

# Design and Development of Materials Requirements Planning Simulation Model Using Visual Basic Programming Language

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**Abstract**– This paper focuses on developing software for the simulation of Materials Requirements Planning (MRP), which is one of the inventory models. Such a simulation model will enhance effective inventory decisions and policy formulation for any profit oriented organization. It is in the light of this that an overview of inventory models and software design and development principles for simulation models became imperative, with the aim of adopting the best design and development principles that could solve the problem at hand. Visual Basic programming language was employed for the implementation of the materials requirements planning model because of the nature of the problems MRP solves, the object-oriented nature of the programming language and also for its simplicity and time saves benefits for the users. To implement the design and development of the Materials Requirements Planning Simulation Model Using Visual Basic Programming Language, the objects (components) of the software were designed and codes were written for the events to occur at the controls and objects. The application was tested and debugged. The validation was ensured by using an already existing problem of materials requirements planning. Guaranteed that the model simulated effectively the test problem, and the results printed out successfully, a standalone executable file was compiled with the window name “Materials Requirements Planning (MRP) Wizard”.

**Keywords**– Development, Simulation Model, Materials Requirements Planning (MRP) and Policy

## I. INTRODUCTION

Decision making is the whole process of the problem through generation and evaluation of alternatives and finally, to the choice itself. It could also expand to include implementation of the decision and control of the decision process to determine when additional decisions are required. In this case, decision making becomes practically synonymous with managing, Roger (1981). Hence, decision making and policy formulation are integral functions of management in industries and organizations. The credibility and reliability of such decisions depend to a very large extent on the means and tools for arriving at such decisions. In our modern world, taking decisions have become more complex

as a result of complexity and uncertainties associated with the factors considered. Therefore, there is the need to develop system that can aid and enhance effective decision making, thus the computer-based system. This class of systems depends on the use of computer for managing business and industrial applications; they depend upon computers for performing their objectives. The use of computer has dramatically changed the field of operations management since computers were introduced into business in the 1950s.

Most manufacturing operations including very little once now employ computers in among other operations inventory management and production schedule. In addition, computers are rapidly making inroads on the automation of office work, and they are used in virtually all types of service operations. Today, the effective use of computer has become an essential part of the operation management field.

A computer based business or industrial system involves six interdependent elements. These are hardware (machines), software, people (programmers, managers or users), procedures, data, and information (processed data). All six elements interact to convert data into information. System analysis relies heavily upon computers to solve problems. Therefore, software is needed to implement such solutions.

### A) Research Motivation

Inventory management decisions are middle level managerial functions of aggregate planning. Aggregate planning is concerned with matching supply and demand of materials over the medium time range, up to approximately 12 months into the future. As a result of aggregate planning, decisions and policies must be made concerning among others, inventory level. Materials Requirements Planning is only one of such inventory models which can be viewed as a way of relating output plans to input requirement. The resulting materials model is often simulated in order to answer “what if” questions. This allows one to examine the effects of proposed changes in the materials' plan before the changes are made. It is based on this backdrop that the need for the design and development of a system for such a simulation becomes imperative. Although, software like Lingo developed by Lingo Corporation of America already

exists in solving such problems, the formulation of the linear equations structure for implementing this is always a herculean task which is beyond the level of the averagely skilled manager. Hence, “The design and development of Materials Requirements Planning Simulation Model using Visual Basic” which is an object-oriented programming language.

Although, Materials Requirements Planning is not a stochastic problem the program is taking advantage of the fact that simulation returns numerical values.

### B) The MRP Program Development Process

1. The aim of the program is to solve the problem of when to order and how much to order.

2. A user interface was created using Visual Basic’s program development tools. This involved two related activities:
  - a. Drawing the controls within the form
  - b. Defining the properties of each control.
3. The Visual basic instructions to carry out the actions resulting from the various program events were written. This involved writing a group of commands, called an event procedure, for each control. Certain control like labels do not have event procedures associated with them.
4. At different stages program validations were carried out to ensure it executes correctly. The flow chart for this process is shown in Fig. 4.

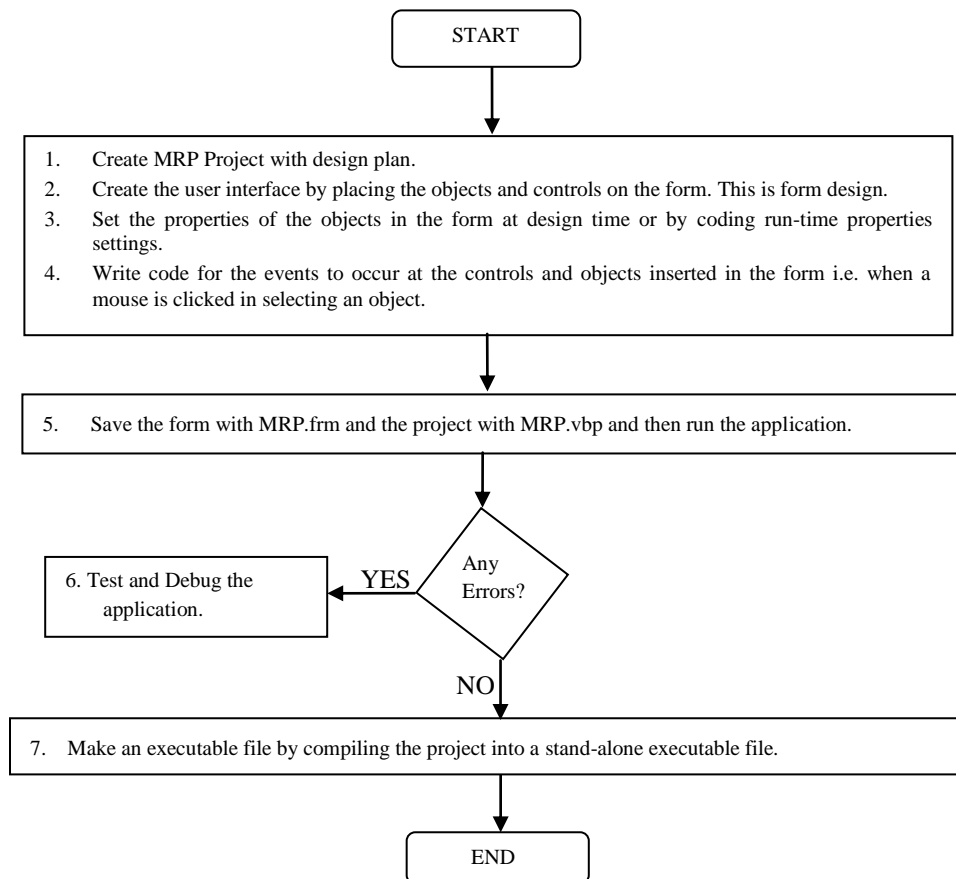


Fig. 4: Flowchart for developing the MRP simulation model using Visual Basic

Based on this framework the objectives of the paper are to design and develop software to: Accept demand data as input, Process the input, determine the quantity of materials to order, determine when to order depending on the lead time of such materials, Determine the total ordering cost of materials, Determine the total holding cost of materials and Perform quickly, sensitivity analysis to view different scenarios of “What if”.

Inventory decisions and policies affect profitability of any manufacturing and business concern. The choice among

policies depends upon their relative profitability. Hence, this work:

- ❖ Provides the solution to inventory problems of how much to order and when to order.
- ❖ Provides for the quick evaluation of the important costs of inventory viz-a-viz holding cost and ordering cost and consequently, the total cost of inventory.
- ❖ Provides for comparative evaluations of different inventory level with their associative cost implications.
- ❖ Enhances effective choice of lot size rule.

- ❖ To show how systematic operation analysis is advantageous to decision making.
- ❖ Serve as a pedagogic tool in topics of inventory management in higher institutions.

**II. THEORETICAL FRAMEWORK**

This paper is hinged on the duo of inventory theory and system theory. The inventory theory comprises inventory models. In inventory models the major objective consists of minimizing the total inventory cost and to balance the economics of large orders or large production runs against the cost of holding inventory and the cost of going short, Nahmias (1997).

The system theory views the System as an integrated set of interoperable elements, each with explicitly specified and bounded capabilities, working synergistically to perform value-added processing to enable a User to satisfy mission-oriented operational needs in a prescribed operating environment with a specified outcome and probability of success. By the International Council on Systems Engineering (INCOSE)

Every system whether it is natural or man-made co-exists with an environment. It is very important for a system to adapt itself to its environment. Also, for a system to exist it should change according to the changing environment. Systems interact with their environment to achieve their targets. Things that are not part of the system are environmental elements for the system. Depending upon the interaction with the environment, systems can be divided into two categories, open and closed.

**Open Systems:** These are systems that interact with their environment. Practically most of the systems are open systems. An open system has many interfaces with its environment. It can also adapt to changing environmental conditions. It can receive inputs from, and delivers output to the outside of system. An information system is an example of this category. The open system construct is shown in Fig. 1.

**Closed Systems:** Systems that don't interact with their environment. Closed systems exist in concept only.

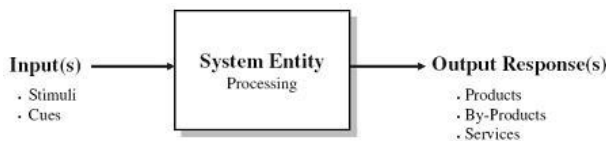


Fig. 1: An open system construct

**A) Managing Inventory Systems**

The inventory system is a typical example of an open system. This is because the total value of all inventory include finished goods, partially finished goods, and raw material, Hillier and Lieberman (2001). Models for the management of inventory systems when the products involved have certain or

uncertain demand abound. Although mathematical models sometimes can help analyze these more complicated systems, simulation often plays a key role as well.

**Inventory Level:** The relation between flow, time and inventory level that is basic to all systems is:

$$Inventory\ Level = (Flow\ Rate) (Residence\ Time)$$

Where the flow rate is expressed in the same time units as the residence time.

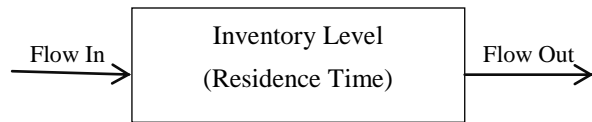


Fig. 2: A system component with inventory

Fig. 2 represents a manufacturing process that takes a fixed amount of time depicting inventory system as an open system. Jesen et al (2001).

The inventory level depends on the relative rates of flow in and out of the system. Define  $y(t)$  as the rate of input flow at time  $t$  and  $Y(t)$  the cumulative flow into the system. Define  $z(t)$  as the rate of output flow at time  $t$  and  $Z(t)$  as the cumulative flow out of the system. The inventory level,  $I(t)$  is the cumulative input less the cumulative output.

$$I(t) = Y(t) - Z(t) = \int_0^t y(x) dx - \int_0^t z(x) dx \quad 1$$

**B) Mathematical Inventory Models**

The mathematical inventory models used can be divided into two broad categories-deterministic models and stochastic models-according to the *predictability of demand* involved. The demand for a product in inventory is the number of units that will need to be withdrawn from inventory for some use (e.g., sales) during a specific period. If the demand in future periods can be forecast with considerable precision, it is reasonable to use an inventory policy that assumes that all forecasts will always be completely accurate. This is the case of *known demand* where a *deterministic* inventory model would be used. However, when demand cannot be predicted very well, it becomes necessary to use a *stochastic* inventory model where the demand in any period is a random variable rather than a known constant.

There are several basic considerations involved in determining an inventory policy that must be reflected in the mathematical inventory model. These are discussed below.

**C) Components of Inventory Models**

According to Tersine (1998), because inventory policies affect profitability, the choice among policies depends upon their relative profitability. Some of the costs that determine this profitability are: the ordering costs, holding costs, shortage costs, revenues, salvage costs, discount rates.

In using quantitative techniques to seek optimal inventory policies, the criterion of minimizing the total (expected) discounted cost is used. Under the assumptions that the price and demand for the product are not under the control of the company and that the lost or delayed revenue is included in the shortage penalty cost, minimizing cost is equivalent to maximizing net income, Liu et al (1990). Another useful criterion is to keep the inventory policy simple, i.e., keep the rule for indicating *when to order* and *how much to order* both understandable and easy to implement. Most of the policies considered in this work possess this property.

As mentioned at the beginning of the chapter, inventory models are usually classified as either *deterministic* or *stochastic* according to whether the demand for a period is known or is a random variable having a known probability distribution.

Another component of an inventory model is the *lead time*.

*Lead time* is the amount of time between the placement of an order to replenish inventory (through either purchasing or producing) and the receipt of the goods into inventory. If the lead time always is the same (a *fixed* lead time), then the replenishment can be scheduled just when desired. Most models in this work assume that each replenishment occurs just when desired, either because the delivery is nearly instantaneous or because it is known when the replenishment will be needed and there is a fixed lead time.

Another classification refers to whether the current inventory level is being monitored continuously or periodically. In *continuous review*, an order is placed as soon as the stock level falls down to the prescribed reorder point. In *periodic review*, the inventory level is checked at discrete intervals, e.g., at the end of each week, and ordering decisions are made only at these times even if the inventory level dips below the reorder point between the preceding and current review times. (In practice, a periodic review policy can be used to approximate a continuous review policy by making the time interval sufficiently small.)

### C) Deterministic Continuous-Review Models

The most common inventory situation faced by manufacturers, retailers, and wholesalers is that stock levels are depleted over time and then are replenished by the arrival of a batch of new units, Silver et al (1998). A simple model representing this situation is the *Economic Order Quantity model* or, for short, the *EOQ model*. (It sometimes is also referred to as the *economic lot-size model*.) Units of the product under consideration are assumed to be withdrawn from inventory continuously at a *known constant rate*, denoted by  $a$ ; that is, the demand is  $a$  units per unit time. It is further assumed that inventory is replenished when needed by ordering (through either purchasing or producing) a batch of fixed size ( $Q$  units), where all  $Q$  units arrive simultaneously at the desired time. For the *basic EOQ model* to be presented first, the only costs to be considered are  $K =$  setup cost for ordering one batch,  $c =$  unit cost for producing or purchasing each unit,  $h =$  holding cost per unit per unit of time held in inventory.

The objective is to determine when and by how much to replenish inventory so as to minimize the sum of these costs per unit time.

*Continuous review* was assumed, so that inventory can be replenished whenever the inventory level drops sufficiently low. We shall first assume that shortages are not allowed (but later we will relax this assumption). With the fixed demand rate, shortages can be avoided by replenishing inventory each time the inventory level drops to zero, and this also will minimize the holding cost.

**Dynamic Economic Quantity Model:** This model differs from the model just discussed in two respects, Taha (2007)

1. The inventory level is reviewed periodically over a finite period number of equal periods.
2. The demand per period, though deterministic, is dynamic, in the sense that it varies from one period to the next.

A situation in which dynamic deterministic demand occurs is Materials Requirements Planning (MRP).

**The Model with Initial Stock Level:** In the above model we assume that there is no initial inventory. As a slight variation, suppose now that there is initial stock level, how does this stock influence the optimal inventory policy?

In general terms, suppose that the initial stock level is given by  $x$ , and the decision

to be made is the value of  $y$ , the inventory level *after replenishment* by ordering (or producing) additional units. Thus,  $y - x$  is to be ordered, so that

$$\text{Amount available } (y) = \text{initial stock } (x) + \text{amount ordered } (y - x)$$

The cost equation presented earlier remains identical except for the term that was previously  $cy$ . This term now becomes  $c(y - x)$ , so that minimizing the expected cost is given by

$$\min_{y \geq x} \left[ c(y - x) + \int_y^{\infty} p(\xi - y)\varphi_D(\xi) d\xi + \int_0^y h(y - \xi)\varphi_D(\xi) d\xi \right]$$

The constraint  $y \geq x$  must be added because the inventory level  $y$  after replenishing cannot be less than the initial inventory level  $x$ .

The optimal inventory policy is the following, Axsäter, S. (2000): If

$$x \begin{cases} < y^0 & \text{order } y^0 - x \text{ to bring inventory level up to } y^0 \\ \geq y^0 & \text{do not order} \end{cases}$$

Where  $y^0$  satisfies

$$\phi(y^0) = \frac{p-c}{p+h}$$

#### D) Materials Requirements Planning

Because of the dependencies and interrelationships involved, managing the inventories of dependent-demand products can be considerably more complicated than for independent-demand products. A popular technique for assisting in this task is *materials requirements planning*, abbreviated as *MRP*. MRP is a computer-based system for planning, scheduling, and controlling the production of all the components of a final product.

Materials requirements planning (MRP) is a set of calculations embedded in a system that helps operations make volume and timing calculations for planning and control purposes, Wight (1984).

Material Requirements Planning (MRP) is a computer-based production planning and inventory control system. MRP is concerned with both production scheduling and inventory control. It is a material control system that attempts to keep adequate inventory levels to assure that required materials are available when needed. MRP is applicable in situations of multiple items with complex bills of materials. MRP is not useful for job shops or for continuous processes that are tightly linked, Volman et al (1992).

Material Requirement Planning is a dependent demand system that calculates materials requirements and production plans to satisfy known and forecast sales orders. It helps to make volume and timing calculations based on an idea of what will be necessary to supply demand in the future, Nigel Slack et al (2001).

In all these definitions of Materials Requirements Planning, they all implied that it is a technique which assists a company in the detailed planning of its production. MRP translates that aggregate plan into an extremely detailed plan.

The system begins by “exploding” the product by breaking it down into all its subassemblies and then into all its individual component parts. A production schedule is then developed, using the demand and lead time for each component to determine the demand and lead time for the subsequent component in the process. In addition to a *master production schedule* for the final product, a *bill of materials* provides detailed information about all its components. Inventory status records give the current inventory levels, number of units on order, etc., for all the components. When more units of a component need to be ordered, the MRP system automatically generates either a purchase order to the vendor or a work order to the internal department that produces the component.

Materials requirements planning systems typically require certain data records which the MRP program checks and updates. The most obvious inputs are customer orders and forecast demand. MRP performs its calculations based on the combination of both firm and forecast orders. All other requirements calculated within the MRP process are derived from these demands thus; MRP is dependent demand system. It is important point to note that MRP is not cost driven i.e. it does not seek to minimise cost. Instead MRP is stockout driven - that is it will always order sufficient to avoid stock outs (using the lot size rule for each item) and order as late as possible. Beasley (N.A).

#### E) Demand Management

Taken together, the management of customer orders and sales forecasts is called ‘demand management’. This is a set of processes which interfaces with the customer market, Hillier et al (2001). Depending on the business, these processes may include sales order entry, demand forecasting, order promising, customer service and physical distribution. For example, if you place an order on the internet and ring up a week later to check why your purchase has not arrived, you will deal with a call centre service operator. He or she can access the details of your particular order and advise why there might have been a hold-up in delivery. In addition, you could be given a delivery promise and information regarding the mode of delivery. That single interaction with a customer triggers a chain of events. The item has to be picked from a warehouse; a stores operator must therefore be given the appropriate information, the delivery must be booked and so on. If demand information is not available or communicated, any subsequent plans will be misleading. Therefore we now need to consider some of the implications of managing demand on MRP.

**Customer orders:** Sales functions typically manage a dynamic, changing order book made up of confirmed orders from customers. Of particular interest to the MRP process are the records of exactly what each customer has ordered, how many they have ordered and when they require delivery. But customers may change their minds after having placed their orders and because customer service and flexibility are increasingly important competitive factors, MRP must be able to react to this. Considering that each of several hundred customers may make changes to their sales orders, not once but possibly several times after the order has been placed, managing the sales order book is a complex and dynamic process.

**Forecast demand:** Using historical data to predict future trends, cycles or seasonality is always difficult. Driving a business using forecasts based on history has been compared to driving a car by looking only at the rear-view mirror, Hillier and Lieberman (2001). In spite of the difficulties; many businesses have no choice but to forecast ahead.

**Combining orders and forecasts:** A combination of known orders and forecast orders is used to represent demand in many businesses. This should be the best estimate at any time of what reasonably could be expected to happen. But the further ahead you look into the future, the less certainty there is about demand. Most businesses have knowledge of short-term demand, but few customers place orders well into the future. Based on history and on market information, a forecast is put together to reflect likely demand, although different operations will have a different mix of known and forecast orders. A make-to-order business, such as a jobbing printer, will have greater visibility of known orders over time than a make-for-stock business, such as a consumer durables manufacturer. Purchase-to-order businesses do not order most of their raw materials until they receive a confirmed customer order. For example, a craft furniture maker may not order materials until the order is certain. Conversely, there are some operations that have very little order certainty at the time they

take most of their decisions. Conceptually therefore there are two related decisions about ordering:

- *timing* - when to order
- *quantity* - how much to order

**Inventory Decisions:** Consider about what have been done with respect to these two decisions of:

- *timing* - when to order
- *quantity* - how much to order

With respect to the timing decision, always order *as late as possible*, but never planned a stock out. This is a driving principle in MRP, never order before it is needed, never plan to stock out. Quantity decision rule can be varied in MRP and are as follow:

- lot for lot rule with respect to the quantity decision is to always ordered *as little as possible*, i.e., just enough to avoid a stock out. It is sometimes called LFL or L4L or LL rule.
- fixed order quantity rule (sometimes called FOQ or FO) - the quantity ordered is an integer multiple of the same fixed amount each time an order is made
- fixed period requirements rule (sometimes called FPR) - the quantity ordered should be enough for a fixed number of periods .

**Choice of lot size rule:** How are the choice made between different lot size rules (LFL, FPR and FOQ)? Redo the MRP calculations with different lot size rules (e.g., a FOQ ordering multiples of 100 each time). Then the different effects would be seen but would still have to choose between them. Beasley (N.A).

According to Beasley, *All* of the rules ensure forecast demand is met, i.e. no stock outs, so this is not a distinguishing feature. The LFL rule (by ordering as little as possible each time) will keep average inventory levels low, but will result in more orders on average. Both the FPR and FOQ rules will have higher inventory levels, but will result in less order on average. Choosing a lot size rule therefore comes down to balancing the number of orders against the cost of holding inventory. Hence, given cost information, it is possible to derive the most effective (least costly) lot rule to use for any particular item. Given all this information then (conceptually at least) it will be possible to *calculate* what will be done, in terms of when to place orders with external suppliers (or internal suppliers) and the size of those orders, so that out of stock of any item is never encountered i.e., always achieve the planned production and meet the sales orders.

This process of calculating the orders needed is called an *MRP EXPLOSION* and produces the materials requirements (hence the name - *Materials Requirements planning*).

#### F) Essence of Simulation

The technique of *simulation* has long been an important tool of the designer. *Simulation* plays essentially this same role in many Operation Research studies. To prepare for simulating a complex system, a detailed *simulation model* needs to be formulated to describe the operation of the system and how it is to be simulated.

Simulation models have several basic building blocks: Law (1986).

Law and Kelton (1991) opined that great progress is being made in developing special software for efficiently integrating the simulation model into a computer program and then performing the simulations. Nevertheless, when dealing with relatively complex systems, simulation tends to be a relatively expensive procedure. After formulating a detailed simulation model, considerable time often is required to develop and debug the computer programs needed to run the simulation.

**Discrete-Event versus Continuous Simulation:** Two broad categories of simulations are discrete-event and continuous simulations.

A *discrete-event simulation* is one where changes in the state of the system occur instantaneously at random points in time as a result of the occurrence of *discrete events*. For example, in a queuing system where the state of the system is the number of customers in the system, the discrete events that change this state are the arrival of a customer and the departure of a customer due to the completion of its service. Most applications of simulation in practice are discrete-event simulations.

A *continuous simulation* is one where changes in the state of the system occur *continuously* over time. For example, if the system of interest is demand and supply its state is defined as the current demand and or supply, then the state is changing continuously over time. Some applications of continuous simulations occur in design studies of such engineering manufacturing systems.

Continuous simulations typically require using differential equations to describe the rate of change of the state variables. Thus, the analysis tends to be relatively complex.

#### G) Software Design Principles and Guidelines

Douglas, (2003) proposed eight software design principles and guideline for software engineers.

In summary, good designs can generally be distilled into a few key principles:

- Separate interface from implementation
- Determine what is common and what is variable with an interface and an implementation
- Allow substitution of variable implementations via a common interface i.e., the “open/closed” principle
- Dividing commonality from variability should be goal-oriented rather than exhaustive

He concluded that design is not simply the act of drawing a picture using a CASE tool or using graphical UML notation. Design is a fundamentally creative activity.

#### H) Selecting the Software and Constructing a Computer Program for Simulation

There are four major classes of software used for computer simulations, Banks (1998). One is *spreadsheet software*. Some excellent Excel add-ins now is available to enhance this kind of spreadsheet modelling. The other three classes of software for simulations are intended for more extensive applications where it is no longer convenient to use

spreadsheet software. One such class is a *general-purpose programming language*, such as C, FORTRAN, PASCAL, BASIC, etc. Such languages (and their predecessors) often were used in the early history of the field because of their great flexibility for programming any sort of simulation. However, because of the considerable programming time required, they are not used nearly as much now. The third class is a *general-purpose simulation language*. These languages provide many of the features needed to program a simulation model, and so may reduce the required programming time substantially. They also provide a natural framework for simulation modelling. Although less flexible than a general-purpose programming language, they are capable of programming almost any kind of simulation model. However, some degree of expertise in the language is needed.

Prominent general-purpose simulation languages include the current version of GPSS, SIMSCRIPT, SLAM, and SIMAN. The initial versions of these languages date back to 1961, 1963, 1979, and 1983, respectively, but all have stood the test of time.

A key development in the 1980s and 1990s has been the emergence of the fourth class of software, called *applications-oriented simulators* (or just *simulators* for short). Each of these simulators is designed for simulating fairly specific types of systems, such as certain types of manufacturing, computer, and communications systems. Some are very specific (e.g., for oil and gas production engineering, or nuclear power plant analysis, or cardiovascular physiology). Their *goal* is to be able to construct a simulation “program” by the use of menus and graphics, without the need for programming. They are relatively easy to learn and have modeling constructs closely related to the system of interest.

**Traverse Software Tools for Material Requirements Planning:** *A true planning tool that gives you the information you need to solve tomorrow’s problems ... today (Open Systems Inc.)*

Most manufacturing problems would be a lot easier to solve if they can be seen coming. Materials planning involve managing sales forecasts, creating master schedules, and running MRP. In short, balancing future supply and demand. TRAVERSE Material Requirements Planning is an example of spreadsheet software which enables you to plan for the future. You’ll be able to meet market demand and address your company’s production plan. With TRAVERSE Material Requirements Planning, it is possible to produce a Master Production Schedule and plan the manufacturing of finished goods in order to meet the expected demand from the sales forecasts. Next, MRP functionality is used to determine the raw materials needed and when it is appropriate to purchase them in order to fulfil the production goals based on the Master Production Schedule.

At the heart of the system is the MRP report, a time-phased glimpse of the future demand for material components and assemblies. Combining the best of both worlds, this report features two formats for users: one for those who prefer bucketless reporting and one for those who prefer the standard MRP report based on daily, weekly, or monthly summaries.

Forecasting can be a challenge, but the TRAVERSE software tools make the job easier than ever. Forecasts can be automatically created for individual parts and assemblies based on current history using multiple methodologies. Forecast flexibility is built in at every step of the process.

### I) Programming in Basic

Udosen (1997), opined that prior to any serious programming, the system analyst or programmer must prepare the program specifications which among other things should include:

1. A description of the program;
2. Specifications and layout for each input file and output of the program;
3. Any formulae and parameters or other special material the programmer will need.

### J) Visual Basic Applications

Visual Basic is an event-driven programming language for creating applications that run under Microsoft’s Windows operating systems. It is an object-oriented programming developing system for creating applications, Byron (2001).

It has the following two major components:

1. An extensive collection of prewritten tools, called controls. These controls are accessible as icons within a graphical programming environment for creating customized windows components. Examples of these are menus, dialog boxes, text boxes, slide bars and others.
2. A complete set of program commands, derived from Microsoft’s implementation of the classic Basic programming language. The command set includes features that embrace contemporary programming practices.

**Object-Related Concepts:** An object is a general term used to describe all the forms and controls or “visual things” that make up a program. The controls are graphic representation of objects, which the user of the application can manipulate to obtain information from (outputting) or provide information (inputting) to the application, Udosen (2007). He opined that this process of outputting and inputting information interactively, using controls or objects is referred to as the interface aspect of the program.

**FORMS:** A window is called a form. The form includes a title bar at the top, and a menu bar. A user area (called a client area) occupies the remaining space of the form. This application is based upon a single form, Byron (2001).

**CONTROLS:** These are the icons with which the users interact. The controls used in this application include command button, text boxes, option buttons, check boxes, labels and menus. The user will typically activate a control (e.g., click on a command button) to produce an event, Byron (2001).

**OBJECTS:** Forms and controls are referred to collectively as objects. Most objects are associated with events; hence, objects may include their own unique event procedures.

Objects are also associated with their own properties and methods, Byron (2001).

**PROPERTIES:** Objects include properties that generally define their appearance or behaviour. The choice of properties depends on the type of object, Byron (2001).

**METHODS:** Some objects also include special program statement called methods. A method brings about some predefined action affecting the associated object. For example, show is a method that can be used with a hidden form to make it visible, Byron (2001).

**III. METHODOLOGY AND DEVELOPMENT**

This paper is based upon an event-driven paradigm, in which each feature included within the program is activated only when the user responds to a corresponding object (any of the components) within the user interface. The program’s response to an action taken by the user is referred to as an *event*. The user initiates the event, but it is the program’s response that actually defines the event. The group of Basic command that brings about this response is called an *event procedure*.

The overall approach to this paper is therefore threefold:

- Creating a user interface that is appropriate to Materials Requirements Planning.
- Adding a group of Basic instruction to carry the actions associated with each of the controls.
- Model validation to ensure it works appropriately.

**A) Materials Requirement Planning Program Components**

The project consists of two separate files:

- A project file whose extension is .vbp
- A form file with extension .frm

**Design:** The design procedures involve creating the user interface. This involves designing the form and the controls, and then specifying their critical properties. The tables below show the design of the different objects of the project.

**Development:** The development of the project then involves keeping track of these two different files, and accessing these files individually within the Visual Basic environment, as needed. The flowchart for designing each of the objects is shown in figure 3. While that for developing the Materials Requirements Planning Simulation Model using Visual Basic is shown in Fig. 4.

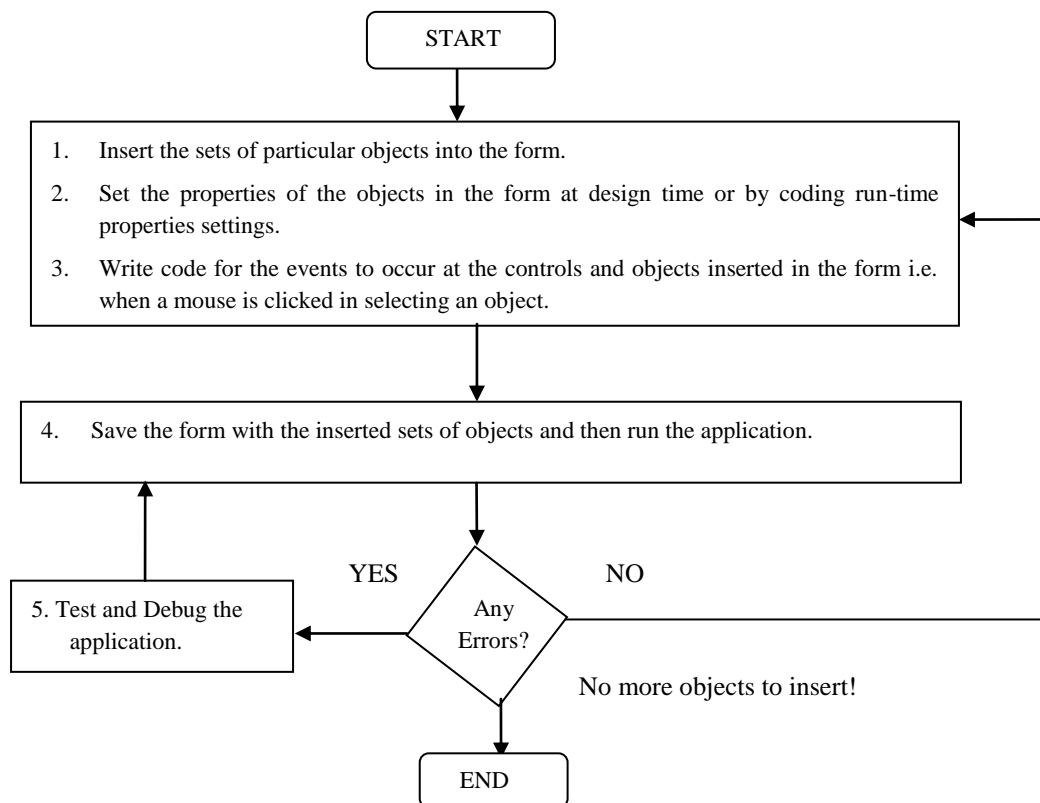


Fig. 3: Flowchart for the design of inserted sets of objects on the form i.e., (Textboxes, Labels, Option buttons, Combo boxes, Command buttons, Menus and Dialog box)



**B) Objects Design**

Table 1: Form Design

OBJECT	PROPERTIES	SPECIFICATIONS
FORM	Appearance	1-3D
	Caption	MATERIALS REQUIREMENTS PLANNING WIZARD
	Visibility	True
	Font	Ms Scan Serif
	Name	Form1
	MaxButton	True
	MDIChild	False
	MinButton	True
	Window State	Normal
	Height	9810
	Left	105
	Movable	True
	Startup Position	3-Window
	Top	105
	Width	19215

Table 2: Common textboxes' properties

PROPERTIES	SPECIFICATIONS
Appearance	1 - 3D
BackColor	&H000000F&
BorderStyle	1 - Fixed Single
ForeColor	&H8000008&
HideSelection	TRUE
Cause Validation	TRUE
DragIcon	None
DragMode	0 – Manual
Enable	TRUE
Locked	FALSE
MaxLength	0
Multiline	FALSE
OLEDragMode	0 – Manual
OLEDropMode	0 – None
ScrollBar	0 – None
TabStop	TRUE
Visible	TRUE
Font	MS Sans Serif

Table 3: Design of textboxes

OBJECTS	PROPERTIES' SPECIFICATIONS						
	NAME	ALIGNMENT	TEXT	HEIGHT	LEFT	TOP	WIDTH
TextBoxes	Text1	O-Left Justify	[ Empty ]	495	1920	4440	1215
	Text2	O-Left Justify	[ Empty ]	495	3120	4440	1215
	Text3	O-Left Justify	[ Empty ]	495	4320	4440	1215
	Text4	O-Left Justify	[ Empty ]	495	5520	4440	1215
	Text5	O-Left Justify	[ Empty ]	495	6720	4440	1215
	Text6	O-Left Justify	[ Empty ]	495	7920	4440	1215
	Text7	O-Left Justify	[ Empty ]	495	9120	4440	1215
	Text8	O-Left Justify	[ Empty ]	495	10320	4440	1215
	Text9	O-Left Justify	[ Empty ]	495	11520	4440	1215
	Text10	O-Left Justify	[ Empty ]	495	12720	4440	1215
	Text11	O-Left Justify	[ Empty ]	495	13920	4440	1215
	Text12	O-Left Justify	[ Empty ]	495	15120	4440	1215
	Text13	O-Left Justify	[ Empty ]	495	1920	5520	1215
TextBoxes	Text14	O-Left Justify	[ Empty ]	495	3120	5520	1215
	Text15	O-Left Justify	[ Empty ]	495	4320	5520	1215
	Text16	O-Left Justify	[ Empty ]	495	5520	5520	1215
	Text17	O-Left Justify	[ Empty ]	495	6720	5520	1215
	Text18	O-Left Justify	[ Empty ]	495	7920	5520	1215
	Text19	O-Left Justify	[ Empty ]	495	9120	5520	1215

	Text20	O-Left Justify	[ Empty ]	495	10320	5520	1215
	Text21	O-Left Justify	[ Empty ]	495	11520	5520	1215
	Text22	O-Left Justify	[ Empty ]	495	12720	5520	1215
	Text23	O-Left Justify	[ Empty ]	495	13920	5520	1215
	Text24	O-Left Justify	[ Empty ]	495	15120	5520	1215
	Text25	O-Left Justify	[ Empty ]	495	1920	6600	1215
	Text26	O-Left Justify	[ Empty ]	495	3120	6600	1215
	Text27	O-Left Justify	[ Empty ]	495	4320	6600	1215
	Text28	O-Left Justify	[ Empty ]	495	5520	6600	1215
	Text29	O-Left Justify	[ Empty ]	495	6720	6600	1215
	Text30	O-Left Justify	[ Empty ]	495	7920	6600	1215
	Text31	O-Left Justify	[ Empty ]	495	9120	6600	1215
	Text32	O-Left Justify	[ Empty ]	495	10320	6600	1215
	Text33	O-Left Justify	[ Empty ]	495	11520	6600	1215
	Text34	O-Left Justify	[ Empty ]	495	12720	6600	1215
	Text35	O-Left Justify	[ Empty ]	495	13920	6600	1215
	Text36	O-Left Justify	[ Empty ]	495	15120	6600	1215
TextBoxes	Text37	O-Left Justify	[ Empty ]	495	6600	1080	1215
	Text38	O-Left Justify	[ Empty ]	495	6600	1800	1215
	Text39	O-Left Justify	[ Empty ]	495	2640	240	8535
	Text40	O-Left Justify	[ Empty ]	495	11760	2880	1215
	Text41	O-Left Justify	[ Empty ]	495	12960	240	2535
	Text42	O-Left Justify	[ Empty ]	495	2280	7440	2415
	Text43	O-Left Justify	[ Empty ]	495	12600	7440	2415
	Text44	O-Left Justify	[ Empty ]	495	2880	2760	1455
	Text45	O-Left Justify	[ Empty ]	495	6720	2640	1575

Table 4: Design of labels

PROPERTIES' SPECIFICATIONS						
OBJECTS	NAME	CAPTION	HEIGHT	LEFT	TOP	WIDTH
Labels	Label1	Period [Lead Time]	495	120	3720	1575
	Label2	Demand	495	120	4440	1215
	Label3	Stock @ Period End	495	120	5520	1935
	Label4	Order	495	120	6600	1335
	Label5	[ Empty ]	495	1920	3840	1095
	Label6	[ Empty ]	495	3120	3840	1095
	Label7	[ Empty ]	495	4320	3840	1095
	Label8	[ Empty ]	495	5520	3840	1095
	Label9	[ Empty ]	495	6720	3840	1095
	Label10	[ Empty ]	495	8040	3840	1095
	Label11	[ Empty ]	495	9240	3840	1095
	Label12	[ Empty ]	495	10440	3840	1095
	Label13	[ Empty ]	495	11640	3840	1095
	Label14	[ Empty ]	495	12840	3840	1095

	Label15	[ Empty ]	495	14040	3840	1095
	Label16	[ Empty ]	495	15120	3840	1095
	Label17	LOT SIZE RULE	495	9360	1080	1335
	Label18	CURRENT STOCK	495	5040	1200	1575
	Label19	SAFETY STOCK	495	5040	1920	1575
	Label20	DATE	495	11880	240	975
Labels	Label21	LEAD TIME	495	14160	1200	1455
	Label22	[ Empty ]	495	1920	5040	1215
	Label23	[ Empty ]	495	3120	5040	1215
	Label24	[ Empty ]	495	4320	5040	1215
	Label25	[ Empty ]	495	5520	5040	1215
	Label26	[ Empty ]	495	6720	5040	1215
	Label27	[ Empty ]	495	7920	5040	1215
	Label28	[ Empty ]	495	9120	5040	1215
	Label29	[ Empty ]	495	10320	5040	1215
	Label30	[ Empty ]	495	11520	5040	1215
	Label31	[ Empty ]	495	12720	5040	1215
	Label32	[ Empty ]	495	13920	5040	1215
	Label33	[ Empty ]	495	15120	5040	1215
	Label35	ORDERING COST	495	120	7440	2055
	Label36	HOLDING COST	495	10680	7440	1815
	Label37	Ordering cost/Unit	495	840	2760	1935
	Label38	Holding Cost/Unit	375	4920	2760	1695
	Label39	A PRODUCT OF OKOUZI, SOLOMON ABHULIMHEN	255	6360	8400	4455

Table 5: Common labels' properties

PROPERTIES	SPECIFICATIONS
Appearance	1 - 3D
BackColor	&H000000F&
BackStyle	(None)
ForeColor	(None)
DragIcon	(None)
DragMode	0 – Manual
Enable	TRUE
OLEDropMode	0 – None
RightToLeft	FALSE

Alignment	2-Center
Visible	TRUE
LinkMode	0 – None
LinkTimeOut	50
Font	MS Sans Serif
MousePointer	0 – Default
MouseIcon	(None)
Use Mnemonic	TRUE
WordWrap	FALSE
AutoSize	FALSE

Table 6: Design of Command Buttons

OBJECTS	PROPERTIES' SPECIFICATIONS					
	NAME	CAPTION	HEIGHT	LEFT	TOP	WIDTH
Command Buttons	Command1	Plan	495	5160	7440	1215
	Command2	Cancel	495	7200	7440	1215
	Command3	Exit	495	9000	7440	1215

Table 7: Design of Option Buttons

OBJECTS	PROPERTIES' SPECIFICATIONS					
	NAME	CAPTION	HEIGHT	LEFT	TOP	WIDTH
Option Buttons	Option1	Lot for lot	495	9360	1680	1695
	Option2	Fixed Period Requirement	495	9360	2280	2295
	Option3	Fixed Order Quantity	495	9360	2880	2295

Table 8: Design of ComboBoxes

OBJECTS	PROPERTIES' SPECIFICATIONS						
	NAME	LIST	TEXT	HEIGHT	LEFT	TOP	WIDTH
ComboBoxes	Combo1	1 Week	LEAD TIME	315	14040	1800	1575
		2 Weeks					
		3 Weeks					
		1 Month					
		2 Months					
		3 Months					
		4 Months					
	Combo2	2 Weeks	FIXED PERIOD	315	11760	2400	1575
		3 Weeks					
		4 Weeks					
		2 Months					
		3 Months					
		4 Months					

Table 9: CommonDialog Properties

PROPERTIES	SPECIFICATIONS
CancelError	FALSE
Name	CommonDialog
Color	&H00000000&
Copies	1
FileName	Form1
MaxFileSize	260
Orientation	2-cdILandscape
PrinterDefault	TRUE
Left	15240
Top	8280

### C) Coding

The Visual basic instructions to carry out the actions resulting from the various program events were written. This involved writing a group of commands, called an event procedure, for each control. Certain control like labels do not have event procedures associated with them.

## IV. MODEL VALIDATION AND DISCUSSION

### A) Inventory Problem for Model Validation

Aldershot Manufacturing is a chair manufacturing Company. The Production manager of Aldershot Manufacturing wishes to develop a materials requirements plan for producing chairs over an eight week period. She estimates that the lead time between releasing an order to the shop floor and producing a finished chair is two weeks. The company currently has 260 chairs in stock and no safety stock (safety stock is stock held in reserve to meet customer demand if necessary). The forecast customer demand is 150 chairs in week 1, 70 in week 3, 175 in week 5, 90 in week 7 and 60 in week 8.

This problem satisfies the conditions for the use of material requirement planning model in that:

- ❖ The problem has forecast demand,
- ❖ The lead time is constant,
- ❖ The forecast demand is dynamic i.e., changes from one period the another,
- ❖ Inventory is continuously reviewed periodically at the end of each period (week)
- ❖ The problems to solve are how much quantity to order and when to order such quantity to avoid stockout.

This problem has been solved using the:

1. Lot for lot rule
2. Fixed period requirement rule
3. Fixed order quantity rule

As presented in tables 10, 11 and 12:

### **B) Result Presentation**

The solutions for each of these rules are presented in the Table 10 to Table 12.

Table 10: MRP with lot for lot rule

Week	1	2	3	4	5	6	7	8
Demand	150	0	70	0	175	0	90	60
On-hand @ week end	110	110	40	40	0	0	0	0
Order	0	0	135	0	90	60	0	0

Table 11: MRP with Fixed Period Requirements of Three weeks

Week	1	2	3	4	5	6	7	8
Demand	150	0	70	0	175	0	90	60
On-hand @ week end	110	110	40	40	90	90	0	0
Order	0	0	225	0	0	60	0	0

Table 12: MRP with Fixed Order Quantity of 190 chairs

Week	1	2	3	4	5	6	7	8
Demand	150	0	70	0	175	0	90	60
On-hand @ week end	110	110	40	40	55	55	155	95
Order	0	0	190	0	190	0	0	0

### **C) Validating the MRP Simulation Model**

1. Enter the forecast demand in the demand role over the required period. Note that this problem has only 8 periods.
2. Enter the current stock at hand (initial stock) of 260 and 0 for safety stock respectively in the provided text boxes.
3. Enter the ordering cost per unit and the holding cost per unit respectively in the text boxes provided.
4. (i) Click on lot for lot for lot for lot rule, or  
(ii) Click on Fixed Period Requirement for FRP rule and then select 3 weeks, or  
(iii) Click on Fixed Order Quantity for FOQ rule and then enter 190
5. Clicking on the arrow in the box labelled "LEAD TIME", and then from the dropdown that appears select 2 Weeks.
6. Click the "Plan" button for each of 4 (i), 4(ii) and 4(iii) to display the results for lot for lot, fixed period requirement and fixed order quantity rule respectively.

Appendix 15, Appendix 16 and Appendix 17 show the computer printout of the results of the problem when

implemented with the Materials Requirements Planning simulation Model using Visual Basic programming language.

### **D) Discussions**

The Lot for lot rule from the solution table 10 and Appendix 15 both suggests that an order of 135 chairs is made in week 3 to make up the deficiency of 170 requirements in week 5, an order of 90 chairs required in week 7 is place in week 5 while the order of the requirement of week 8 is placed in week 6. The timing decision here is always to order as late as possible but never to plan a stockout. This is to avoid carrying cost.

The quantity decision here is always to order as little as possible, i.e. just enough to avoid stock out, with a total cost of N2062.50.

The Fixed Period Requirement specifies that the quantity ordered should be enough for a period of 3 weeks. With this in mind, table 11 and Appendix 16 both shows that 225 chairs are to be ordered in week 3 to make up the requirements of 265 chairs needed in weeks 5, 6 and 7 while the requirement of 60 chairs is ordered in week 6. This is with a total cost of N2872.50.

The Fixed Order Quantity specifies an order of 190 chairs any time an order is made. Table 12 and Appendix 18 both confirm the order of 190 chairs twice that is, in week 3 and week 5. They both also confirm an excess of 95 chairs at the end of week 8 (and then up to the week 12 in the case of the

model). This has a total cost of N5630 from the model based on the cost per unit chair ordered.

This correspondence between Table 10 to Table 12 and Appendices 15, 16 and 17 validates this material Requirements Planning Simulation Model.

### **E) Generating the MRP Stand-alone Executable Program**

The MRP simulation model debugged, validated and guaranteed that it simulated properly, the stand-alone version was generated. The stand-alone is convenient because it can be run independently of the Visual Basic development system, and they can easily be transported from one computer to another. The generation of the stand-alone resulted in a new file with the name MRP.exe which can then be moved out of the Visual Basic System or move to different computers, and then execute on it own. The MRP.exe is a single file created from the three files MRP.frm, MRP.vbp and MRP.vbw that originally comprised the project. However, the new file is substantially larger than the combined size of the original three files. The exact file size will vary from one computer to another. The stand-alone version has the window title "MATERIALS REQUIREMENTS PLANNING (MRP) WIZARD".

## **V. CONCLUSION**

### **A) Users Instructions**

The model is used by following the steps below:

1. Enter the forecast demand in the demand role over the required period. Note that the model only provided for 12 periods.
2. Enter the current stock at hand (initial stock) and the safety stock if any.
3. Enter the ordering cost per unit and the holding cost per unit respectively in the text boxes provided.
4. Select among the option button the lot size rule by clicking on any of the buttons.
  - a. If fixed period requirement is the selected lot size rule, then click on the arrow on the box labelled "FIXED PERIOD" from the dropdown that appears; select the required fixed period either in weeks or months.
  - b. If fixed order quantity is the selected lot size rule, then enter the fixed quantity on the box beside "Fixed Order Quantity"
5. Select the lead time by clicking on the arrow in the box labelled "LEAD TIME", then from the dropdown that appears; select the required lead time either in week(s) or month(s).

*Note:* Once the lead time is selected, the selected lead time appear on the Period (lead time) role above demand role over the entire planning period.

6. Click the "Plan" button to display the results of the stock at each end of period, the quantities to be ordered and when to order such quantities, the total

ordering cost, the total holding cost and the total cost of inventory. The time and date of planning is also displayed by clicking the "Plan" button.

7. To cancel all entries click on the "Cancel" button, then on the message box that appears click "Yes" to cancel or "No" to exit the message box.
8. To exit the model window click on the "End" button, then on the message box that appears click "Yes" to exit or "No" to exit the message box.

### **B) Warnings for users**

The model does not work if:

1. No lot size rule is selected.
2. No lead time is selected.
3. The fixed order quantity is not entered in the case of fixed order quantity lot size rule.

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- (\*Any part of it is not directly quoted in the thesis only the principles and ideas were used).