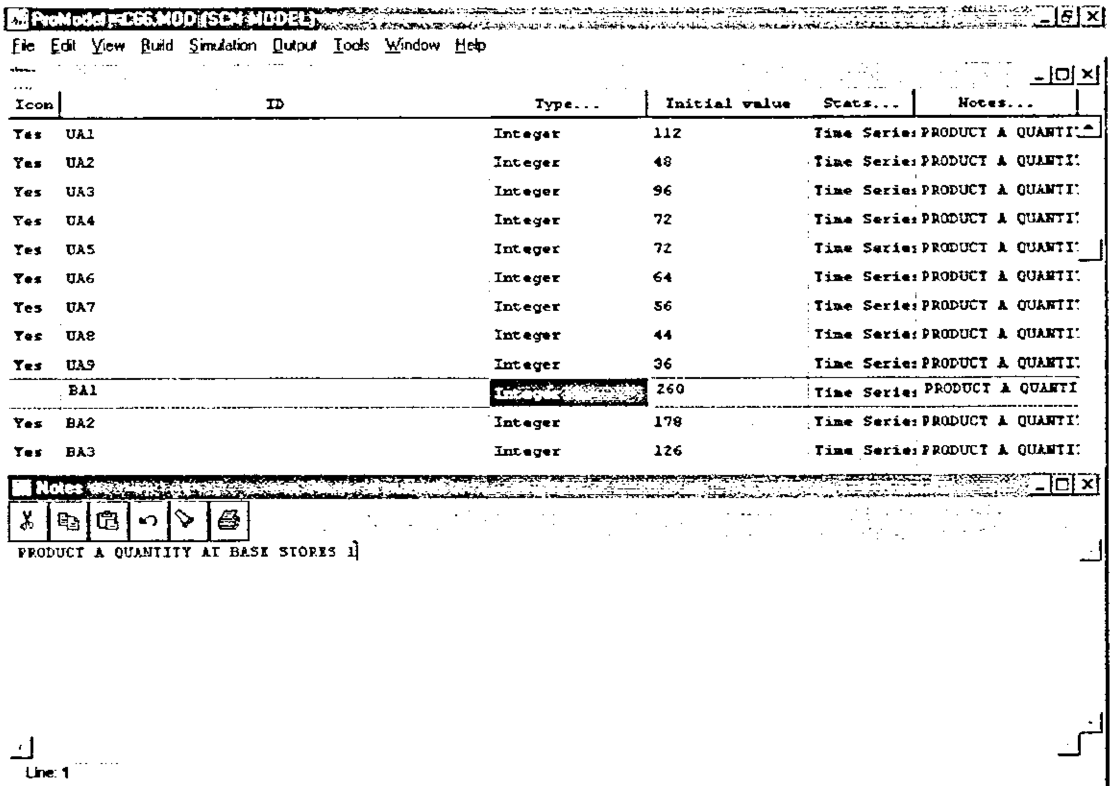


Figure (A-12) Variables screen

Macros were used to accomplish what if questions? For example RTI represents run –time interface. ure (A-13) shows this screen.

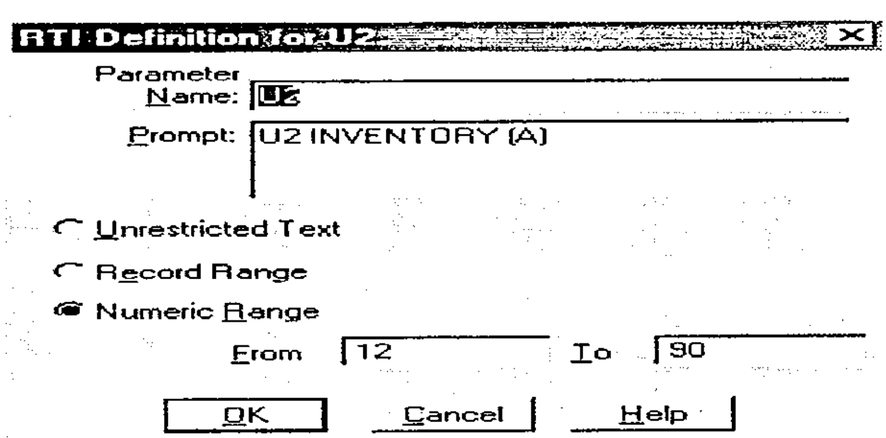


Figure (A-13) RTI of macros

j. Costs

Figure (A-14) shows the entry cost for each location, resource and entity, which is the initial or usage cost plus operation cost.

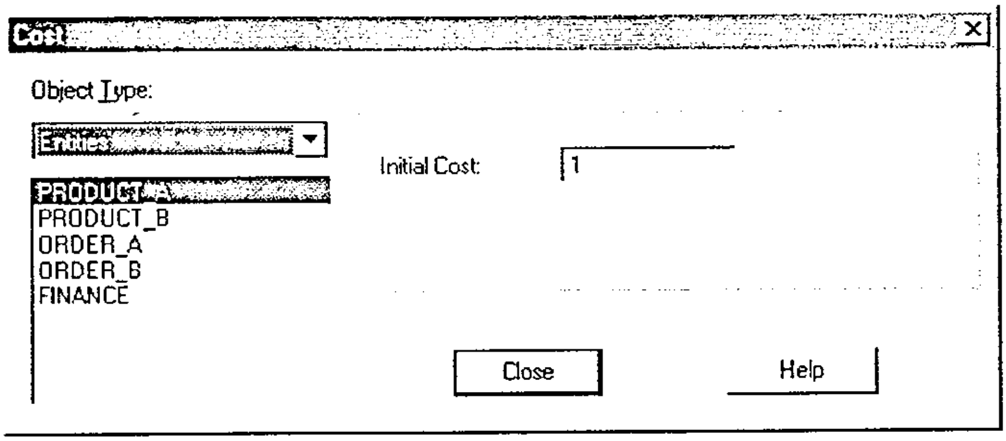


Figure (A-14) Cost screen

VI. Simulation Output

The performance measures of this model, as stated earlier in section 4.4, were average delay time, average inventory level, average cost, and the service level In this section the mean and standard deviation was taken from the model after running the simulation.

The simulation model was run 100 times, each for one year; the mean and standard deviation were taken. Therefore it is possible to find any confidence interval (C.I.) of the output data for the following performance measures:

- Table (A-8) shows mean, variance, and standard deviation for the average inventory level at each location.
- Table (A-9) shows mean, variance, a ·· ·andard deviation for the average delay time between locations.
- Table (A-10), (A-11), and (A-12) shows mean, variance, and standard deviation for the average cost.
- Table (A-13) shows mean, variance, and standard deviation for the minimum inventory value.

Table (A-8) Inventory level of product A

Location	Mean	STD
Unit1	176.97	15.3
Unit2	99.08	10.3
Unit3	126.31	10.7
Unit4	148.43	12.8
Unit5	148.13	14.2
Unit6	158.16	14.5
Unit7	108.63	9.7
Unit8	59.51	7.2
Unit9	59.34	9.1
Base1	533.17	14.42
Base2	581.36	17.43
Base3	286.65	21.59
Main stores	3119.64	57.00

Table (A-9) Delay time in hours

Delay time	Location		Mean	STD.
Order process time	Main stores	Local supplier	4.95	0.32
Financial process time	Main stores	Local supplier	9.89	0.41
Lead time	Main stores	Local supplier	21.07	0.41
Order process	Main stores	External supplier	49.57	8.49
Financial process	Main stores	External supplier	11.79	1.2
Shipping process time	Main stores	External supplier	9.74	1.4
Lead time	Main stores	External supplier	1078.72	85.49

Table (A-10) Inventory cost (JDs)

Location	Mean	STD.
Unit1	365.44	7.1
Unit2	364.96	7.3
Unit3	364.93	7.4
Unit4	364.97	6.2
Unit5	369.9	6.1
Unit6	365.00	6.3
Unit7	364.99	6.4
Unit8	365.01	6.7
Unit9	365.99	6.6
Base1	86.58	10.1
Base2	68.54	8.1
Base3	67.46	9.7
Main stores	291.09	13.3

Table (A-11) Resources cost (JDs)

Resource	Mean	STD
Truck	674.54	8.57
Pickup1	3386.35	25.99
Pickup2	2016.65	19.59
Pickup3	1604.09	19.48

The average total operation cost in JDs statistics is:

Mean 9794.89.

Standard deviation, 473.4

Table (A-12) Average entity cost (JDs)

Location	Mean	STD
Product A	27552.57	31.09
Product B	43674.94	50.38
Order A	765.36	68.4
Order B	797.07	35.82
Financial process	268.17	21

The average total cost statistics:

- Mean, 73058.12
- Standard deviation, 652.7

Location	Mean	STD
Unit1	38.13	2.45
Unit2	22.13	1.92
Unit3	30.6	2.46
Unit4	34.26	2.29
Unit5	34.81	2.31
Unit6	38.89	1.95
Unit7	24.19	1.82
Unit8	11.89	1.53
Unit9	13.77	1.27
Base1	44.82	5.68
Base2	157.86	14
Base3	25.8	3.39
Main stores	718.9	264.13

Table (A-13) Minimum inventory level of product A

Collected Data

The daily arrival quantity for product A and product B in all the nine units were gathered and tabulated. One example of detailed calculations for finding the appropriate distribution representing the data for the daily arrival quantity of product A at unit one is illustrated.

I. Collected Data

All the data were gathered from the quarter's reports prepared by directorate of supply at RAF. The data collected is supplied in this appendix.

Table (B-1): Unit 1 Data.

Year/ Quarter	Product A					Product B			
	1st.	2nd.	3rd.	4th.		1st.	2nd.	3rd.	4th.
2000	18	14	16	15		17	14	7	12
1999	15	16	12	13		12	17	4	6
1998	15	13	17	17		10	6	7	9
1997	11	16	14	8		7	9	13	7
1996	8	10	9	14		11	6	9	13

Table (B-2): Unit 2 Data.

Year/ Quarter	Product A					Product B			
	1st.	2nd.	3rd.	4th.		1st.	2nd.	3rd.	4th.
2000	8	6	11	9		3	1	5	5
1999	7	5	6	5		4	5	2	7
1998	6	3	5	2		2	4	2	2
1997	1	4	8	7		5	4	2	3
1996	7	7	7	1		2	6	5	1

Table (B-3): Unit 3 Data.

Year/ Quarter	Product A					Product B			
	1st.	2nd.	3rd.	4th.		1st.	2nd.	3rd.	4th.
2000	12	10	10	15		11	4	10	11
1999	10	10	12	14		11	5	11	11
1998	14	12	9	10		6	8	4	8
1997	9	9	15	14		6	11	9	8
1996	14	11	12	9		5	14	5	8

Table (B-4): Unit 4 Data.

Year/ Quarter	Product A					Product B			
	1st.	2nd.	3rd.	4th.		1st.	2nd.	3rd.	4th.
2000	10	9	9	9		10	4	10	10
1999	5	9	9	9		4	4	10	10
1998	9	2	11	5		6	4	5	3
1997	12	15	4	12		7	2	10	10
1996	6	12	12	3		10	7	1	4

Table (B-5): Unit 5 Data.

Year/ Quarter	Product A					Product B			
	1st.	2nd.	3rd.	4th.		1st.	2nd.	3rd.	4th.
2000	9	15	6	14		3	10	4	5
1999	5	14	5	9		1	3	3	7
1998	7	4	6	10		4	15	7	7
1997	8	6	11	4		4	9	7	3
1996	4	13	8	10		3	4	10	10

Table (B-6): Unit 6 Data.

Year/ Quarter	Product A					Product B			
	1st.	2nd.	3rd.	4th.		1st.	2nd.	3rd.	4th.
2000	13	8	16	7		9	8	7	10
1999	3	2	6	6		5	7	4	4
1998	5	7	15	7		5	6	2	1
1997	2	3	2	7		6	4	5	3
1996	3	8	14	9		2	8	2	1

Table (B-7): Unit 7 Data.

Year/ Quarter	Product A					Product B			
	1st.	2nd.	3rd.	4th.		1st.	2nd.	3rd.	4th.
2000	9	7	7	11		6	3	5	3
1999	7	9	7	2		3	6	4	3
1998	10	7	2	5		5	3	5	6
1997	2	11	6	5		4	5	3	3
1996	9	8	2	9		6	7	2	4

Table (B-8): Unit 8 Data.

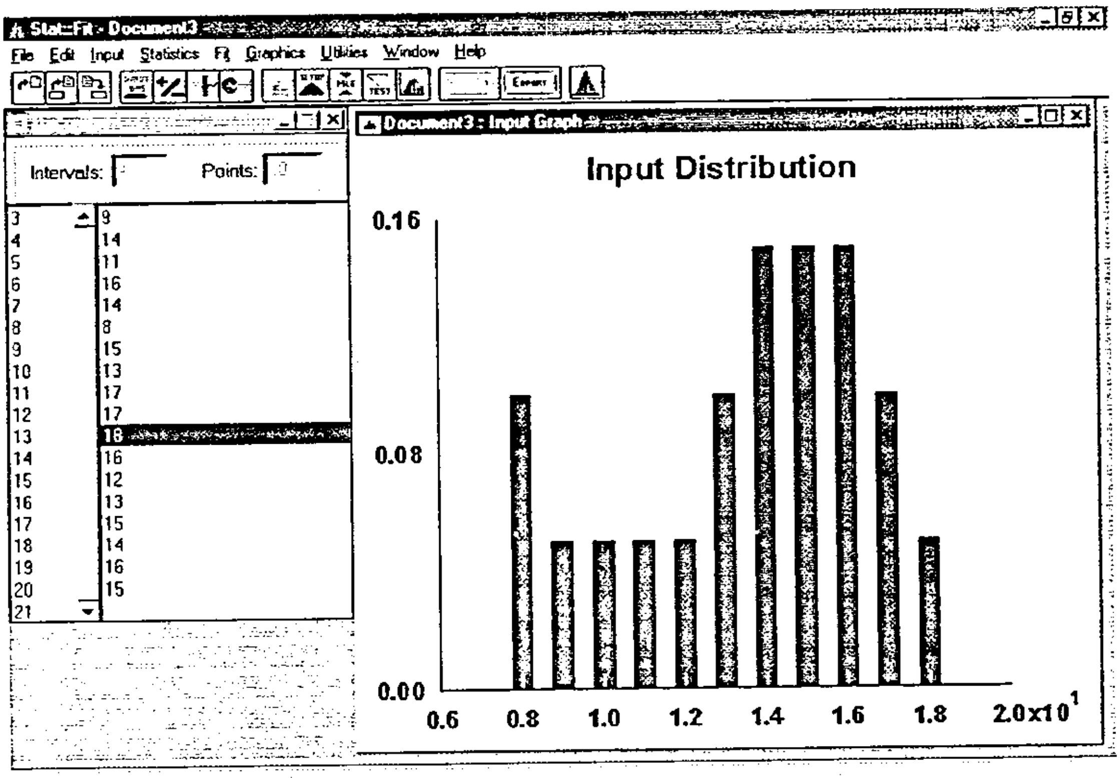
Year/ Quarter	Product A					Product B			
	1st.	2nd.	3rd.	4th.		1st.	2nd.	3rd.	4th.
2000	2	5	6	6		3	2	3	7
1999	6	6	1	6		3	1	3	1
1998	6	1	5	3		3	2	2	1
1997	3	2	4	1		2	1	5	2
1996	4	4	1	6		1	7	1	2

Table (B-9): Unit 9 Data.

Year/ Quarter	Product A					Product B			
	1st.	2nd.	3rd.	4th.		1st.	2nd.	3rd.	4th.
2000	6	3	2	2		2	6	3	1
1999	4	1	4	3		3	1	2	2
1998	2	2	1	2		3	3	1	1
1997	2	1	4	2		1	3	1	2
1996	3	6	1	2		1	2	1	1

II. Extended Example

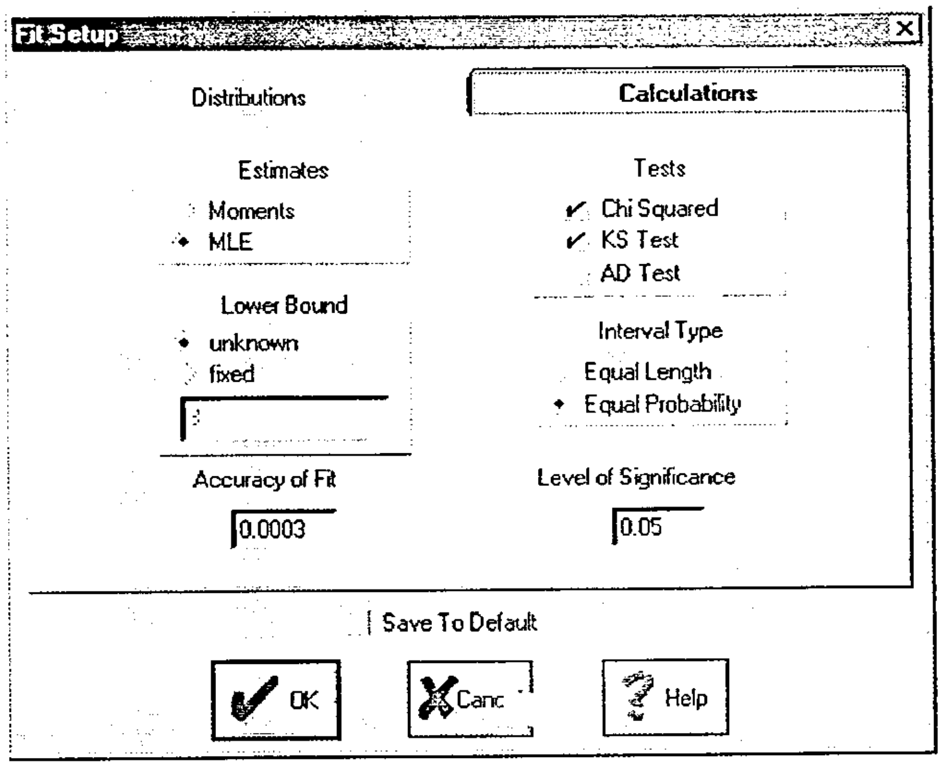
Following is an extended example illustrating how to fit a probabilistic distribution to the end users demand (arrival quantity) at unit1 using ProModel Stat Fit.
Figure (B-1) shows the input data and input data distribution.



The goodness of fit data are shown below:

Data points	20
Estimates	maximum likelihood estimates
Accuracy to fit	0.0003
Level of significance	0.05

Figure (B-2) The fit setup calculations used.



The goodness of fit summary are shown below:

Distribution	Chi squared	Kolmogorov smirnov(Ks)
Binomial (34, 0.399)	0.631(2)	0.0978
Discrete uniform (8,18)	1.71 (2)	0.155
Geometric (0.0687)	Not available	0.373
Poisson (13.6)	0.429 (2)	0.113

The goodness of fit details is as follows:

1.Binomial

n = 34

p = 0.398529

Chi squared

Total classes	11
Interval type	equal probable
Net bins	3
Chi**2	0.631
Degree of freedom	2
Alpha	0.05

Chi**2(2,0.05)	5.99
p-value	0.73
result	DO NOT REJECT

Kolmogorov-Smirnov

data point	20
Ks stat	0.0978
alpha	0.05
Ks stat (20,0.05)	0.294
p-value	0.981
result	DO NOT REJECT

2. Discrete Uniform

minimum = 8

maximum = 18

Chi squared

Total classes	11
Interval type	equal probable
Net bins	3
Chi**2	1.71
Degree of freedom	2
Alpha	0.05
Chi**2(2,0.05)	5.99
p-value	0.426
result	DO NOT REJECT

Kolmogorov-Smirnov

data point	20
Ks stat	0.155
alpha	0.05
Ks stat (20,0.05)	0.294
p-value	0.67
result	DO NOT REJECT

3. Geometric

p = 0.0687285

Chi squared

Too few intervals for chi squared test.

Kolmogorov-Smirnov

data point	20
Ks stat	0.373
alpha	0.05
Ks stat (20,0.05)	0.294
p-value	0.00523
result	REJECT

4. Poisson

lambda = 13.6

Chi squared

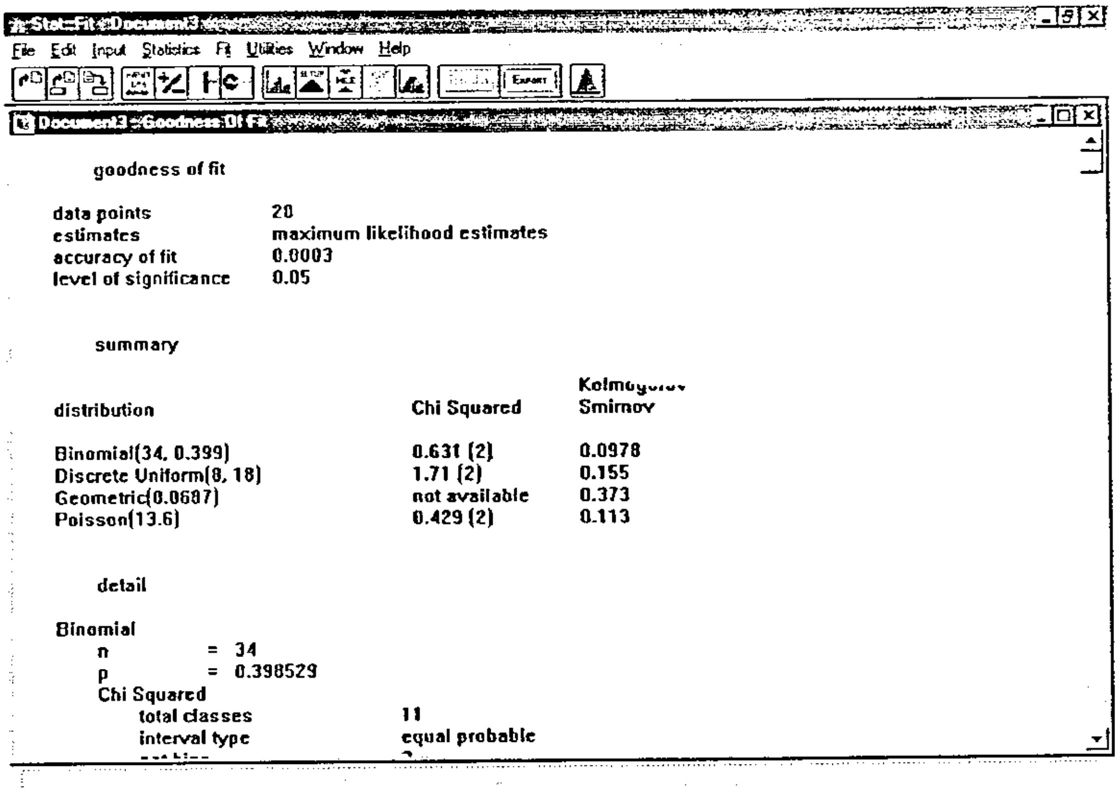
Total classes	11
Interval type	equal probable
Net bins	3

Chi**2	0.429
Degree of freedom	2
Alpha	0.05
Chi**2(2,0.05)	5.99
p-value	0.807
result	DO NOT REJECT

Kolmogorov-Smirnov

data point	20
Ks stat	0.113
alpha	0.05
Ks stat (20,0.05)	0.294
p-value	0.936
result	DO NOT REJECT

figure (B-3) : The goodness of fit test data.



The maximum likelihood estimate was fo· l to be as follows:

*	Binomial	n	=	34
		P	=	0.398529
*	Discrete Uniform	minimum	=	8
		Maximum	=	18
*	Geometric	p	=	0.0687285
*	Poisson	lambda	=	13.6

Figure (B-4): The maximum likelihood estimate.

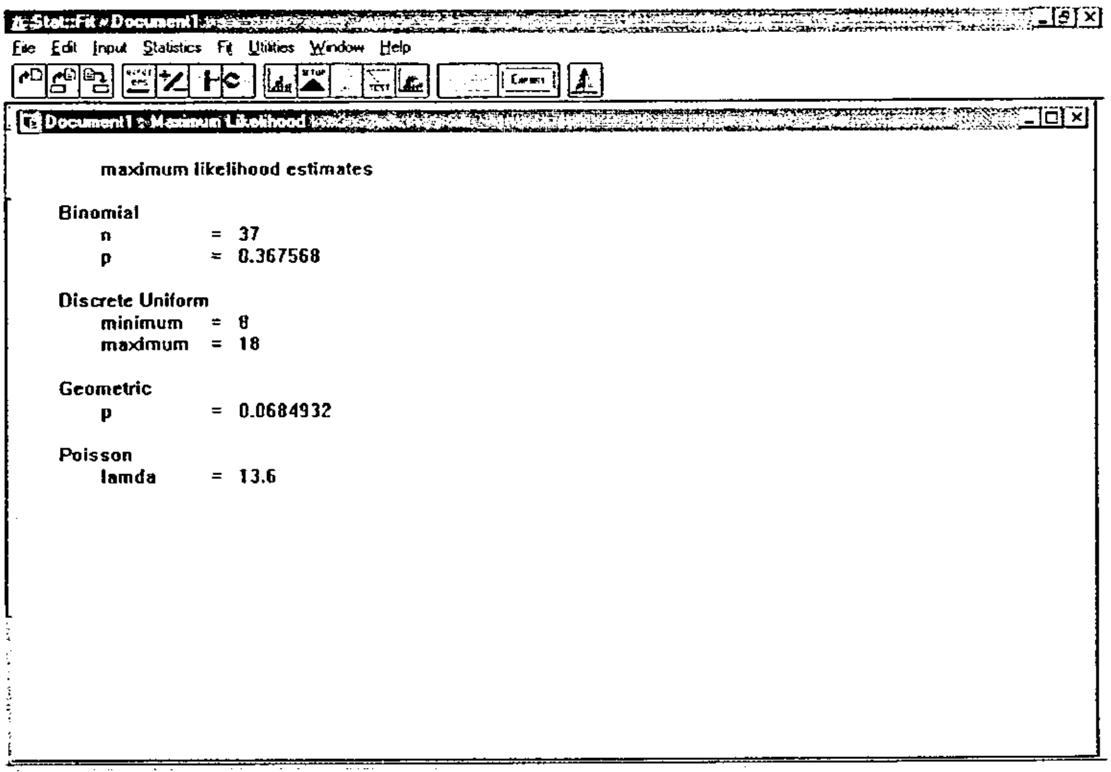
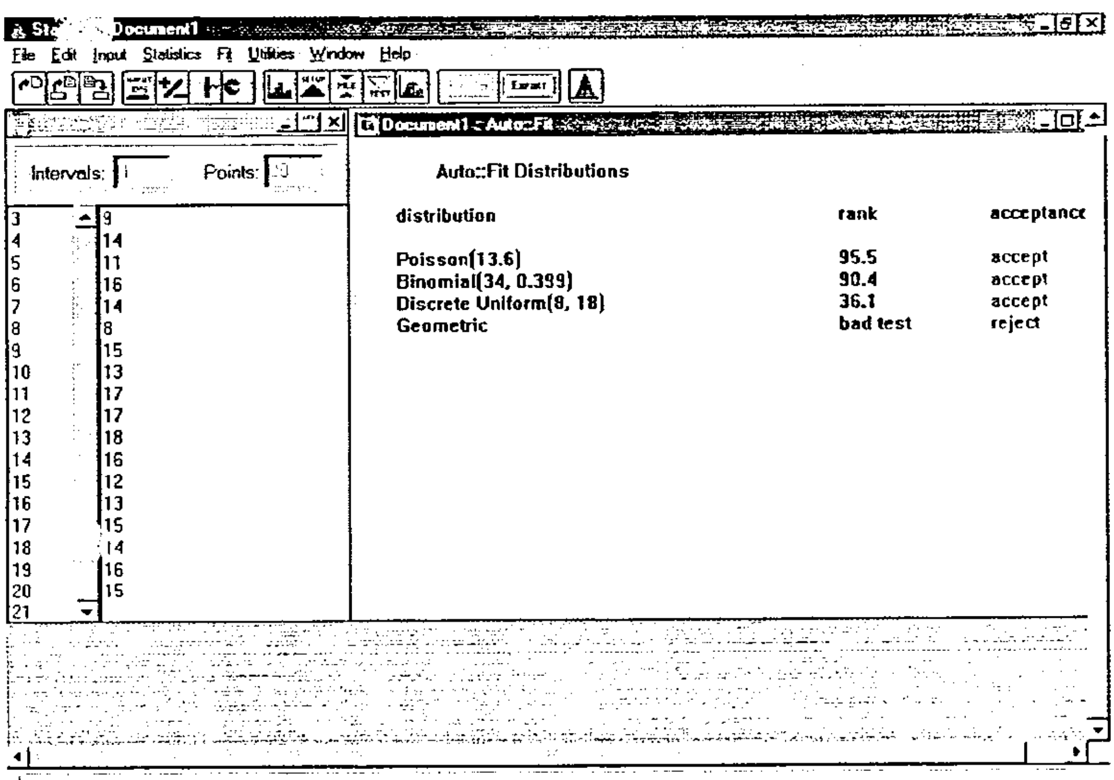


Figure (B-5): The data summary(fit distribution)



Therefore, the best distribution to be used is the Poisson distribution.

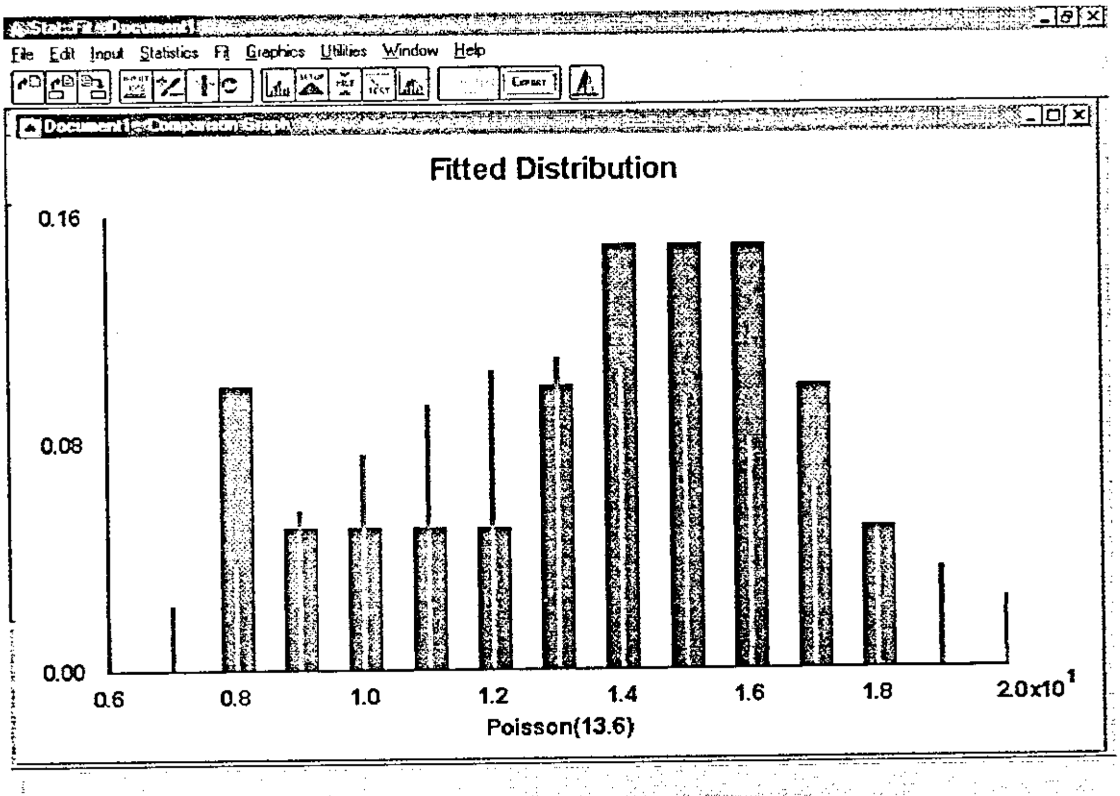


Figure (B-6) The fitted distribution of Poisson.

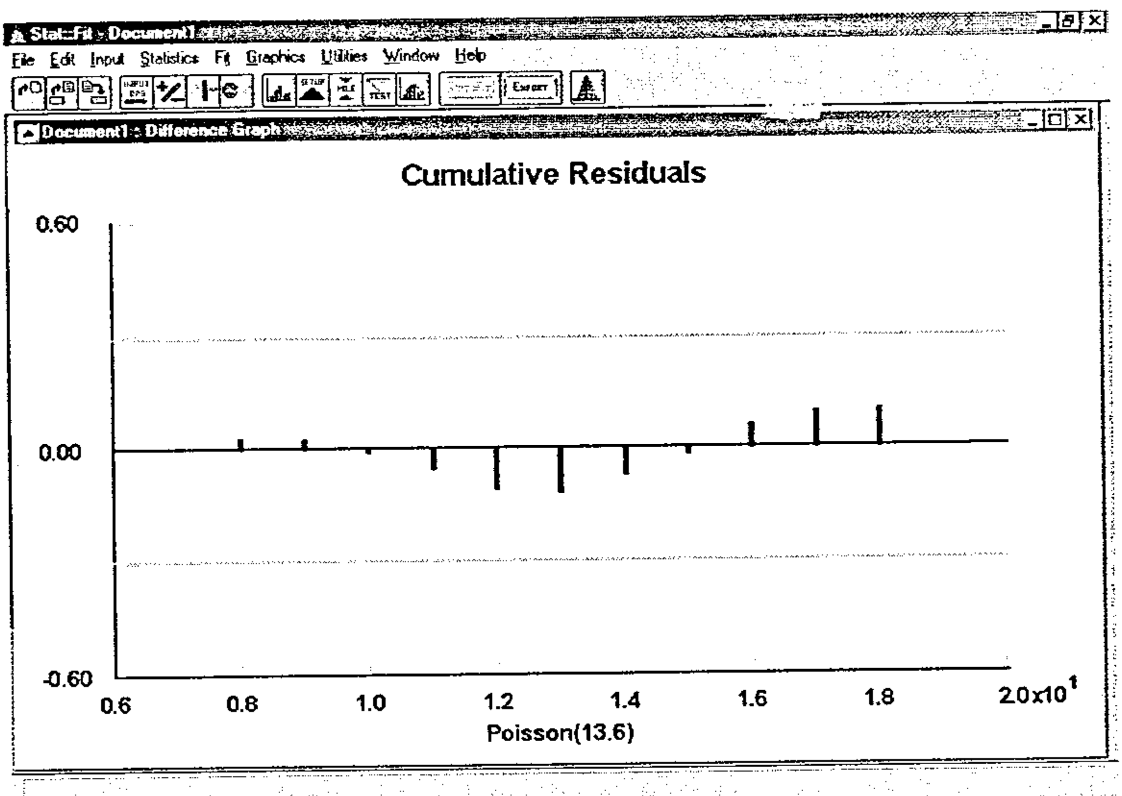


Figure (B-7) Cumulative residuals.

III. Comments

The difference in the daily demand in the same unit is due to the following reasons:

- Equipment transfers and changes from one place to another.
- Equipment may be supported by other units during training periods.
- Unserviceable equipment may take long time to be repaired due to the delay in spare parts support.
- The change in duty and tasks.

SIMULATION LOGIC AND DATA

```
********************************************************************************
*                                                                              *
*                         Formatted Listing of Model:                          *
*                E:\ProModel 2001\models\MODEL1 FINAL.MOD                      *
*                                                                              *
********************************************************************************

  Model Notes:
#
#                                    SCM MODEL
#The model is presented to describe the supply chain network for small and
 Medium size enterprises in Jordan .The model demonstrates the SCM process
 That include material and information flow between twenty locations. The
 Locations consist of two suppliers (external, and local), main stores,
 Three bases, nine units, three end users "to represent the customers", bank
 , And freight forwarder.
#Two types of products (product A, and B) are acquired, transformed, and
 Delivered to the end users. Financial and shipping processes are accomplished
 Through the bank and freight forwarder.
  Time Units:                        Hours
  Distance Units:                    Meters
  Initialization Logic:               activate animate_sub


********************************************************************************
*                                  Locations                                   *
********************************************************************************

  Name                 Cap  Units Stats        Rules      Cost
  -----------------  ---- ----- -----------  ---------- ------------
#
#EXTERNAL SUPPLIER (OUT SIDE JORDAN) :SUPPLY PRODUCT B
  EXTERNAL_SUPPLIER INF  1      Time Series Oldest, ,  0/hr
#
#FRIEGHTER IS RESPONSIBLE FOR SHIPPING  PRODUCT B FROM EXTERNAL SUPPLIER
  FRIEGHT_FORWORDER INF  1      Time Series Oldest, ,  0/hr
#
#LOCAL SUPPLIER (IN SIDE JORDAN) :SUPPLY PRODUCT A
  LOCAL_SUPPLIER    INF  1      Time Series Oldest, ,  0/hr
#
#MAIN STORES; RESPONSIPLE FOR STRATIGIC INVENTORY AND ORDER QUANTITY FROM
 LOCAL AND EXTERNAL SUPPLIERS
  MAIN_STORES       INF  1      Time Series Oldest, ,  25/day
#
#TO SEND MONEY TO EXTERNAL AND LOCAL SUPPLIERS(MONEY PAID FROM MAIN STORES
 FOR PRODUCT A&B):MONEY TRANSFERE.
  BANK              INF  1      Time Series Oldest, ,  0/day
#
#NORTH WAREHOUSES  AT BASE1 STORES THAT WILL SUPPLY PRODUCT A&B TO NORTH UNITS
  BASE_1            1000 1      Time Series Oldest, ,  17/day
#
#MIDDLE WAREHOUSES  AT BASE2 STORES THAT WILL SUPPLY PRODUCT A&B TO MIDDLE UNITS
  BASE_2            800  1      Time Series Oldest, ,  17/day
#
#SOUTH WAREHOUSES AT BASE1 STORES THAT WILL SUPPLY PRODUCT A&B TO SOUTH UNITS
  BASE_3            600  1      Time Series Oldest, ,  17/day
#
#UNIT1 STORES FOR BOTH PRODUCTS : A&B: MAINTENANCE SECTION STORES
  UNIT_1            500  1      Time Series Oldest, ,  1.5/day
#
#UNIT2 STORES FOR BOTH PRODUCTS : A&B: MAINTENANCE SECTION STORES
  UNIT_2            500  1      Time Series Oldest, ,  1.5/day
#
#UNIT3 STORES FOR BOTH PRODUCTS : A&B: MAINTENANCE SECTION STORES
  UNIT_3            500  1      Time Series Oldest, ,  1.5/day
#
#UNIT4 STORES FOR BOTH PRODUCTS : A&B: MAINTENANCE SECTION STORES
  UNIT_4            500  1      Time Series Oldest, ,  1.5/day
#
#UNIT5 STORES FOR BOTH PRODUCTS : A&B: MAINTENANCE SECTION STORES
  UNIT_5            500  1      Time Series Oldest, ,  1.5/day
#
#UNIT6 STORES FOR BOTH PRODUCTS : A&B: MAINTENANCE SECTION STORES
  UNIT_6            500  1      Time Series Oldest, ,  1.5/day
```

```
#
#UNIT71 STORES FOR BOTH PRODUCTS : A&B: MAINTENANCE SECTION STORES
  UNIT_7             500  1     Time Series Oldest, ,  1.5/day
#
#UNIT8 STORES FOR BOTH PRODUCTS : A&B: MAINTENANCE SECTION STORES
  UNIT_8             500  1     Time Series Oldest, ,  1.5/day
#
#UNIT9 STORES FOR BOTH PRODUCTS : A&B: MAINTENANCE SECTION STORES
  UNIT_9             500  1     Time Series Oldest, ,  1.5/day
#
#REPRESENTS THE END USER AT NORTH REGION: NORTH MAINTENANCE GROUPS(PESONNEL)
  END_USER_1         INF  1     Time Series Oldest, ,  0/day
#
#REPRESENTS THE END USER AT MIDDLE REGION: MIDDLE MAINTENANCE GROUPS(PESONNEL)
  END_USER_2         INF  1     Time Series Oldest, ,  0/day
#
#REPRESENTS THE END USER AT SOUTH REGION: SOUTH MAINTENANCE GROUPS(PESONNEL)
  END_USER_3         INF  1     Time Series Oldest, ,  0/day


*******************************************************************************
*                                   Entities                                  *
*******************************************************************************

  Name       Speed (mpm)  Stats       Cost
  ---------- ------------ ----------- ------------
#
#ENGINE OIL PURCHASED FROM LOCAL SUPPLIER
  PRODUCT_A  150          Time Series 1
#
#HYDROLIC OIL IMPORTED FROM EXTERNAL SUPPLIER
  PRODUCT_B  150          Time Series 2
#
#ORDERS FOR PRODUCT A
  ORDER_A    150          Time Series 21
#
#ORDERS FOR PRODUCT B
  ORDER_B    150          Time Series 34
#
#MONEY ORDERS AND PAYMENTS FOR SUPPLIERS
  FINANCE    150          Time Series 25


*******************************************************************************
*                                Path Networks                                *
*******************************************************************************

  Name     Type        T/S              From     To       BI   Dist/Time  Speed Factor
  -------- ----------- ---------------- -------- -------- ---- ---------- ------------
  Net1     Passing     speed & distance N1       N2       Bi   5000000    1
                                        N2       N3       Bi   375000     1
                                        N3       N4       Bi   130000     1
                                        N3       N5       Bi   12000      1
                                        N3       N6       Bi   150000     1
                                        N4       N7       Bi   23000      1
                                        N4       N8       Bi   38000      1
                                        N4       N9       Bi   44000      1
                                        N5       N10      Bi   25000      1
                                        N5       N11      Bi   31000      1
                                        N5       N12      Bi   40000      1
                                        N6       N14      Bi   60000      1
                                        N6       N15      Bi   15000      1
                                        N6       N16      Bi   110000     1
  Net2     Passing     Time             N1       N2       Bi   960


*******************************************************************************
*                                  Interfaces                                 *
*******************************************************************************

  Net        Node       Location
  ---------- ---------- ----------------
  Net1       N1         EXTERNAL_SUPPLIER
             N2         LOCAL_SUPPLIER
             N3         MAIN_STORES
             N4         BASE_1
             N5         BASE_2
```

```
                N6          BASE_3
                N7          UNIT_1
                N8          UNIT_2
                N9          UNIT_3
                N10         UNIT_4
                N11         UNIT_5
                N12         UNIT_6
                N14         UNIT_7
                N15         UNIT_8
                N16         UNIT_9
  Net2          N1          EXTERNAL_SUPPLIER
                N2          LOCAL_SUPPLIER

********************************************************************************
*                                  Resources                                   *
********************************************************************************

                                Res     Ent
  Name       Units Stats       Search  Search Path       Motion          Cost
  -------- ----- -------- ------- ------ ---------- -------------- ------------
 *
 *TO BRING PRODUCT B FRM EXTERNAL SUPPLIER
  SHIP       2     By Unit  Closest Oldest Net2       Empty: 86.8 mpm .155/day
                                          Home: N1   Full: 86.8 mpm  500/Use
                                          (Return)

 *
 *TO BRING PRODUCT A FRM LOCAL SUPPLIER
  Truck      2     By Unit  Closest Oldest Net1       Empty: 1150 mpm 0.1/day
                                          Home: N2   Full: 1050 mpm  50/Use
                                          (Return)

 *
 *TO SEND PRODUCTS TO THE BASE STORES
  PICKUP1   7     By Unit  Closest Oldest Net1       Empty: 1160 mpm 0.1/day
                                          Home: N3   Full: 1060 mpm  18/Use
                                          (Return)

 *
 *TO SEND PRODUCTS TO UNITS:1,2, AND 3.
  PICKUP2   4     By Unit  Closest Oldest Net1       Empty: 1160 mpm 0.1/day
                                          Home: N4   Full: 1060 mpm  18/Use
                                          (Return)

 *
 *TO SEND PRODUCTS TO UNIT7,UNIT8, AND UNIT9.
  PICKUP3   4     By Unit  Closest Oldest Net1       Empty: 1160 mpm 0.1/day
                                          Home: N6   Full: 1060 mpm  18/Use
                                          (Return)

********************************************************************************
*                                  Processing                                  *
********************************************************************************

                                     Process                           Routing

 Entity    Location          Operation            Blk  Output    Destination
Rule     Move Logic
 --------- ----------------- ------------------   ---- --------- ----------------- ---
----  ------------
 ORDER_A   END_USER_1        INC DV,1             1    ORDER_A   UNIT_1
TURN 1   MOVE FOR 1
                                                       ORDER_A   UNIT_2
TURN     MOVE FOR 1
                                                       ORDER_A   UNIT_3
TURN     MOVE FOR 1
 ORDER_A   UNIT_1            WAIT N(1,.1)
                             DEC UA1, ORDER_QUANT_A
                             IF UA1 <= 54 THEN ROUTE 1
                             IF UA1 > 54 THEN ROUTE 2
                             ELSE WAIT UNTIL UA1<=54

                                                  1    ORDER_A   BASE_1
TURN 2   MOVE FOR 1
```

```
                                                                   PRODUCT_A END_USER_1
TURN      MOVE FOR 1
                                                              2    PRODUCT_A END_USER_1
TURN 1    MOVE FOR 1

 ORDER_A   BASE_1            WAIT N(4,.2)
                             DEC BA1, 252
                             IF BA1 <= 252 AND DUMMY1=0 THEN ROUTE 1
                             ELSE ROUTE 2

                                                              1    ORDER_A   MAIN_STORES
TURN 2    INC DUMMY1,1

MOVE FOR 1
                                                                   PRODUCT_A UNIT_1
TURN      MOVE WITH PICKUP2 THEN FREE

INC UA1, 252

                                                              2    PRODUCT_A UNIT_1
TURN 2    MOVE WITH PICKUP2 THEN FREE

INC UA1,252
                                                                   ORDER_A   EXIT
TURN
 ORDER_A   UNIT_2            WAIT N(1,.1)
                             DEC UA2, ORDER_QUANT_A
                             IF UA2 <= 30 THEN ROUTE 1
                             IF UA2 > 30 THEN ROUTE 2
                             ELSE WAIT UNTIL UA2<=30
                                                              1    ORDER_A   BASE_1
TURN 2    MOVE FOR 1
                                                                   PRODUCT_A END_USER_1
TURN      MOVE FOR 1

                                                              2    PRODUCT_A END_USER_1
FIRST 1   MOVE FOR 1

 ORDER_A   BASE_1            WAIT N(4,.2)
                             DEC BA1, 140
                             IF BA1 <=252 AND DUMMY1=0 THEN ROUTE 1
                             ELSE ROUTE 2

                                                              1    ORDER_A   MAIN_STORES
TURN 2    INC DUMMY1,1

MOVE FOR 1

                                                                   PRODUCT_A UNIT_2
TURN      MOVE WITH PICKUP2 THEN FREE

INC UA2,140

                                                              2    PRODUCT_A UNIT_2
TURN 2    MOVE WITH PICKUP2 THEN FREE

INC UA2,140

                                                                   ORDER_A   EXIT
TURN
 ORDER_A   UNIT_3            WAIT N(1,.1)
                             DEC UA3, ORDER_QUANT_A
                             IF UA3 <= 45 THEN ROUTE 1
                             IF UA3 > 45 THEN ROUTE 2
                             ELSE WAIT UNTIL UA3<=45
                                                              1    ORDER_A   BASE_1
TURN 2    MOVE FOR 1
                                                                   PRODUCT_A END_USER_1
TURN      MOVE FOR 1

                                                              2    PRODUCT_A END_USER_1
FIRST 1   MOVE FOR 1
```

```
 ORDER_A   BASE_1           WAIT N(4,.2)
                            DEC BA1, 210
                            IF BA1 <=252 AND DUMMY1=0 THEN ROUTE 1
                            ELSE ROUTE 2
                                                  1    ORDER_A   MAIN_STORES
TURN 2   MOVE FOR 1

INC DUMMY1,1

                                                       PRODUCT_A UNIT_3
TURN     MOVE WITH PICKUP2 THEN FREE

INC UA3, 168

                                                  2    PRODUCT_A UNIT_3
TURN 2   MOVE WITH PICKUP2 THEN FREE

INC UA3, 168

                                                       ORDER_A   EXIT
TURN
 ORDER_A   MAIN_STORES      WAIT N(4,.2)
                            DEC MA, 602
                            IF MA <= 1120 AND DUMMY_A=0 THEN ROUTE 1
                            ELSE ROUTE 2

                                                  1    ORDER_A   LOCAL_SUPPLIER
TURN 2   INC DUMMY_A,1

MOVE FOR 1

                                                       PRODUCT_A BASE_1
TURN     MOVE WITH PICKUP1 THEN FREE

INC BA1, 602

DEC DUMMY1,1
                                                  2    PRODUCT_A BASE_1
TURN 2   MOVE WITH PICKUP1 THEN FREE

INC BA1, 602

DEC DUMMY1,1
                                                       ORDER_A   EXIT
TURN
 PRODUCT_A BASE_1                                 1    PRODUCT_A EXIT
FIRST 1
 PRODUCT_A UNIT_1                                 1    PRODUCT_A EXIT
FIRST 1
 PRODUCT_A UNIT_2                                 1    PRODUCT_A EXIT
FIRST 1
 PRODUCT_A UNIT_3                                 1    PRODUCT_A EXIT
FIRST 1
 PRODUCT_A END_USER_1                             1    PRODUCT_A EXIT
FIRST 1
 ORDER_A   END_USER_2                             1    ORDER_A   UNIT_4
TURN 1   MOVE FOR 1
                                                       ORDER_A   UNIT_5
TURN     MOVE FOR 1
                                                       ORDER_A   UNIT_6
TURN     MOVE FOR 1
 ORDER_A   UNIT_4           WAIT N(1,.1)
                            DEC UA4, ORDER_QUANT_A
                            IF UA4 <= 45 THEN ROUTE 1
                            IF UA4 > 45 THEN ROUTE 2
                            ELSE WAIT UNTIL UA4<=45
                                                  1    ORDER_A   BASE_2
TURN 2   MOVE FOR 1
                                                       PRODUCT_A END_USER_2
TURN     MOVE FOR 1

                                                  2    PRODUCT_A END_USER_2
FIRST 1  MOVE FOR 1

 ORDER_A   BASE_2           WAIT N(4,.2)
                            DEC BA2, 210
```

```
                              IF BA2 <= 224 AND DUMMY2=0 THEN ROUTE 1
                              ELSE ROUTE 2
                                                   1     ORDER_A    MAIN_STORES
TURN 2    MOVE FOR 1

INC DUMMY2,1
                                                         PRODUCT_A UNIT_4
TURN      MOVE WITH PICKUP1 THEN FREE

INC UA4,210

                                                   2     PRODUCT_A UNIT_4
TURN 2    MOVE WITH PICKUP1 THEN FREE

INC UA4,210

                                                         ORDER_A    EXIT
TURN
 ORDER_A    UNIT_5            WAIT N(1,.1)
                              DEC UA5, ORDER_QUANT_A
                              IF UA5 <= 45 THEN ROUTE 1
                              IF UA5 > 45 THEN ROUTE 2
                              ELSE WAIT UNTIL UA5<=45
                                                   1     ORDER_A    BASE_2
TURN 2    MOVE FOR 1
                                                         PRODUCT_A END_USER_2
TURN      MOVE FOR 1

                                                   2     PRODUCT_A END_USER_2
FIRST 1   MOVE FOR 1

 ORDER_A    BASE_2            WAIT N(4,.2)
                              DEC BA2,210
                              IF BA2 <= 224 AND DUMMY2=0 THEN ROUTE 1
                              ELSE ROUTE 2
                                                   1     ORDER_A    MAIN_STORES
TURN 2    MOVE FOR 1

INC DUMMY2,1
                                                         PRODUCT_A UNIT_5
TURN      MOVE WITH PICKUP1 THEN FREE

INC UA5, 210

                                                   2     PRODUCT_A UNIT_5
TURN 2    MOVE WITH PICKUP1 THEN FREE

INC UA5, 210

                                                         ORDER_A    EXIT
TURN
 ORDER_A    UNIT_6            WAIT N(1,.1)
                              DEC UA6, ORDER_QUANT_A
                              IF UA6 <= 48 THEN ROUTE 1
                              IF UA6 > 48 THEN ROUTE 2
                              ELSE WAIT UNTIL UA6<=48
                                                   1     ORDER_A    BASE_2
TURN 2    MOVE FOR 1
                                                         PRODUCT_A END_USER_2
TURN      MOVE FOR 1



                                                         PRODUCT_A END_USER_2
FIRST 1   MOVE FOR 1

 ORDER_A    BASE_2            WAIT N(4,.2)
                              DEC BA2, 224
                              IF BA2 <= 224 AND DUMMY2=0 THEN ROUTE 1
                              ELSE ROUTE 2
                                                   1     ORDER_A    MAIN_STORES
TURN 2    MOVE FOR 1

INC DUMMY2,1
                                                         PRODUCT_A UNIT_6
TURN      MOVE WITH PICKUP1 THEN FREE
```

```
INC UA6,224
                                                        2     PRODUCT_A UNIT_6
TURN 2   MOVE WITH PICKUP1 THEN FREE

INC UA6,224

                                                              ORDER_A   EXIT
TURN
 ORDER_A   MAIN_STORES        WAIT N(4,.2)
                              DEC MA, 644
                              IF MA <= 1120 AND DUMMY_A=0 THEN ROUTE 1
                              ELSE ROUTE 2
                                                        1     ORDER_A   LOCAL_SUPPLIER
TURN 2   MOVE FOR 1

INC DUMMY_A,1

                                                              PRODUCT_A BASE_2
TURN     MOVE WITH PICKUP1 THEN FREE

INC BA2, 644

DEC DUMMY2,1
                                                        2     PRODUCT_A BASE_2
TURN 2   MOVE WITH PICKUP1 THEN FREE

INC BA2, 644

DEC DUMMY2,1
                                                              ORDER_A   EXIT
TURN
 PRODUCT_A BASE_2                                       1     PRODUCT_A EXIT
FIRST 1
 PRODUCT_A UNIT_4                                       1     PRODUCT_A EXIT
FIRST 1
 PRODUCT_A UNIT_5                                       1     PRODUCT_A EXIT
FIRST 1
 PRODUCT_A UNIT_6                                       1     PRODUCT_A EXIT
FIRST 1
 PROD'    \ END_USER_2        wait 8767                 1     PRODUCT_A EXIT
FIRST 1
 ORDER_A   END_USER_3                                   1     ORDER_A   UNIT_7
TURN 1   MOVE FOR 1
                                                              ORDER_A   UNIT_8
TURN     MOVE FOR 1
                                                              ORDER_A   UNIT_9
TURN     MOVE FOR 1
 ORDER_A   UNIT_7             WAIT N(1,.1)
                              DEC UA7, ORDER_QUANT_A
                              IF UA7 <= 33 THEN ROUTE 1
                              IF UA7 > 33 THEN ROUTE 2
                              ELSE WAIT UNTIL UA7<=33
                                                        1     ORDER_A   BASE_3
TURN 2   MOVE FOR 1
                                                              PRODUCT_A END_USER_3
TURN     MOVE FOR 1

                                                        2     PRODUCT_A END_USER_3
FIRST 1  MOVE FOR 1

 ORDER ^   BASE_3             WAIT N(4,.2)
                              DEC BA3, 154
                              IF BA3 <= 154 AND DUMMY3=0 THEN ROUTE 1
                              ELSE ROUTE 2
                                                        1     ORDER_A   MAIN_STORES
TURN 2   MOVE FOR 1

INC DUMMY3,1
                                                              PRODUCT_A UNIT_7
TURN     MOVE WITH PICKUP3 THEN FREE

INC UA7,154

                                                        2     PRODUCT_A UNIT_7
TURN 2   MOVE WITH PICKUP3 THEN FREE
```

```
INC UA7,154
                                                                  ORDER_A   EXIT
TURN
 ORDER_A   UNIT_8               WAIT N(1,.1)
                                DEC UA8, ORDER_QUANT_A
                                IF UA8 <= 18 THEN ROUTE 1
                                IF UA8 > 18 THEN ROUTE 2
                                ELSE WAIT UNTIL UA8<=18
                                                             1    ORDER_A   BASE_3
TURN 2   MOVE FOR 1
                                                                  PRODUCT_A END_USER_3
TURN     MOVE FOR 1

                                                             2    PRODUCT_A END_USER_3
FIRST 1  MOVE FOR 1

 ORDER_A   BASE_3               WAIT N(4,.2)
                                DEC BA3,84
                                IF BA3 <= 154 AND DUMMY3=0 THEN ROUTE 1
                                ELSE ROUTE 2
                                                             1    ORDER_A   MAIN_STORES
TURN 2   MOVE FOR 1

INC DUMMY3,1
                                                                  PRODUCT_A UNIT_8
TURN     MOVE WITH PICKUP3 THEN FREE

INC UA8, 84

                                                             2    PRODUCT_A UNIT_8
TURN 2   MOVE WITH PICKUP3 THEN FREE

INC UA8, 84

                                                                  ORDER_A   EXIT
TURN
 ORDER_A   UNIT_9               WAIT N(1,.1)
                                DEC UA9, ORDER_QUANT_A
                                IF UA9 <= 18 THEN ROUTE 1
                                IF UA9 > 18 THEN ROUTE 2
                                ELSE WAIT UNTIL UA9<=18
                                                             1    ORDER_A   BASE_3
TURN 2   MOVE FOR 1
                                                                  PRODUCT_A END_USER_3
TURN     MOVE FOR 1

                                                             2    PRODUCT_A END_USER_3
FIRST 1  MOVE FOR 1

 ORDER_A   BASE_3               WAIT N(4,.2)
                                DEC BA3, 84
                                IF BA3 <= 154 AND DUMMY3=0 THEN ROUTE 1
                                ELSE ROUTE 2
                                                             1    ORDER_A   MAIN_STORES
TURN 2   MOVE FOR 1

INC DUMMY3,1
                                                                  PRODUCT_A UNIT_9
TURN     MOVE WITH PICKUP3 THEN FREE

INC UA9,84

                                                             2    PRODUCT_A UNIT_9
TURN 2   MOVE WITH PICKUP3 THEN FREE

INC UA9,84

                                                                  ORDER_A   EXIT
TURN
 ORDER_A   MAIN_STORES          WAIT N(4,.2)
                                DEC MA, 322
                                IF MA <= 1120 AND DUMMY_A=0 THEN ROUTE 1
                                ELSE ROUTE 2
                                                             1    ORDER_A   LOCAL_SUPPLIER
TURN 2   MOVE FOR 1
```

```
INC DUMMY_A,1
                                                                      PRODUCT_A BASE_3
TURN      MOVE WITH PICKUP1 THEN FREE

INC BA3,322

DEC DUMMY3,1
                                                              2     PRODUCT_A BASE_3
TURN 2    MOVE WITH PICKUP1 THEN FREE

INC BA3,322

DEC DUMMY3,1
                                                                    ORDER_A    EXIT
TURN
 PRODUCT_A BASE_3                                             1     PRODUCT_A EXIT
FIRST 1
 PRODUCT_A UNIT_7                                             1     PRODUCT_A EXIT
FIRST 1
 PRODUCT_A UNIT_8                                             1     PRODUCT_A EXIT
FIRST 1
 PRODUCT_A UNIT_9                                             1     PRODUCT_A EXIT
FIRST 1
 PRODUCT_A END_USER_3          wait 8767                      1     PRODUCT_A EXIT
FIRST 1
 ORDER_A   LOCAL_SUPPLIER      ATA=CLOCK()
                               WAIT N(6,.2)
                               GRAPHIC 3

                                                              1     ORDER_A    MAIN_STORES
FIRST 1  MOVE FOR 1
 ORDER_A   MAIN_STORES         WAIT N(4,.2)
                               LOG"ORDER A PROCESS TIME M&L",ATA
                                                              1     FINANCE    BANK
TURN 2   MOVE FOR 1
                                                                    ORDER_A    EXIT
TURN
 FINANCE   BANK                WAIT N(4,.2)
                               GRAPHIC 3                      1     FINANCE    LOCAL_SUPPLIER
FIRST 1  MOVE FOR 1
 FINANCE   LOCAL_  PLIER       LOG"FINANCIAL PROCESS TIME  M&L",ATA
                               WAIT N(4,.2)
                               DEC LA,3360
                                                              1     PRODUCT_A MAIN_STORES
FIRST 1  MOVE WITH TRUCK THEN FREE

INC MA, 3360

DEC DUMMY_A,1

LOG"TOTAL LEAD TIME M&L",ATA
 PRODUCT_A MAIN_STORES         wait 8770                      1     PRODUCT_A EXIT
FIRST 1
 ORDER_B   END_USER_1                                         1     ORDER_B    UNIT_1
TURN 1   MOVE FOR 1
                                                                    ORDER_B    UNIT_2
TURN     MOVE FOR 1
                                                                    ORDER_B    UNIT_3
TURN     MOVE FOR 1
 ORDER_B   UNIT_1              WAIT N(1,.1)
                               DEC UB1, ORDER_QUANT_B
                               IF UB1 <= 51 THEN ROUTE 1
                               IF UB1 > 51 THEN ROUTE 2
                               ELSE WAIT UNTIL UB1<=51
                                                              1     ORDER_B    BASE_1
TURN 2   MOVE FOR 1
                                                                    PRODUCT_B END_USER_1
TURN     MOVE FOR 1
                                                              2     PRODUCT_B END_USER_1
FIRST 1  MOVE FOR 1
 ORDER_B   BASE_1              WAIT N(4,.2)
                               DEC BB1, 238
                               IF BB1 <= 238 AND DUMMY4=0 THEN ROUTE 1
                               ELSE ROUTE 2
                                                              1     ORDER_B    MAIN_STORES
TURN 2   INC DUMMY4,1
```

```
MOVE FOR 1
                                                                  PRODUCT_B UNIT_1
TURN      MOVE WITH PICKUP2 THEN FREE

INC UB1,238
                                                             2    PRODUCT_B UNIT_1
TURN 2    MOVE WITH PICKUP2 THEN FREE

INC UB1,238
                                                                  ORDER_B   EXIT
TURN
 ORDER_B   UNIT_2              WAIT N(1,.1)
                               DEC UB2, ORDER_QUANT_B
                               IF UB2 <= 21 THEN ROUTE 1
                               IF UB2 > 21 THEN ROUTE 2
                               ELSE WAIT UNTIL UB2<=21
                                                             1    ORDER_B   BASE_1
TURN 2    MOVE FOR 1
                                                                  PRODUCT_B END_USER_1
TURN      MOVE FOR 1
                                                             2    PRODUCT_B END_USER_1
FIRST 1   MOVE FOR 1
 ORDER_B   BASE_1              WAIT N(4,.2)
                               DEC BB1,98
                               IF BB1 <= 238 AND DUMMY4=0 THEN ROUTE 1
                               ELSE ROUTE 2
                                                             1    ORDER_B   MAIN_STORES
TURN 2    INC DUMMY4,1

MOVE FOR 1

                                                                  PRODUCT_B UNIT_2
TURN      MOVE WITH PICKUP2 THEN FREE

INC UB2,98
                                                             2    PRODUCT_B UNIT_2
TURN 2    MOVE WITH PICKUP2 THEN FREE

INC UB2,98
                                                                  ORDER_B   EXIT
TURN
 ORDER_B   UNIT_3              WAIT N(1,.1)
                               DEC UB3, ORDER_QUANT_B
                               IF UB3 <= 42 THEN ROUTE 1
                               IF UB3 > 42 THEN ROUTE 2
                               ELSE WAIT UNTIL UB3<=42
                                                             1    ORDER_B   BASE_1
TURN 2    MOVE FOR 1
                                                                  PRODUCT_B END_USER_1
TURN      MOVE FOR 1
                                                             2    PRODUCT_B END_USER_1
FIRST 1   MOVE FOR 1
 ORDER_B   BASE_1              WAIT N(4,.2)
                               DEC BB1,196
                               IF BB1 <= 238 AND DUMMY4=0 THEN ROUTE 1
                               ELSE ROUTE 2
                                                             1    ORDER_B   MAIN_STORES
TURN 2    INC DUMMY4,1

MOVE FOR 1

                                                                  PRODUCT_B UNIT_3
TURN      MOVE WITH PICKUP2 THEN FREE

INC UB3,196
                                                             2    PRODUCT_B UNIT_3
FIRST 1   MOVE WITH PICKUP2 THEN FREE

INC UB3,196
 ORDER_B   MAIN_STORES         WAIT N(4,.2)
                               DEC MB, 532
                               IF MB <= 4092 AND DUMMY_B=0 THEN ROUTE 1
                               ELSE ROUTE 2             1    ORDER_B   EXTERNAL_SUPPLIER
TURN 2    MOVE FOR 1
```

```
INC DUMMY_B,1
                                                                PRODUCT_B BASE_1
TURN      MOVE WITH PICKUP1 THEN FREE

INC BB1,532

DEC DUMMY4,1
                                                          2     PRODUCT_B BASE_1
TURN 2    MOVE WITH PICKUP1 THEN FREE

INC BB1,532

DEC DUMMY4,1
                                                                ORDER_B   EXIT
TURN
 PRODUCT_B BASE_1                                         1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B UNIT_1                                         1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B UNIT_2                                         1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B UNIT_3                                         1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B END_USER_1        wait 8767                    1     PRODUCT_B EXIT
FIRST 1
 ORDER_B   END_USER_2                                     1     ORDER_B   UNIT_4
TURN 1    MOVE FOR 1
                                                                ORDER_B   UNIT_5
TURN      MOVE FOR 1
                                                                ORDER_B   UNIT_6
TURN      MOVE FOR 1
 ORDER_B   UNIT_4            WAIT N(1,.1)
                             DEC UB4, ORDER_QUANT_B
                             IF UB4 <= 30 THEN ROUTE 1
                             IF UB4 > 30 THEN ROUTE 2
                             ELSE WAIT UNTIL UB4<=30
                                                          1     ORDER_B   BASE_2
TURN 2    MOVE FOR 1
                                                                PRODUCT_B END_USER_2
TURN      MOVE FOR 1
                                                          2     PRODUCT_B END_USER_2
FIRST 1   MOVE FOR 1
 ORDER_B   BASE_2            WAIT N(4,.2)
                             DEC BB2, 140
                             IF BB2 <= 210 AND DUMMY5=0 THEN ROUTE 1
                             ELSE ROUTE 2
                                                          1     ORDER_B   MAIN_STORES
TURN 2    MOVE FOR 1

INC DUMMY5,1
                                                                PRODUCT_B UNIT_4
TURN      MOVE WITH PICKUP1 THEN FREE

INC UB4,140
                                                          2     PRODUCT_B UNIT_4
TURN 2    MOVE WITH PICKUP1 THEN FREE

INC UB4,140
                                                                ORDER_B   EXIT
TURN
 ORDER_B   UNIT_5             AIT N(1,.1)
                             DEC UB5, ORDER_QUANT_B
                             IF UB5 <= 45 THEN ROUTE 1
                             IF UB5 > 45 THEN ROUTE 2
                             ELSE WAIT UNTIL UB5<=45
                                                          1     ORDER_B   BASE_2
TURN 2    MOVE FOR 1
                                                                PRODUCT_B END_USER_2
TURN      MOVE FOR 1
                                                          2     PRODUCT_B END_USER_2
FIRST 1   MOVE FOR 1
 ORDER_B   BASE_2            WAIT N(4,.2)
                             DEC BB2,210
                             IF BB2 <= 210 AND DUMMY5=0 THEN ROUTE 1
```

```
                              ELSE ROUTE 2          1     ORDER_B    MAIN_STORES
TURN 2    MOVE FOR 1

INC DUMMY5,1
                                                          PRODUCT_B UNIT_5
TURN      MOVE WITH PICKUP1 THEN FREE

INC UB5,210
                                                    2     PRODUCT_B UNIT_5
TURN 2    MOVE WITH PICKUP1 THEN FREE

INC UB5,210
                                                          ORDER_B    EXIT
TURN
 ORDER_B    UNIT_6            WAIT N(1,.1)
                              DEC UB6, ORDER_QUANT_B
                              IF UB6 <= 30 THEN ROUTE 1
                              IF UB6 > 30 THEN ROUTE 2
                              ELSE WAIT UNTIL UB6<=30
                                                    1     ORDER_B    BASE_2
TURN 2    MOVE FOR 1
                                                          PRODUCT_B END_USER_2
TURN      MOVE FOR 1
                                                    2     PRODUCT_B END_USER_2
FIRST 1   MOVE FOR 1
 ORDER_B    BASE_2            WAIT N(4,.2)
                              DEC BB2,140
                              IF BB2 <= 210 AND DUMMY5=0 THEN ROUTE 1
                              ELSE ROUTE 2          1     ORDER_B    MAIN_STORES
TURN 2    MOVE FOR 1

INC DUMMY5,1
                                                          PRODUCT_B UNIT_6
TURN      MOVE WITH PICKUP1 THEN FREE

INC UB6,140
                                                    2     PRODUCT_B UNIT_6
FIRST 1   MOVE WITH PICKUP1 THEN FREE

INC UB6,140
 ORDER_B    MAIN_STORES       WAIT N(6,.2)
                              DEC MB, 490
                              IF MB <= 4092 AND DUMMY_B=0 THEN ROUTE 1
                              ELSE ROUTE 2          1     ORDER_B    EXTERNAL_SUPPLIER
TURN 2    MOVE FOR 1

INC DUMMY_B,1


                                                          PRODUCT_B BASE_2
TURN      MOVE WITH PICKUP1 THEN FREE

INC BB2,490

DEC DUMMY5,1

                                                    2     PRODUCT_B BASE_2
TURN 2    MOVE WITH PICKUP1 THEN FREE

INC BB2,490

DEC DUMMY5,1
                                                          ORDER_B    EXIT
TURN
 PRODUCT_B BASE_2                                   1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B UNIT_4                                   1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B UNIT_5                                   1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B UNIT_6                                   1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B END_USER_2                               1     PRODUCT_B EXIT
FIRST 1
 ORDER_B    END_USER_3                              1     ORDER_B    UNIT_7
TURN 1    MOVE FOR 1
```

```
                                                            ORDER_B    UNIT_8
TURN      MOVE FOR 1
                                                            ORDER_B    UNIT_9
TURN      MOVE FOR 1
 ORDER_B   UNIT_7              WAIT N(1,.1)
                               DEC UB7, ORDER_QUANT_B
                               IF UB7 <= 21 THEN ROUTE 1
                               IF UB7 > 21 THEN ROUTE 2
                               ELSE WAIT UNTIL UB7<=21
                                                     1      ORDER_B    BASE_3
TURN 2    MOVE FOR 1
                                                            PRODUCT_B END_USER_3
TURN      MOVE FOR 1
                                                     2      PRODUCT_B END_USER_3
FIRST 1   MOVE FOR 1
 ORDER_B   BASE_3              WAIT N(4,.2)
                               DEC BB3, 98
                               IF BB3 <= 98 AND DUMMY6=0 THEN ROUTE 1
                               ELSE ROUTE 2
                                                     1      ORDER_B    MAIN_STORES
TURN 2    MOVE FOR 1
INC DUMMY6,1
                                                            PRODUCT_B UNIT_7
TURN      MOVE WITH PICKUP3 THEN FREE
INC UB7,98
                                                     2      PRODUCT_B UNIT_7
TURN 2    MOVE WITH PICKUP3 THEN FREE
INC UB7,98
                                                            ORDER_B    EXIT
TURN
 ORDER_B   UNIT_8              WAIT N(1,.1)
                               DEC UB8, ORDER_QUANT_B
                               IF UB9 <= 21 THEN ROUTE 1
                               IF UB8 > 21 THEN ROUTE 2
                               ELSE WAIT UNTIL UB8<=21
                                                     1      ORDER_B    BASE_3
TURN 2    MOVE FOR 1
                                                            PRODUCT_B END_USER_3
TURN      MOVE FOR 1
                                                     2      PRODUCT_B END_USER_3
FIRST 1   MOVE FOR 1
 ORDER_B   BASE_3              WAIT N(4,.2)
                               DEC BB3,98
                               IF BB3 <= 98 AND DUMMY6=0 THEN ROUTE 1
                               ELSE ROUTE 2
                                                     1      ORDER_B    MAIN_STORES
TURN 2    MOVE FOR 1
INC DUMMY6,1
                                                            PRODUCT_B UNIT_8
TURN      MOVE WITH PICKUP3 THEN FREE
INC UB8,98
                                                     2      PRODUCT_B UNIT_8
TURN 2    MOVE WITH PICKUP3 THEN FREE
INC UB8,98
                                                            ORDER_B    EXIT
TURN
 ORDER_B   UNIT_9              WAIT N(1,.1)
                               DEC UB9    DER_QUANT_B
                               IF UB9 <= 18 THEN ROUTE 1
                               IF UB9 > 18 THEN ROUTE 2
                               ELSE WAIT UNTIL UB9<=18
                                                     1      ORDER_B    BASE_3
TURN 2    MOVE FOR 1
                                                            PRODUCT_B END_USER_3
TURN      MOVE FOR 1
                                                     2      PRODUCT_B END_USER_3
FIRST 1   MOVE FOR 1
 ORDER_B   BASE_3              WAIT N(4,.2)
                               DEC BB3,84
                               IF BB3 <= 98 AND DUMMY6=0 THEN ROUTE 1
```

```
                              ELSE ROUTE 2          1     ORDER_B   MAIN_STORES
TURN 1   MOVE FOR 1

INC DUMMY6,1
                                                          PRODUCT_B UNIT_9
TURN     MOVE WITH PICKUP3 THEN FREE

INC UB9,84
                                                    2     PRODUCT_B UNIT_9
TURN 2   MOVE WITH PICKUP3 THEN FREE

INC UB9,84
                                                          ORDER_B   EXIT
TURN
 ORDER_B   MAIN_STORES        WAIT N(6,.2)
                        .     DEC MB, 280
                              IF MB <= 4092 AND DUMMY_B=0 THEN ROUTE 1
                              ELSE ROUTE 2          1     ORDER_B   EXTERNAL_SUPPLIER
TURN 2   MOVE FOR 1

INC DUMMY_B,1
                                                          PRODUCT_B BASE_3
TURN     MOVE WITH PICKUP1 THEN FREE

INC BB3,280

DEC DUMMY6,1
                                                    2     PRODUCT_B BASE_3
TURN 2   MOVE WITH PICKUP1 THEN FREE

INC BB3,280

DEC DUMMY6,1
                                                          ORDER_B   EXIT
TURN
 ORDER_B   EXTERNAL_SUPPLIER ATB=CLOCK()
                              WAIT N(6,.2)
                              GRAPHIC 3             1     ORDER_B   MAIN_STORES
FIRST 1  MOVE FOR 1
 ORDER_B   MAIN_STORES        WAIT N(4,.2)
                              LOG"ORDER B PROCESS TIME M&E",ATB
                              ATF=CLOCK()           1     FINANCE   BANK
TURN 2   MOVE FOR 1
                                                          ORDER_B   EXIT
TURN
 FINANCE   BANK               WAIT N(4,.2)
                              GRAPHIC 3             1     FINANCE   EXTERNAL_SUPPLIER
TURN 2   MOVE FOR 1

                                                          FINANCE   FRIEGHT_FORWORDER
TURN     MOVE FOR 1

DUMMY_F=0

 FINANCE   FRIEGHT_FORWORDER LOG "FINANCIAL PROCESS TIME FOR ORDER B", ATF
                              WAIT 6
                              GRAPHIC 2
                              INC DUMMY_F,1


                                                    1     FINANCE   EXTERNAL_SUPPLIER
FIRST 1  MOVE FOR 1
 FINANCE   EXTERNAL_SUPPLIER WAIT N(4,0.1)
                              IF  DUMMY_F=1 THEN ROUTE 1
                              ELSE ROUTE 2
                              LOG "SHIPPING PROCESS TIME FOR ORDER B", ATF
                                                    1     PRODUCT_B LOCAL_SUPPLIER
TURN 2   DEC EB,5000

MOVE WITH SHIP THEN FREE

                                                          FINANCE   EXIT
TURN
                                                    2     FINANCE   EXIT
FIRST 1
 PRODUCT_B LOCAL_SUPPLIER     WAIT N(4,.1)
```

```
                                                             1     PRODUCT_B MAIN_STORES
FIRST 1  MOVE WITH TRUCK THEN FREE

INC MB, 5000

DEC DUMMY_E,1

DEC DUMMY_F,1

LOG"LEAD TIME M&E",ATB
 FINANCE    UNIT_5              WAIT N(4,0.2)        1     FINANCE   EXIT
FIRST 1
 PRODUCT_B MAIN_STORES                               1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B BASE_3                                    1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B UNIT_7                                    1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B UNIT_8                                    1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B UNIT_9                                    1     PRODUCT_B EXIT
FIRST 1
 PRODUCT_B END_USER_3
                                DEC DV, 1
                                wait 8767            1     PRODUCT_B EXIT
FIRST 1


*******************************************************************************
*                                  Arrivals                                   *
*******************************************************************************

  Entity   Location   Qty each   First Time Occurrences Frequency  Logic
  -------- ---------- ---------- ---------- ----------- ---------- ------------
  ORDER_A  END_USER_1 1          0          INF         N(24,2)    ORDER_QUANT_A=
P(13.55)
  ORDER_A  END_USER_1 1          8          INF         N(24,2)
ORDER_QUANT_A=P(5.75)
  ORDER_A  END_USER_1 1          16         INF         N(24,2)
ORDER_QUANT_A=P(11.55)
  ORDER_A  END_USER_2 1          2          INF         N(24,2)
ORDER_QUANT_A=P(8.55)
  ORDER_A  END_USER_2 1          10         INF         N(24,2)
ORDER_QUANT_A=P(8.4)
  ORDER_A  END_USER_2 1          18         INF         N(24,2)
ORDER_QUANT_A=P(7.15)
  ORDER_A  END_USER_3 1          3          INF         N(24,2)
ORDER_QUANT_A=P(6.75)
  ORDER_A  END_USER_3 1          11         INF         N(24,2)
ORDER_QUANT_A=P(3.95)
  ORDER_A  END_USER_3 1          19         INF         N(24,2)
ORDER_QUANT_A=P(2.85)
  ORDER_B  END_USER_1 1          4          INF         N(24,2)
ORDER_QUANT_B=P(9.8)
  ORDER_B  END_USER_1 1          12         INF         N(24,2)
ORDER_QUANT_B=P(3.5)
  ORDER_B  END_USER_1 1          20         INF         N(24,2)
ORDER_QUANT_B=P(8.3)
  ORDER_B  END_USER_2 1          6          INF         N(24,2)
ORDER_QUANT_B=P(6.55)
  ORDER_B  END_USER_2 1          14         INF         N(24,2)
ORDER_QUANT_B=P(5.95)
  ORDER_B  END_USER_2 1          22         INF         N(24,2)
ORDER_QUANT_B=P(4.95)
  ORDER_B  END_USER_3 1          8          INF         N(24,2)
ORDER_QUANT_B=P(4.3)
  ORDER_B  END_USER_3 1          16         INF         N(24,2)
ORDER_QUANT_B=P(2.6)
  ORDER_B  END_USER_3 1          24         INF         N(24,2)    ORDER_QUANT_B=P(2)
  FINANCE  UNIT_5     1          0          10          877


*******************************************************************************
*                                 Attributes                                  *
*******************************************************************************

  ID             Type          Classification
```

```
 ------------- ------------ --------------
#
#ATTRIBUTE FOR ORDER QUANTITY A
 ORDER_QUANT_A Integer        Entity
#
#ATTRIBUTE FOR ORDER QUANTITY B
 ORDER_QUANT_B Integer        Entity
#
#ATTRIBUTE TO DISPLAY LEAD& PROCESS TIME FOR PRODUCT A
 ATA           Real           Entity
#
#ATTRIBUTE TO DISPLAY LEAD& PROCESS TIME FOR PRODUCT B
 ATB           Real           Entity
#
#ATTRIBUTE TO DISPLAY LEAD& PROCESS TIME FOR FINANIAL PROCESS B
 ATF           Real           Entity


**************************************************************************
*                          Variables (global)                            *
**************************************************************************

 ID         Type         Initial value Stats
 ---------- ------------ ------------- -----------
#
#PRODUCT A QUANTITY AT UNIT STORES 1
 UA1        Integer      MUA1          Time Series
#
#PRODUCT A QUANTITY AT UNIT STORES 2
 UA2        Integer      80            Time Series
#
#PRODUCT A QUANTITY AT UNIT STORES 3
 UA3        Integer      120           Time Series
#
#PRODUCT A QUANTITY AT UNIT STORES 4
 UA4        Integer      120           Time Series
#
#PRODUCT A QUANTITY AT UNIT STORES 5
 UA5        Integer      120           Time Series
#
#PRODUCT A QUANTITY AT UNIT STORES 6
 UA6        Integer      128           Time Series
#
#PRODUCT A QUANTITY AT UNIT STORES 7
 UA7        Integer      88            Time Series
#
#PRODUCT A QUANTITY AT UNIT STORES 8
 UA8        Integer      48            Time Series
#
#PRODUCT A QUANTITY AT UNIT STORES 9
 UA9        Integer      48            Time Series
#
#PRODUCT A QUANTITY AT BASE STORES 1
 BA1        Integer      MBA1          Time Series
#
#PRODUCT A QUANTITY AT BASE STORES 2
 BA2        Integer      MBA2          Time Series
#
#PRODUCT A QUANTITY AT BASE STORES 3
 BA3        Integer      MBA3          Time Series
#
#PRODUCT A QUANTITY AT MAIN STORES
 MA         Integer      MMA           Time Series
#
#PRODUCT A QUANTITY AT LOCAL SUPPLIER :(ASSUMPTION)
 LA         Integer      30000         Time Series
#
#PRODUCT B QUANTITY AT UNIT STORES 1
 UB1        Integer      MUB1          Time Series
#
#PRODUCT B QUANTITY AT UNIT STORES 2
 UB2        Integer      56            Time Series
#
#PRODUCT B QUANTITY AT UNIT STORES 3
 UB3        Integer      112           Time Series
#
#PRODUCT B QUANTITY AT UNIT STORES 4
```

```
  UB4          Integer       80               Time Series
#
#PRODUCT B QUANTITY AT UNIT STORES 5
  UB5          Integer       120              Time Series
#
#PRODUCT B QUANTITY AT UNIT STORES 6
  UB6          Integer       80               Time Series
#
#PRODUCT B QUANTITY AT UNIT STORES 7
  UB7          Integer       56               Time Series
#
#PRODUCT B QUANTITY AT UNIT STORES 8
  UB8          Integer       56               Time Series
#
#PRODUCT B QUANTITY AT UNIT STORES 9
  UB9          Integer       48               Time Series
#
#PRODUCT B QUANTITY AT BASE STORES 1
  BB1          Integer       MBB1             Time Series
#
#PRODUCT B QUANTITY AT BASE STORES 2
  BB2          Integer       MBB2             Time Series
#
#PRODUCT B QUANTITY AT BASE STORES 3
  BB3          Integer       MBB3             Time Series
#
#PRODUCT B QUANTITY AT MAIN STORES
  MB           Integer       MMB              Time Series
#
#PRODUCT B QUANTITY AT EXTERNAL SUPPLIER: (ASSUMPTION)
  EB           Integer       30000            Time Series
#
#DUMMY VARIABLE TO ENSURE THE ORDER SENT TO LOCAL SUPPLIER(PRODUCT A)
  DUMMY_A      Integer       0                Time Series
#
#DUMMY VARIABLE TO ENSURE THE ORDER SENT TO EXTERNAL SUPPLIER(PRODUCT B)
  DUMMY_B      Integer       0                Time Series
#
#DUMMY VARIABLE TO ENSURE THE SHIPPING ORDER SENT TO EXTERNAL SUPPLIER(PRODUCT
 B)FROM FRIEGHTER.
  DUMMY_F      Integer       0                Time Series
#
#DUMMY VARIABLE TO ENSURE THE  ORDER SENT TO MAIN STORES (PRODUCT A).
  DUMMY1       Integer       0                Time Series
#
#DUMMY VARIABLE TO ENSURE THE  ORDER SENT TO MAIN STORES (PRODUCT A).
  DUMMY2       Integer       0                Time Series
#
#DUMMY VARIABLE TO ENSURE THE  ORDER SENT TO MAIN STORES (PRODUCT A).
  DUMMY3       Integer       0                Time Series
  DUMMY4       Integer       0                Time Series
  DUMMY5       Integer       0                Time Series
  DUMMY6       Integer       0                Time Series
#
#DUMMY TO VIEW THE LOCATIONS
  DV           Integer       0                Time Series


*****************************************************************************
*                                  Macros                                   *
*****************************************************************************

   ID               Text
   ---------------  ------------
   MUA1             144
   MUB1             136
   MBA1             344
   MBB1             304
   MBA2             368
   MBB2             280
   MBA3             184
   MBB3             160
   MMA              1792
   MMB              2593
   Macl
```

****
* Subroutines *
****

ID	Type	Parameter	Type	Logic
ANIMATE_SUB	None			VIEW "ALL" WAIT 300 HR VIEW "BASE1" WAIT 100 HR VIEW "BASE2" WAIT 100 HR VIEW "BASE3" WAIT 200 HR VIEW "MAIN STORES" WAIT 150 HR VIEW "LOCAL" WAIT 50 HR VIEW "ALL" WAIT 1140 HR VIEW "EXTERNAL SUPPLIER" WAIT 70 HR VIEW "ALL"

ملخص

تطوير نموذج لإدارة السلسلة التزويد يه للمؤسسات الصغيرة والمتوسطة في الأردن باستخدام تكنولوجيا الإنترنت

إعداد

غازي مصطفى مقابله

المشرف

الدكتور محمود أبو علي

في هذه الرسالة تم تطوير نموذج اعتمادا" على تكنولوجيا الإنترنت وعلى احتياجات ومتطلبات المؤسسات الصغيرة والمتوسطة. تم تقديم النموذج ليصف مكونات شبكة السلسلة التزويديه والتي تتكون من المؤسسة، المزودين، الموزعين الرئيسيين، الموزعين الفرعيين والمستهلكين بالأضافه إلى الإجراءات المالية وإجراءات الشحن. من خلال هذه السلسلة يتم طلب ونقل وتوزيع البضائع والخدمات والمواد حتى تصل إلى المستهلكين.نظرا" للتغيرات الكبيرة التي حدثت من حيث العولمه واستخدام الإنترنت كوسيلة رخيصة وسريعه لتبادل المعلومات بالأضافه إلى التغيير الكبير في إنتاج المواد وقصر عمر المنتجات وسرعة ردة الفعل من قبل المستهلكين والتي تتطلب من هذه الشركات السرعة في مواكبة هذه التطورات والتكيف مع التكنولوجيا الحديثة لذلك فان التغيير السريع اصبح من مستلزمات البقاء أولا" وللحفاظ على المنافسة ثانيا".

يهدف النموذج إلى تحسين مستوى الخدمات وتقليل المستوى التخزيني بالأضافه إلى تقليل الوقت الضائع في إجراءات الطلبيات والإجراءات المالية وإجراءات الشحن. حيث تم تطوير النموذج وتعديله لاظهار العلاقات التي تؤثر على التكلفة عن طريق تحسين انتقال وإدارة النظم المعلوماتية عبر السلسلة التزويديه في الأردن. إن فحص واختبار دقة وصحة النموذج ومدى قابليته للتطبيق أنجزت من خلال استخدام المحاكاة حيث تم تنفيذ النموذج المطور من خلال محاكاته باستخدام برنامج بروموديل وهو برمجية من إنتاج شركة بروموديل وتم تطبيقه على السلسلة التزويد يه الخاصة بسلاح الجو الملكي الأردني لنوعين من المنتجات المستهلكة والخاصة بصيانة المعدات والمهمات المستخدمة والتي يتم شراؤها من مزودين ومنتجين محليين وخارجيين.

أوضحت الدراسة انه من خلال تطبيق هذا النموذج الذي يستخدم الإنترنت كأساس لتبادل المعلومات فانه يمكن تقليل التكلفة بشكل كبير ويمكن تحسين مستوى الخدمات المقدمة وكذلك فانه يظهر التخفيض الملحوظ في الوقت الضائع في الإجراءات -ذة لإحضار هذه المواد. بناء" على النتائج التي ظهرت من خلال استخدام وتطبيق هذا النظام فانه من الواضح أن المؤسسات الصغيرة والمتوسطة في الأردن يمكنها الأستفاده بشكل كبير عند تطبيق وتطوير إدارة السلسلة التزويديه لديها باستخدام الإنترنت من خلال زيادة انتباه واهتمام المدراء للسلسله والتي ينتج عنها تطوير وتحسين المؤسسة والتي تنعكس في النهاية على زيادة منافسة هذه المؤسسات في السوق من خلال تقليل سعر المواد وزيادة كسب ثقة المستهلكين.