CHAPTER - I

INTRODUCTION TO SIMULATION
USING A COMPUTER
1.0 INTRODUCTION

Computer simulation is one of the most widely used quantitative methods of analysis. Through simulation it is possible to analyze the behaviour of a system that can not be analyzed by alternative methods. It is one of the fun methods of analysis /1/.

This chapter provides introduction about, what is simulation ?, uses of simulation, reasons for using simulation, simulation as a research technique and its nature. Different types of simulation and introducing simulation as a tool for educational purpose even in the field of science will be discussed.

1.1 BACKGROUND

Simulation emerged as an identifiable numerical problem solving technique during World War II when the so-called Monte-Carlo methods /2/ were successfully used by John Von Neumann and Stanislaw Ulam /3/ for solving neutron diffusion problems. Though simulation need not necessarily involve computers, but with evolution of modern computers and high level simulation languages /4/ the application of simulation for solving real life problems in several disciplines, and the expected advances in computer technology indicate that this trend will continue.

Computer simulation was introduced into university curricular in 1960's, and books /5, 6/ and periodicals /7, 8/ on the subject began to appear around the same time. The multidisciplinary character of simulation is evident from the fact that the subject is being taught by different departments in different universities around the world.

In June 1980, the third IASTAD conference on simulation techniques was being at Interlaken, Switzerland. This conference, called SIMULATION' 80, discussed the advanced topics in simulation and methodology /9/.
In 1980's quite a large number of conferences on simulation techniques have taken place responding to an ever-growing demand for simulation technology from a large variety of diverse disciplines reaching from the many areas of engineering division to biology, medical research, and even social sciences. As the growing simulation community originally suffered from tremendous communication problem (each discipline used a separate terminology not understood by the outsider), it was not easy for them to exchange information among themselves before a common terminology, founded on the grounds of general theory, was developed. For this task, a framework had to be derived which is called simulation methodology. This methodology presents a common usable language which unifies the concepts developed for the different application fields /9/.

In the due course of time, simulation technique has become more and more accepted as an invaluable tool for system analysis in a wide variety of different disciplines. Today almost all scientific disciplines make use of simulation in one way and another to understand the scientific problem.

1.2 WHAT IS SIMULATION ?

Almost as soon as computers were born, it became clear that the new machines carried an exceptional promise for solving problems. In the beginning, their role in the context of man's scientific engineering activities was limited. They were essentially used as powerful fast, though rather dumb, computing machines. In those early days the word simulation was coined. Since then the role of the computer has gradually increased while the machine has become more sophisticated and better educated. Table 1.1 provide a schematic survey of the evolution in the modelling and simulation field /10/
<table>
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<th>Year</th>
<th>Historical Perspective</th>
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<tr>
<td>1600-1940</td>
<td>Modelling in the physical science.</td>
</tr>
<tr>
<td>1940</td>
<td>Advent of the electronic computer.</td>
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<td>1955</td>
<td>Simulation in the aerospace industry.</td>
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<tr>
<td>1960</td>
<td>Simulation of industrial operation scheduling.</td>
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<tr>
<td>1970</td>
<td>Simulation of large scale systems including economic, social and environmental factors.</td>
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<td>1975</td>
<td>Systems simulation merge.</td>
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<td>1975</td>
<td>System simulation and higher decision making</td>
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During 1967 the word *Simulation* has been adopted from colloquial language to serve as a technical term. Because of this the word has been used in different and often conflicting senses. Its history and usage in non-technical contexts have made it a rather poor choice for technical use since dictionaries present exceedingly broad and vague definitions for the word /11/.

As a result, the word has long been used to stand for an assortment of different ideas, some of them quite imprecisely defined. This ambiguity has been carried over to the scientific and technical fields to the extent that few refer to certain kinds of models as simulation, whereas other writers hold that a model is not itself a simulation, but rather a thing used in simulation. Similarly, in some situations where both a model and a computer routine are used some writers say that the computer routine simulates the model but other writers mention that the routine performs a function entirely different from that of simulating the model. Some people speak of simulation as if it were a thing, activity, relationship and so on /11/.

For example, to a management scientist simulation is a mathematical model that describe the behaviour of system over time
Management scientists use the simulation model to conduct the experiments. By observing the behaviour of the model during the experiments the analyst is able to make inferences about the possible behaviour of the real world system.

According to Nain /12/ simulation is the process of building and experimenting with (manipulating) a computerized system model such that a specific purpose of the study is achieved through observing model's behaviour under assumptions defined by the experimenter. The experimenter is meant to be a modeler, user, and/or decision-maker. Therefore the simulation process, encompasses the activities included in model building as well as the analytical use of it.

Simulation is a method used to study the dynamics of a system. The SYSTEM used here mean a group of units which operate in some interrelated manner. Often the purpose of system studies is to gain an understanding of overall operation when a group of well-understood units are connected. Simulation provides a description of system behaviour as it evolves over a period of time /13/.

1.3 SIMULATION USING COMPUTERS

Simulation does not necessarily involve computers, but the availability of these devices has been the impetus to extend the application of simulation to many new areas. This process begun with the development of analog computers which were primarily applied to engineering design problem involving continuous model. Later, the development of digital computers led to increased use of simulation in the areas of business and economics where discrete models were prevalent /13/.

Eventhough, the term computer model and computer simulation are interchangeable, there are subtle differences /14/. Thus Schultz et al defined simulation as ....the modelling of a process by a process /15/. It means that the simulation itself is a process - the operation of a
model- but a process that is in some sense a copy of or parallel to a real process.

When the computer program, or some other representation, is considered as a model, the actual operation of the model is the simulation or in the other way simulation is the model in operation.

As digital computing has reduced in cost and became more available, it has become the dominant mode for the simulation of both discrete and continuous models. After a computer model of the system is available, simulation is used to investigate the performance of the system. Each simulation run is essentially an experiment on the system. The advantage of simulation is that these experiments can be completely controlled and observed. The use of digital computer for simulation in real time started in the mid 1960s when faster digital computer were developed /12/.

1.3.1 DIFFERENT TYPES OF COMPUTER & SIMULATION

Electronic analog computer consists of basic elements that are capable of performing summation, integration, multiplication, nonlinear function generation, and logical operations /16/. In Simulating, linear and nonlinear systems, the analog computer performs all the required operations necessary, with dc voltage (on the computer) representing the system variables (pressure, temperature, distance, etc.). The variables are continuous and time is the independent variable. Simulation results are generally accessible to the user on a voltmeter, oscilloscope, or x-t plotter. Equations are programmed and carefully designed (by interconnecting the computer elements), and as a result, the analog computer program (setup) has a unique relationship to the system being simulated. In developing a solution, the analog computer performs parallel operations (occurring simultaneously) thus making computational speed a salient feature of the analog computation. This parallel operation performance and the operational amplifiers capability of integration make real time solution feasible.
Two types of scaling are often required, these are magnitude and time scaling. Scaling is usually a time consuming task and is considered as a disadvantage of the analog computer. Difficulty of storing the information is another disadvantage. On the positive side, the fact that the user can change the value of a coefficient just by adjusting a potentiometer setting on the computer allows repeated (relatively easy) real-time simulation runs, and thus insight into the system being simulated, is gained at a relatively low cost.

Rather than imitating a physical phenomenon as on an analog computer, a digital computer operates in a logical manner in solving the mathematical model of a system numerically. On a digital computer the variables are discretely defined and the variables are defined at specified intervals of time. Digital signals are binary in nature and represented by a two-state voltage levels. The basic digital computer can be divided into logic elements and storage elements, thus allowing performance of a variety of arithmetic and logical functions as well as storage of information. The physical subsystems of general-purpose digital computer are the input, control, storage (memory), arithmetic, and output units. Basic arithmetic operations possible are counting, addition, subtraction, multiplication, and division. Floating-point arithmetic and digital large memory are among its important features /12/.

For an analog computer, computing time is invariant, and is proportional to problem complexity on a digital computer. Hardware configuration (number of amplifiers, integrator, etc.) grows in proportion to problem size , whereas a digital computer hardware configuration is not usually dependent on problem size & it plays a completely different role in simulation. The technique, in which applications of simulation make use of digital computer are called digital computer simulation /17/.
1.3.2 THE AIM OF COMPUTER SIMULATION

Simulation is the most frequently used management science technique and its popularity is growing continuously. Let us understand why simulation is being so widely used. A possible point for the exploration is to consider an alternative to simulation.

1. Use of other kinds of mathematical model /11/.

2. Experimentation with either the actual system or a prototype of the actual system.

3. Reliance on experience and intuition /18/.

In most cases, simulation is used when there are only poor mathematical modeling alternatives. In fact, simulation is often referred to as a method of last resort. Simulation can have many aims & there are others alternatives of simulation as well. However, the problem is that there are many systems that do not lend themselves to other modelling approaches and consequently simulation must be employed. For example in system queuing.

For simple system such as customers arriving at a ticket booth, the behaviour of the system can often be explained (or predicted) by mathematical models. However, if we are discussing more complex system such as the flow of a product through a production process (once again a queuing system), the complexity of the system is typical such that simulation is probably the only way to describe the behaviour of the system. The complexity of the system is such that no appropriate analytical model currently exist or could be developed.

Another advantage of simulation is that it is possible to experiment on a system without exposing the organization to real word dangers. For this reason, simulation has been referred to as the manager's laboratory /11/. By investigating the possible changes in a real-word system through a simulation model, we can often learn how to
improve the behaviour of a system without actually trying out both good and bad proposals on the system.

In a simulation model it is possible to compress long periods of time into seconds of computer time. As an example, in a new product proposal, a simulation model can describe quickly the product’s movement through the introducing, growth maturity, and decline stages of the product life cycle.

1.4 THE NATURE OF SIMULATION

The various kind of real world facilities or processes are simulated using computers. The facility or process of interest is usually called a system, and in order to study it scientifically we often have a set of assumptions, which usually take the form of mathematical or logical relationships, that constitute a model that is used to gain some understanding of how the corresponding system behaves.

Simulation has its origin in the study of systems. Often the need for simulation arises in the study of real systems that is, systems that actually exist. But frequently it arises in the study of hypothetical systems. The fact that a system is hypothetical does not make its constitution less definite than that of a real system; in fact, the system may be better defined simply because it is hypothesized and therefore can be assumed to have just those properties represented by the model. A model does not represent the activity, or behaviour, of a system directly. Instead, the state history of a model provides a means of representing activity or behaviour. The concept of simulation consists of the construction of state history, it is an use of the model to produce chronologically a state history of the model, which is regarded as a state history of the modeled system /11/.

If the relationships that compose the model are simple enough, it may be possible to use mathematical methods (such as algebra, calculus, or probability theory) to obtain exact information in questions of interest; this is called an analytic system. However most real-word
systems are too complex to allow realistic models to be evaluated analytically, and those models must be studied by means of simulation. In simulation we use a computer to evaluate a model numerically and data are gathered in order to estimate the desired true characteristics of the model /19/.

1.5 SYSTEM, MODELS AND SIMULATION

A system is defined to be a collection of entities, e.g. people or machines, students, customers, that act and interact together toward the accomplishment of some logical end /20/. In practice, what is meant by the system depends on the objectives of a particular study. The collection of entities that compose a system for one study might be only a subset of the overall. For example, if one wants to study a bank to determine the number of tellers needed to provide adequate service for customers who want just to cash a cheque or make a saving deposit, the system can be defined to be that portion of the bank consisting of the tellers and the customers waiting in line or being served. On the other hand if the loan after and the safety deposit boxes are to be included, the definition of the system must be expanded in an obvious way.

1.5.1 TYPES OF THE SYSTEM

Systems can be categorized as discrete & continuous

(i) DISCRETE SYSTEM

A discrete system is one for which the state variable change instantaneously at separated points in time. A bank is an example of discrete system.

(ii) CONTINUOUS SYSTEM

A continuous system is one for which the state variable change continuously with respect to time. An airplane moving through the air is
an example of a continuous system, since state variable such as position and velocity can change continuously with respect to time.

Few systems in practice are wholly discrete or wholly continuous, but since one type of change predominates for most systems, it will usually be possible to classify a system as being either discrete or continuous. At some point in the lives of most systems there is a need to study them to try to gain some insight into the relationship among various components to predict performance under some new condition being considered. Fig (1.1) maps out different ways in which a system might be studied /19,21/.

Fig. 1.1 : Ways to study A System
1.5.2 ACTUAL SYSTEM VS MODEL OF THE SYSTEM

It is possible principally to alter the system physically and then let it operate under the new conditions, it is probably desirable to do so, for in this case there is no question about whether what we study is relevant. However, it is rarely feasible to do this, because such an experiment would often be too descriptive to be of any use.

Frequently, the system might not even exist, but we nevertheless want to study it in its various proposed alternative configurations to see how it should be build in the first place; example of this situation might be modern flexible manufacturing facilities, or strategic nuclear weapon systems. For this reason, it is usually necessary to build a model as a representation of the system and study it as a surrogate for the actual system /22/.

1.5.3 PHYSICAL MODEL VS MATHEMATICAL MODEL

Physical & mathematical models are further divided into static and dynamic.

*Static physical model* :

The best known example of physical model is shipbuilding in which making a scale model provides a simple way of determining the exact measurements of the plates covering the hull, rather than having to produce drawings of complicated, three-dimensional shapes. Scientists have used models in which sphere represent atom, and rod shaped sheets of metal connect the spheres to represent atomic bonds. A model of this nature played an important role in the deciphering of the DNA molecule, work that was the subject of Nobel Prize /22/. These models are static physical models. They are sometimes said to be ionic model, a term meaning look-alike /23/.
Dynamic physical models:

Dynamic physical model rely upon an analogy between the system being studied and some other system of different nature. The analogy usually depends upon an underlying similarity in the forces governing the behaviour of the system. For example, if the motion of the wheel is limited by physical stops, a non-linear equation that is difficult to solve will be needed to describe the system. It is easy to model the effect electrically by placing limits on the voltage that can exist on the capacitance /21/.

Static Mathematical Model:

A static model gives the relationship between the system attributes when the system is in equilibrium. If the point of equilibrium is changed by altering any of the attribute values, the model enables the new values for all the attributes to be derived but does not show the way in which they changed to their new values.

For example, in marketing a commodity there is a balance between the supply and demand for the commodity. Both factors depend upon price: a simple market model will show what is the price at which the balance occurs/21/.

Dynamic mathematical model:

A dynamic mathematical model allows the changes of system attributes to be derived as a function of time. The derivation may be made with an analytical solution or with a numerical computation depending upon the complexity of the model.

1.5.4 ANALYTICAL SOLUTION VS SIMULATION

Once we have built a mathematical model, it must then be examined to answer the interesting questions about the system it is supposed to represent. If the model is simple enough it may be possible
to work with its relationship and quantities to get an exact analytical solution.

If an analytical solution to a mathematical model is available and is computationally efficient, it is usually desirable to study the model in this way rather than via simulation /22/. However many systems are highly complex, precluding any possibility of an analytical solution. In this case the model must be studied by means of simulation.

1.6 THE SIMULATION PROCESS

Simulation is the actual running of the model system to gain insight into its performance. It is used for the better understanding of the expected performance of the real system and to test the effectiveness of the system design. Simulation is thus a descriptive tool, allowing us to experiment with model instead of the factory. Simulation tool allows the development of an efficient design before any physical changes have been initiated. Simulation can effectively save development time and the financial resources thereby delivering its users productivity and reduced manufacturing costs.

There are three major activities in a simulation process /24/

1. Model development

2. Model execution

3. Model output

1. Model development :

Simulation models can be developed by four different methods i.e. textual definition, graphics definition, digitizing and CAD interfacing.

2. Model execution :

Model execution focuses primarily on the execution of the programming statements generated during model development.
3. Model output:

Though the development effort and model accuracy remain major concerns of those who must actively perform the simulation, model output has caught the attention of many new simulation enthusiasts.

The purpose of building the simulation and its use, generally falls in to one of these three categories:

I. Comparison:

A comparison of simulation runs can be used to assess the effects of changing one or more input variable. The results of the different runs are then be evaluated in terms of the objectives.

II. Prediction:

A simulation may be used for predictive purpose to determine the state of system at some future point in time, subject to assumptions about how it behaves and will continue to behave. New plants can be optimized using simulation before investment decisions are made.

III. Investigation:

Some simulations are carried out to provide an insight into the behaviour of the system, rather than to perform detailed experimentation. This type of activity is done to improve the performance of the factory or in the educational field, it can be used in laboratory or in the classroom for better understanding of the problem by the students.

In simulation process, a model is created or created and established experiments are simulated.

1.7 TYPES OF SIMULATION

1.7.1 Statistical Simulation

A statistical simulation describes system which can be either stochastic and deterministic and is used to estimate values that cannot
be easily deduced mathematically. This type of simulation is also called Monte-Carlo simulation. Statistical simulation techniques are used widely in risk analysis for assessing the risk/benefit of different and often expensive decisions /24/.

1.7.2 Continuous simulation

Continuous simulation is used to model systems which vary continuously with time. The system may be dynamic but may be either deterministic or stochastic /19/. Continuous simulation models, often composed of scores of feedback loops and hundreds of differential equations are used extensively in mechanical, production and electrical engineering. Fig 1.2 shows a characteristic output from a continuous variation over a time interval /3,21 &24/.

![Continuous Simulation Graph]

Fig. 1.2 : Continuous Simulation

1.7.3 Discrete simulation

Discrete-event simulation is concerned with the modelling of system that can be represented by a series of events, moving from one to the next as time progresses. The system modelled are dynamic and almost invariably, stochastic /21,24/.

Fig 1.3 shows a typical output from a discrete process which has sudden changes in process variable/output.

![Discrete Simulation Graph]

Fig. 1.3 : Discrete Simulation
1.7.4 Combined Simulation

Combined simulation consist of combination of continuous and discrete elements, in the sense that the dependent variable of the model may involve continuous or discrete variation in nature. For example, in a manufacturing system the amount of wear on a tool might be modelled as a continuous variable and the movement of work through the system and the machines discretely. Outputs from a combined model is shown in Fig (1.4) /24/

![Diagram of Combined Simulation](image)

Fig. 1.4 : Combined Simulation

1.8 SIMULATION METHODOLOGY

Simulation can be carried out in different ways

(I) Developing a dedicated model:

By the use a higher level language (like BASIC, FORTRAN and C) or any object oriented language (C++) a system can be modelled/simulated. This has the advantage of incorporating a specific to a particular system and this can be more efficient. If adequate resources are available this can be attempted /3,24/. In selecting a computer language, the following areas should be considered to assess its efficiency and suitability: program execution speed, computer memory and language availability /12/.

(II) Using simulation software:

Several general purpose simulation softwares, used for setting up and to run the simulation are available in market. These include
SIMAN (system modelling Inc.), SLAM II, MAP/1, SIMPLE I, CINEMA, WITNESS, GPSS (Minuteman software) /25/, SIMULA, GEMS, SIMSCRIPT (CACI) /26/ etc. /1, 24/.

SLAM II allows the user to develop models on personal computers, then run them on a larger computer. MAP/1 discrete manufacturing simulator enable users with a relatively low levels of computer skills, to model and analyze a system.

SIMAN and FORTRAN based packages, have a lot of capabilities for simulating manufacturing system elements such a stackers, AGVS, and robotic system. Without writing a lot of codes SIMAN, can be used to execute on personal, mini and mainframe computers. Models can be developed on a personal computer, loaded into a large computer to get faster running time when required, and the simulation results loaded back into the personal computer for further analysis /3/.

Lotus 1-2-3 also supports for probabilistic simulation /1/.

1.9 INTERACTIVE SIMULATION USING COMPUTER

Simulation is definitely cheaper than real experiments. Speed is often essential, either because many simulation runs of large model are needed, or because a model must run in real time, as for partial system tests and training simulators. As a result, massive, computing resources, including dedicated mainframes and special purpose computers, have been allocated to critical simulation.

Simulation can be run on several computer including mainframes and on the platforms as /24/:

(i) Mainframe computers with workstation PC front ends.

(ii) Workstations like HP 9000 series sparc-station 10, Silicon graphics, DEC Alpha series etc.

(iii) Pentium based workstations.
(iv) PC/AT 486 or PC/AT 386 with SVGA / VGA monitors.

1.10 WHEN IS SIMULATION THE APPROPRIATE TOOL?

The availability of special-purpose simulation languages, massive computing capabilities at a decreasing cost per operation, and advances in simulation methodologies have made simulation one of the most widely used and accepted tools in operations research and system analysis circumstances /27/.

Simulation can be used for the following purpose:

1. To study, and experimentation with internal interactions of a complex system, or of a subsystem within a complex system.

2. To gain information, organizational and environmental changes and the effect of alternations on the model's behaviour.

3. To gain knowledge in designing a system may be of great value.

4. By changing simulation input and observing the resulting output, valuable insight may be obtained about variables that are most important and the way variable interact.

5. Simulation can be used to pedagogical devices to reinforce analysis solution methodologies.

6. Simulation can be used to experiment with new designs or policies prior to implementation, so as to prepare them for what may happen?.

7. Simulation can be used to verify analytic solutions.

1.11 THE USE OF SIMULATION

Simulation is a slow, iterative, experimental problem solving technique. Sometimes it is referred to as the method of last resort & one should contemplate problem solving by simulation only when:/3,11,13 &28/
a. The real system does not exist and it is expensive, time consuming hazardous, or impossible to build and experiment with prototype. (new design of computer, solar system, nuclear reactor).

b. **Experimentation with the real system is expensive, dangerous, or likely to cause serious disruptions (transport system, nuclear reactor, manufacturing system).**

c. There is a need to study the past, or future behaviour of the system in real time, expanded time or compressed time e.g. real-time control systems, slow-motion studies, population growth, side-effects of new drugs.

d. Mathematical modelling of system is impossible e.g. soil exploration, meteorology, world economy, international conflicts, computer network.

e. Mathematical models have no simple and practical analytical or numerical solutions. For example in nonlinear differential equation, stochastic problems etc.

f. Satisfactory validation of simulation and the result is possible.

The expected accuracy (result cannot be better than input data) of simulation results is consistent with the requirements of the particular problem for example, the accuracy of radiation dosage for treating cancer patients is critical compared to the accuracy of forecasts on world tiger population.

**1.12 LIMITATION OF THE SIMULATION**

Computer simulation is neither a science nor an art, but a combination of both. The art is that of programming: a simulation program should do what its user intends, and should do it efficiently. However, it is not enough to write a correct and efficient program; one should know how to use it to answer questions about the system being
simulated. This is where the science comes in /29/. It is a method of
last resort. Simulation has some limitation such as: /3 & 18/

i. It is expensive in terms of manpower and computer time.

ii. Iterative, experimental problem solving technique.

iii. Generally yields suboptimum solutions.

iv. Validation difficulty.

V. Collection analysis and interpretation of results require a
good knowledge of probability and statistics.

vi. Results can be easily misinterpreted and difficult to trace for
errors.

vii. Difficult to convince others.

1.13 ADVANTAGES AND DISADVANTAGES OF SIMULATION

Simulation is intuitively appealing to a client because it mimics
what happens in real system or what is perceived for a system than a
tory or a methodology of problem solving. Furthermore, it is only one
of several valuable problem solving approaches, available to the
ystems analyst. We have defined simulation as experimentation with a
model of a real system. An experimental problem becomes apparent
when a need develops for specific information about a system that is
ot available from the existing known sources /30/. Barich /31/ points
out that direct experimentation upon the real life system eliminates
many of the difficulties in obtaining a good match between the model
and actual conditions, however, the disadvantages of direct
experimentation are sometimes great. In contrast to optimization
models, simulation models are run rather than solved.

Simulation has many advantages, and even some disadvantages.
These are listed by Pegden et al /32/.

The advantages of simulation can be:
1. New policies, operating procedures, decision rules, information flows, organization procedures, and so on can be explored without disrupting ongoing operations of the real system.

2. New hardware designs, physical layouts, transportation system, and so on, can be tested without committing resources for their acquisition.

3. Hypotheses about how and why certain phenomena occur can be tested for feasibility.

4. Time can be compressed or expanded allowing for a speed up or slow down of the phenomenon under investigation.

5. Insight can be obtained about the importance of variable on the performance of the system.

6. Bottleneck analysis can be performed indicating where work in process, information, materials, and so on are being excessively delayed.

7. A simulation study can help in understanding how the system operates rather than how individuals think the system operates.

8. *What if?* question can be answered. This is particularly useful in the design of new systems.

An additional advantage of simulation is its powerful educational and training application. The development and use of a simulation model allows the analyst to see and play with the system.

**The disadvantages are** :-

1. Model building require special training. It is an art that is learned over time and through experience. Furthermore, if two models are constructed by two competent individuals, they may have similarities, but it is highly unlikely that they will be the same.
2. Simulation results may be difficult to interpret. Since most simulation outputs are essentially random variables, it may be hard to determine whether an observation is a result of system interrelationships or randomness.

3. Simulation modeling and analysis can be time consuming and expensive. When the resources for modeling and analysis are used carelessly or in insufficient amount it may result in a simulation model or analysis that is not sufficient for the task.

4. Simulation is used in some cases, when an analytical solution is possible, or even preferable.

1.14 TRENDS IN SIMULATION

One of the most important developments in recent past is the ability to define portions of the system graphically. Using either a mouse or cursor keys on the keyboard, the modeller describe the physical characteristics of the system on a graphics screen. This method is primarily limited to defined components and their physical location within the system. Any logical description of how the components interact must still be input textually, usually as a post processing activity.

Dynamic display of the system, is more effective, for the user, with the necessary text. Graphics definition provides significant benefits over textual modelling. The model can be developed more quickly.

A recent development that offers even faster model development than graphics input is digitizing a drawing. Many systems to be simulated already reside in some form of facility layout drawing. Today's simulation technology allows this drawing to be digitized onto the graphics screen.

Another development and the one with the great potential, involves capturing the system description directly from a CAD system.
Transferring the description from the CAD file directly to the simulation system can reduce model development time several fold.

Interactive execution is an important development, which allows the user to interface with the model as it is being executed, it offers the modeller/user greater control over experimentation.

Traditionally, simulation has provided vast amount of statistical data in the form of tables. It was the responsibility of the modeller to analyze this data and summarize what it meant. Today, those who are not familiar with the model's creation can understand the results of the simulation effort as it is brought to life by animation. Animation allows the viewer to see the system operating with the flow of materials and interaction of processes. The most advanced systems, present the model in three dimensions, where it can be viewed from any angle or distance.

The trends as given are classified as follows: /24/

(a) **User oriented development trends:**

a. Creation of integrated simulation environments.

b. Creation of explicit concepts in simulation language to represent complex, behaviour such as decision making.

c. Creation of intelligent integrated simulation environment.

(b) **System oriented development trends:**

i. Creation of open ended simulation software which can be functionally integrated with other manufacturing software.

ii. System simulation as an integral part of a manufacturing control system.

(c) **Use of expert system in manufacturing simulation**.
1.15 COMPUTER SIMULATION IN CLASSROOM TEACHING

Apart from a large number of applications of the computer simulation /33/, one of them is it's use for classroom teaching or it's use for education /34/.

As we have stated earlier, simulation is a very powerful tool to solve the problems which are very lengthy and too cumbersome if done manually. Beside these applications, simulation enable a teacher to present near real life versions of real-life situations that are too costly, time consuming, dangerous, or complicated to recreate in a classroom /35/.

In this sort of instruction, the computer is able to simulate the conditions of an experiment or situation. The student can set conditions and make decisions, and the computer will show or demonstrate their implications. One well known computer simulation, the flight simulator /36/, has been used for years in training pilots to fly commercial and military aircraft. The simulator includes an exact replica of the cockpit and controls of a given type of aircraft. The mock-up is connected to computer system, that is programmed to give a trainee seated in the cockpit the experience of the inflight movements of aircraft and visual effects which result from adjustments to the controls and instruments. Flight simulators work quite well and provide valuable training before actual flights, without risking aircraft or life. There is considerable flexibility regarding how computers can be used in simulations. They can control mechanical movement (as flight simulators do), or graphic displays, or text shown on a CRT screen. The success of these applications depend on the imagination and skill of the person developing them. Of-course, costs are a concern in simulations as well as real-life experiments, particularly when complicated mechanical or scientific equipment is required.

In the classroom, one of the very important role of computer is to simulate the situation, to create the kind of model of an actual situation
and work with it. For example, if a teacher used a program that simulated a typical natural environment, say a rice-growing one, and then removed from the environment water, or any one other aspect, the children would see very quickly how dependent rice is on its environment /37/ and an experiment can make students think and around their motivation and interest in learning /38/. Besides common tool of teaching like; chalk, duster & blackboard, with the aid of computer and simulation we can replace a teacher by a computer.

1.16 SIMULATION AS A TECHNIQUE

As a technique, simulation is most widely used in operations research and management science. In a survey of graduates of the department of operations research at Case Western Reserve University, Rasmussen and George /39/ found that among M.S. graduates, simulation ranked fifth among some fifteen subject areas in terms of its value after graduation. Among Ph.D. graduates, simulation tied for second. Thomas and DaCosta /40/ in a survey of a different type, asked some 137 large firms to indicate which of fourteen techniques they used, and simulation came in second, with 84 percent of the firms responding that they used it. The members of the operations research division of the American Institute of Industrial Engineers were surveyed by Shannon et al /41/, who reported that simulation ranked second in familiarity, but first in terms of utility and interest, among some twelve methodologies. Forgione /42/ and Harpell et al /43/ also reported that simulation ranked second in utilization among eight tools in a survey of large corporations. All these surveys are by now several years old, and we can assume that simulation's value and usage have since then increased due to improvement in computing power and simulation software.

Simulation models that are built for use of digital computer can be considered as a laboratory version of a system. Once a simulation
model is developed, experiments, or simulations, permit inferences to be drawn about system. It is an abstraction of system /44/.  

* Without building them, if they are only proposed system.  
* Without disturbing them, if they are costly or unsafe to experiment with;  
* Without destroying them, if the object of an experiment is to determine their limits of stress.  

In this way, simulation model can be used for design, procedural analysis and performance assessment /45/.

1.17 CONCLUSION

With the easy and cheaper availability of the computer systems, especially PC, computer have found many unconventional uses. Microprocessor based computer systems are now very powerful and have lot of computer memory. The speed of computer and accuracy has increased tremendously, specially with the availability of INTEL 80486 and Pentium based system.

With the given power, speed and memory capacity, it is possible to do simulation on even small system. Simulation is the popular and expandry use of computer & it has been on the rise for the last three decades or so. In recent years, simulation technique have become invaluable tool for system analysis, in wide variety of different disciplines. There is hardly a discipline or an industry that does not use simulation. More and more emphasis is being placed upon the technological advancement in accuracy, capacity, speed and reliability, as well as convenience although accurate estimates of current worldwide expenditures on simulation activities are not available, it is not difficult to agree that it is probably in billions of dollars annually /12/.
Simulation is an almost indispensable tool when it comes to the study of complex and/or large systems. Among the applications where simulation has been widely used and accepted are those in civilian and military aerospace, manufacturing, computer-aided design, economics, health/medicine, power/energy and Education.

In the field of education, educational packages are being developed to simulate laboratory situations, where real experiments may be expensive, technically difficult, time consuming and even dangerous in many cases.

The experiments done on models instead of real systems, using simulation technique, are certainly more convenient, less time consuming and cheaper. There exists a large number of problem from physical, chemical, mathematical, engineering fields which are simulated on computers. The success of application of simulation depend upon the knowledge, imagination and skill of the persons developing them. Of course, costs are a concern in simulation as well as in real life experiments, particularly when complicated mechanical or scientific equipment is required.
REFERENCES


