## Principles used in Modeling

Guidelines used in modeling

- It is not possible provide rule by which models are built. But a number of guidelines can be stated.
- The different viewpoints from which we can judge whether certain info. Should be included as excluded in models are:

1. **Block –Building:** The description of system should be organized as a sequence of blocks. It simplifies the interaction between block within system. Then it will be easy to describe the whole system in terms of interaction between the block and can be represented graphically as simple block diagram. For example: -the block of factory system. Fig: Block diagram of factory system

2. **Relevance:** The model should only include relevant information. For example, if the factory system study aims to compare the efficient of different operating rules efficiency it is not relevant to consider the mining of employee as an activity. Irrelevant information should not include despite of being no harm because it increases the complexity of model and takes more time and effort to solve model.

3. **Accuracy:** The gathered information should be accurate as well. For example, in aircraft system the accuracy as movement of the aircraft depends upon the representations of airframe such as a rigid body.

4. **Aggregation:** It should be considered that to which numbers of individual entities can be grouped into a block. For example in factory system, different department are grouped together handled by production manager.

## Distributed lag model

Models that have the property of changing only at fixed interval of time. It is used to predict current values of a dependent variable based on both the current values of an explanatory variable (independent variable) and the lagged (past period) values of this explanatory variable. In economic studies some economic data are collected over uniform time interval such as a month or year. This model consists of linear algebraic equations that represent continuous system but data are available at fixed points in time.

**For example: Mathematical model of national economy**

Let

C=consumption

I=investment

T=Taxes

G=government expenditures

Y=national income

Then

$C=20+0.7(Y-T)$

$I=2+0.1Y$

$T=0.2Y$

$Y=C+I+G$

All the equation are expressed in billions of rupees. This is static model and can be made dynamic by lagging all the variables as follows

$C=20+0.7(Y-1-T-1)$

$I=2+0.1Y-1$

$T=0.2Y-1$

$Y=C-1+I-1+G-1$

Any variable that can be expressed in the form of its current value and one or more previous value is called lagging variable. And hence this model is given the name distributed lag model. The variable in a previous interval is denoted by attaching –n suffix to the variable. Where –n indicate the nth interval.

## Advantages of distributed lag model

- Simple to understand and can be computed by hand, computers are extensively used to run them.
- There is no need for special programming language to organize simulation task.

## Steps on simulation Study

### 1. Problem formulation

Every study begins with a statement of the problem, provided by policy makers. Analyst ensures it is clearly understood. If it is developed by analyst policy makers should understand and agree with it.

### 2. Setting of objectives and overall project plan

The objectives indicate the questions to be answered by simulation. At this point a determination should be made concerning whether simulation is the appropriate methodology. Assuming it is appropriate, the overall project plan should include

- A statement of the alternative systems
- A method for evaluating the effectiveness of these alternatives
- Plans for the study in terms of the number of people involved
- Cost of the study

- The number of days required to accomplish each phase of the work with the anticipated results.

**Model conceptualization**

The construction of a model of a system is probably as much art as science. The art of modeling is enhanced by ability:

- To abstract the essential features of a problem.
- To select and modify basic assumptions that characterizes the system.
- To enrich and elaborate the model until a useful approximation results. Thus, it is best to start with a simple model and build toward greater complexity. Model conceptualization enhances the quality of the resulting model and increases the confidence of the model user in the application of the model.

**Data collection**

There is a constant interplay between the construction of model and the collection of needed input data. It is done in the early stages. Objective kinds of data are collected.

**Model translation**

Real-world systems result in models that require a great deal of information storage and computation. It can be programmed by using simulation languages or special purpose simulation software. Simulation languages are powerful and flexible. Simulation software models development time can be reduced.

**Verified**

It pertains to the computer program and checking the performance. If the input parameters and logical structure are correctly represented, verification is completed.

**Validated**

It is the determination that a model is an accurate representation of the real system. It is achieved through calibration of the model. The calibration of model is an iterative process of comparing the model to actual system behavior and the discrepancies between the two.

**Experimental Design**

The alternatives that are to be simulated must be determined. Which alternatives to simulate may be a function of runs? For each system design, decisions need to be made concerning

· Length of the initialization period

· Length of simulation runs

· Number of replication to be made of each run

**Production runs and analysis**

They are used to estimate measures of performance for the system designs that are being simulated.

**More runs**
Based on the analysis of runs that have been completed, the analyst determines if additional runs are needed and what design those additional experiments should follow.

**Documentation and reporting**

Two types of documentation:
· Program documentation
· Process documentation
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**Program documentation**
Can be used again by the same or different analysts to understand how the program operates. Further modification will be easier. Model users can change the input parameters for better performance.

**Process documentation**
It gives the history of a simulation project. The result of all analysis should be reported clearly and concisely in a final report. This enables to review the final formulation and alternatives, results of the experiments and the recommended solution to the problem. The final report provides a vehicle of certification.

**Implementation**
Success depends on the previous steps. If the model user has been thoroughly involved and understands the nature of the model and its outputs, likelihood of a vigorous implementation is enhanced. The simulation model building can be broken into 4 phases.

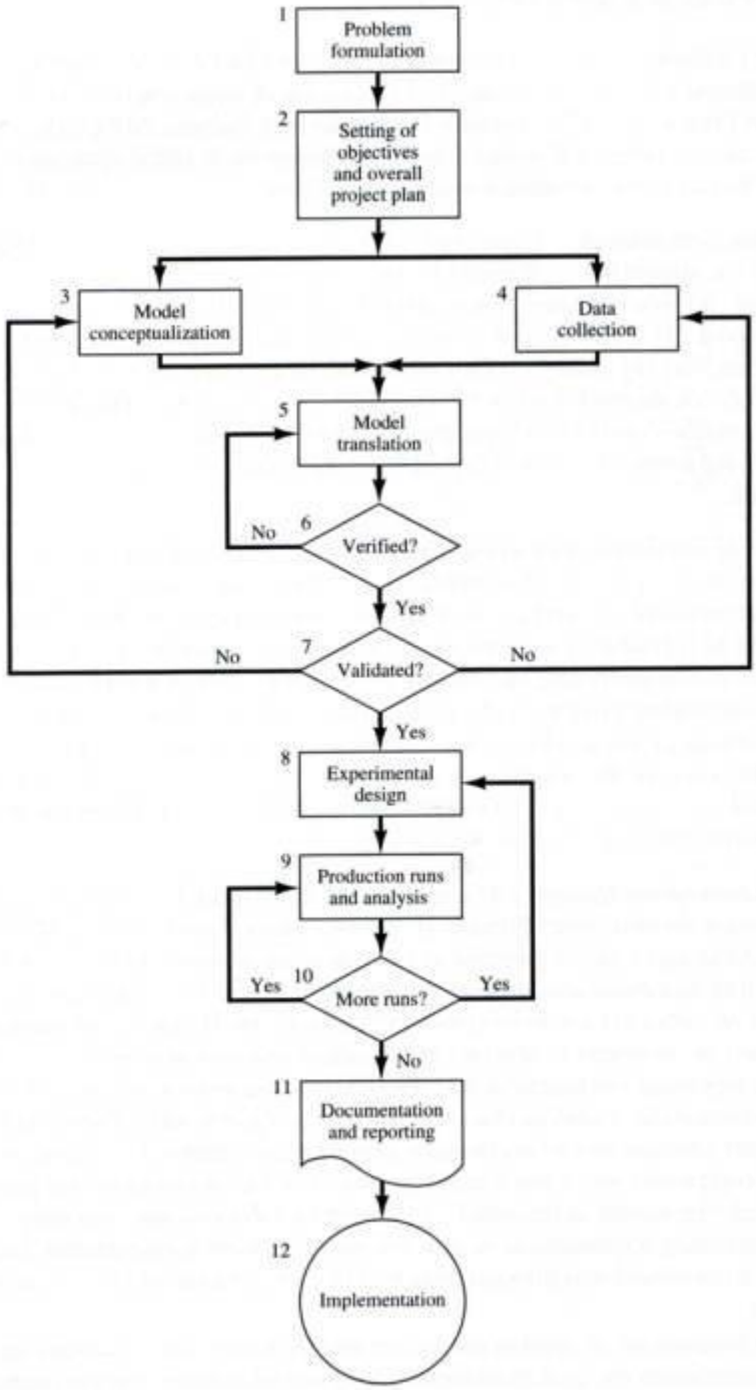


**Figure 1.3.** Steps in a simulation study.

## Phase of
## Simulation Study

### I Phase

- Consists of steps 1 and 2

- It is period of discovery/orientation
- The analyst may have to restart the process if it is not fine-tuned
- Recalibrations and clarifications may occur in this phase or another phase.

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**II Phase**

- Consists of steps 3,4,5,6 and 7
- A continuing interplay is required among the steps
- Exclusion of model user results in implications during implementation

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**III Phase**

- Consists of steps 8,9 and 10
- Conceives a thorough plan for experimenting
- Discrete-event stochastic is a statistical experiment
- The output variables are estimates that contain random error and therefore proper statistical analysis is required.

**IV Phase**

- Consists of steps 11 and 12
- Successful implementation depends on the involvement of user and every steps successful completion.

**When simulation is 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 systems analysis.

Simulation can be used for the following purposes:

1. Simulation enables the study of, and experimentation

with, the internal interactions of a complex system, or of a subsystem within a complex system.

2. Informational, organizational, and environmental changes can be simulated, and the effect of these alterations on the model's behavior can be observed.

3. The knowledge gained in designing a simulation model may be of great value toward suggesting improvement in the system under investigation.

4. By changing simulation inputs and observing the resulting outputs, valuable insight may be obtained into which variables are most important and how variables interact.

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

6. Simulation can be used to verify analytic solutions.

7. By simulating different capabilities for a machine, requirements can be determined.

8. Simulation models designed for training allow learning without the cost and disruption of on- the-job learning.

**When the simulation is not appropriate?**

To recognize if simulation is the correct approach to solving a particular problem, four items should be evaluated before deciding to conduct the study:

***Type of Problem***: If a problem can be solved by common sense or analytically, the use of simulation is unnecessary. Additionally, using algorithms and mathematical equations

may be faster and less expensive than simulating. Also, if the problem can be solved by performing direct experiments on the system to be evaluated, then conducting direct experiments may be more desirable than simulating.
***Availability of Resources***: People and time are the determining resources for conducting a simulation study. An experienced analyst is the most important resource since such a person has the ability and experience to determine both the model's appropriate level of detail and how to verify and validate the model. Without a trained simulator, the wrong model may be developed which produces unreliable results. Additionally, the allocation of time should not be so limited so as to force the simulator to take shortcuts in designing the model. The schedule should allow enough time for the implementation of any necessary changes and for verification and validation to take place if the results are to be meaningful.

***Costs***: Cost considerations should be given for each step in the simulation process, purchasing simulation software if not already available, and computer resources. Obviously if these costs exceed the potential savings in altering the current system, then simulation should not be pursued.

***Availability of Data*****:** The necessary data should be identified and located, and if the data does not exist, then the data should be collectible. If the data does not exist and cannot be collected, then continuing with the simulation study will eventually yield unreliable and useless results. The simulation output cannot be compared to the real system's performance, which is vital for verifying and validating the model.

**Advantages of simulation**

1. Simulation can also be used to study systems in the design stage.
2. Simulation models are run rather than solver.
3. New policies, operating procedures, decision rules, information flow, etc can be explored without disrupting the ongoing operations of the real system.
4. New hardware designs, physical layouts, transportation systems can be tested without committing resources for their acquisition.
5. Hypotheses about how or why certain phenomena occur can be tested for feasibility.
6. Time can be compressed or expanded allowing for a speedup or slowdown of the phenomena under investigation.
7. Insight can be obtained about the interaction of variables.
8. Insight can be obtained about the importance of variables to the performance of the system.
9. Bottleneck analysis can be performed indication where work-in process, information materials and so on are being excessively delayed.
10. A simulation study can help in understanding how the system operates rather than how individuals think the system operates.
11. "what-if" questions can be answered. So it is useful in the design of new systems.

**Disadvantage of simulation**

1. Model building requires special training.

2. Simulation results may be difficult to interpret.
3. Simulation modeling and analysis can be time consuming and expensive.
4. Simulation is used in some cases when an analytical solution is possible or even preferable.

**Applications of Simulation**

**Manufacturing Applications**

1. Analysis of electronics assembly operations
2. Design and evaluation of a selective assembly station for high precision scroll compressor shells.
3. Comparison of dispatching rules for semiconductor manufacturing using large facility models.
4. Evaluation of cluster tool throughput for thin-film head production.
5. Determining optimal lot size for a semiconductor backend factory.
6. Optimization of cycle time and utilization in semiconductor test manufacturing.
7. Analysis of storage and retrieval strategies in a warehouse.
8. Investigation of dynamics in a service oriented supply chain.
9. Model for an Army chemical munitions disposal facility.

**Semiconductor Manufacturing**

1. Comparison of dispatching rules using large-facility models.
2. The corrupting influence of variability.
3. A new lot-release rule for wafer fabrication.
4. Assessment of potential gains in productivity due to proactive

retied management.
5. Comparison of a 200 mm and 300 mm X-ray lithography cell.
6. Capacity planning with time constraints between operations.

**Military Applications**

1. Modeling leadership effects and recruit type in a Army recruiting station.
2. Design and test of an intelligent controller for autonomous underwater vehicles.
3. Modeling military requirements for non war fighting operations.
4. Multi trajectory performance for varying scenario sizes.
5. Using adaptive agents in U.S. Air Force retention.

**Hybrid Simulation:** For most studies, the system under study is clearly either of continuous or discrete nature and it is the determining factor in deciding whether to use an analog or digital computer for system simulation. If the system being simulated is an interconnection of continuous and discrete subsystem, then such system simulation is known as hybrid simulation. Such hybrid system can be digital computer being linked together. Hybrid simulation required high speed converters to transform signals from analog to digital from and vice –versa.

**Real time simulation:** In real time simulation, actual device (which are part of a system) are used in conjunction with either digital computer or hybrid computer. It provides the simulation of the points of systems that do not exist or that cannot be easily used in an

experiment i.e. the basic idea of real time simulation is „uses the actual part if they are appropriate to use in experiment otherwise use the simulation of the points of the system‟.
A well-known example is "simulation to train pilots". It uses the devices for training pilots by giving them the impression that is at the control of an aircraft. It requires real time simulator of the plane its control system, the weather and other environmental conditions. Sometimes, real time simulation also refers to a computer model of a physical system that can execute at the same rate as actual system can. For example: if a machine takes 10 minutes to fill a tank in real world, the simulation also would take 10 minutes. Real time simulation of an engineering system becomes possible when we replace physical device with virtual device.