

University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

Industrial and Management Systems
Engineering -- Presentations

Industrial and Management Systems
Engineering

2003

Discrete-Event Simulation: Simulation Practices and Trends

Paul Savory

University of Nebraska at Lincoln, psavory2@gmail.com

Follow this and additional works at: <https://digitalcommons.unl.edu/imsepresentations>



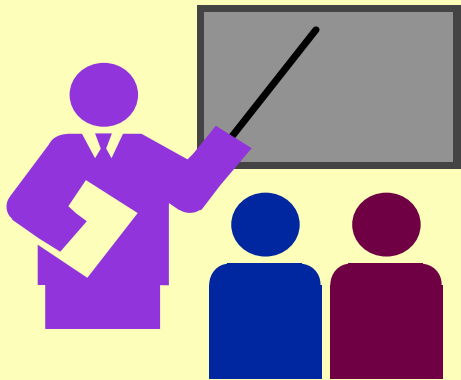
Part of the [Industrial Engineering Commons](#), and the [Operational Research Commons](#)

Savory, Paul, "Discrete-Event Simulation: Simulation Practices and Trends" (2003). *Industrial and Management Systems Engineering -- Presentations*. 2.
<https://digitalcommons.unl.edu/imsepresentations/2>

This Article is brought to you for free and open access by the Industrial and Management Systems Engineering at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Industrial and Management Systems Engineering -- Presentations by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

Simulation Practices and Trends

Paul A. Savory, Ph.D.



**Industrial and Management
Systems Engineering
University of Nebraska - Lincoln**

What is a Model?

A **model** is a simplified representation of a system (or process or theory) intended to enhance one's ability to understand, predict, and possibly control the behavior of the system

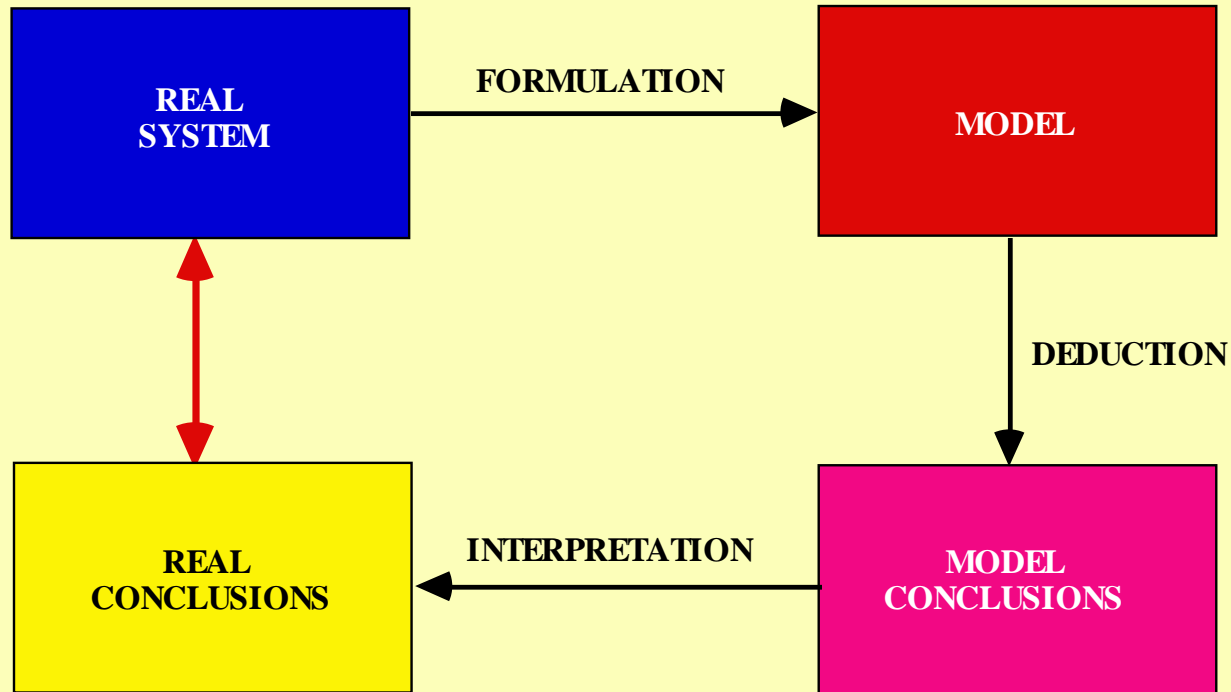


Why Develop a Model?

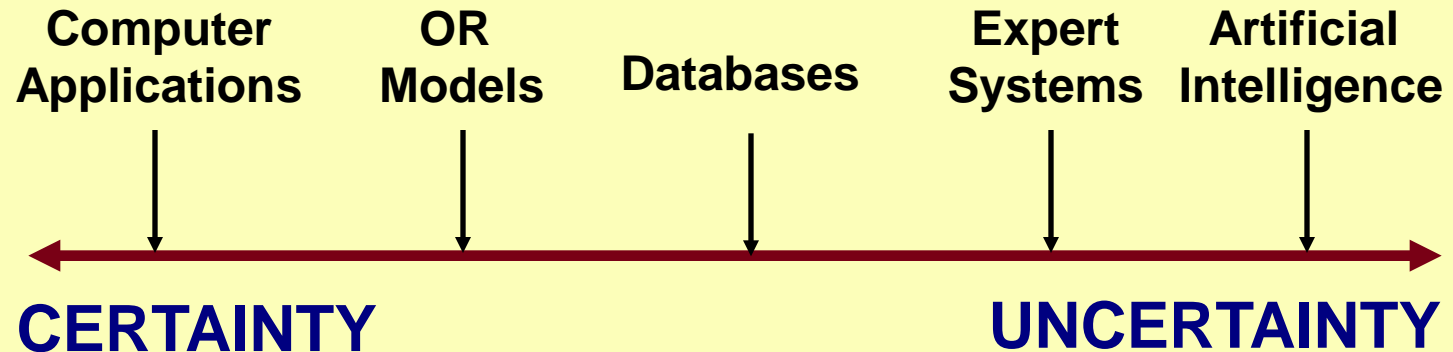


- ▶ **an aid to experimentation**
- ▶ **a tool of prediction**
- ▶ **an aid to thought**
- ▶ **an aid to communication**
- ▶ **an aid to training and instruction**

How the Model is Used

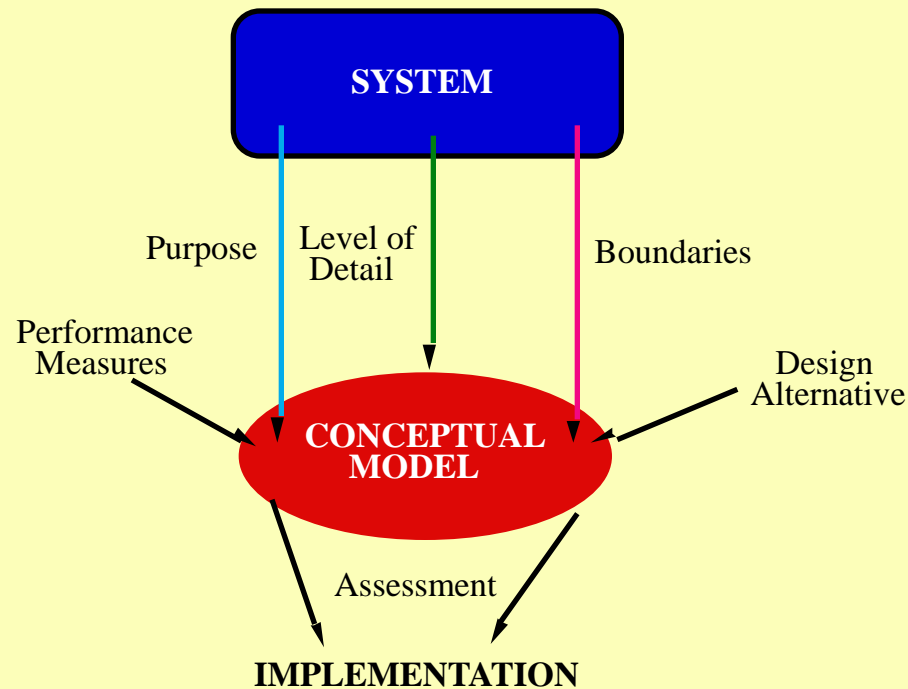


Problem Solving Approaches



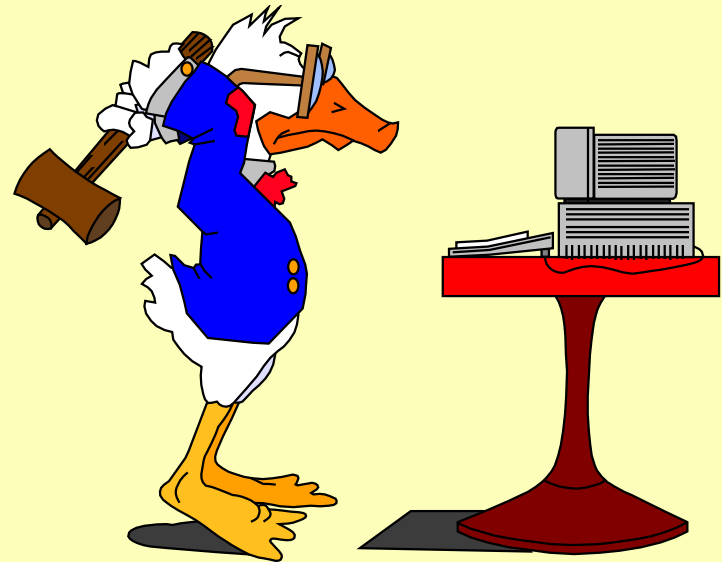
The spectrum goes from physical models or prototypes which are expensive and time consuming to build and need exact conditions to model the real system and proceeds to completely abstract mathematical models

Factors Affecting the Development of a Model



What is a Computer Simulation?

Process of developing a mathematical-logical model of a system and experimenting with that model on a computer



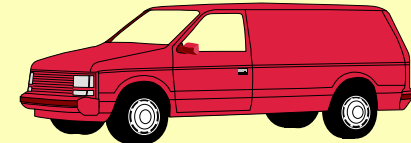
Why Use Simulation?

- ▶ The real system does not exist and it is too costly, time-consuming, hazardous, or impossible to build

- ▶ The real system exists but experimentation is expensive, hazardous, or seriously disruptive

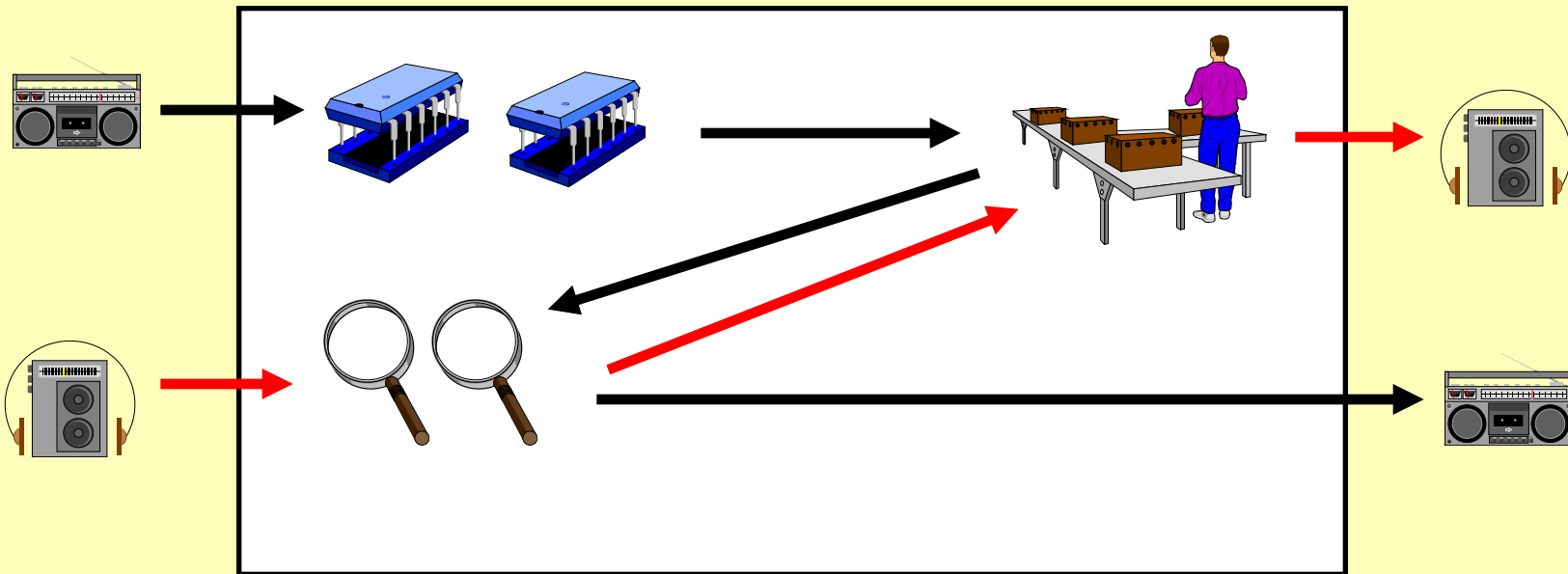


- ▶ The real system exists but experimentation may destroy it



- ▶ Mathematical modeling of the system has no practical or numeric solutions

A Job Shop Example



Analysis of a Job Shop

Factors affecting our analysis

set-up times; unique production sequence of each part; machine breakdowns; limited waiting space

What types of performance measures would you like to obtain?

work-in-progress; production time; machine/worker utilization

A Heuristic Model

One approach to studying this system is to an analytical technique which seeks to get some unique and/or optimal solution

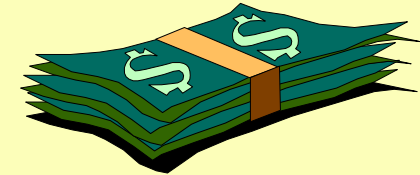
Due to this complexity, possibly we can build a heuristic model

- construct a model of the system
- observe the behavior of the performance variables over time
- based on the observations, hypothesize how the real system is behaving

These three tasks describe what simulation performs!

Simulation Disadvantages

- ▶ Simulation models are expensive and time consuming to develop



- ▶ Simulation models give **estimates** of performance characteristics and offer few procedures for optimization
- ▶ Simulation models produce large quantities of output. **This does not mean the model is correct!**

The Simulation Process

Step 1: Problem Definition

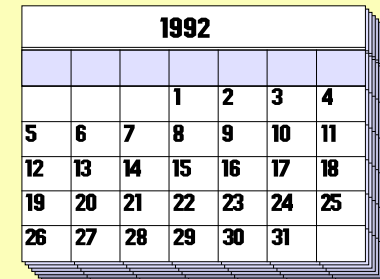
Develop the preliminary model

Step 2: Project Planning

Decide on personnel, management support, computer hardware, and budget for the study

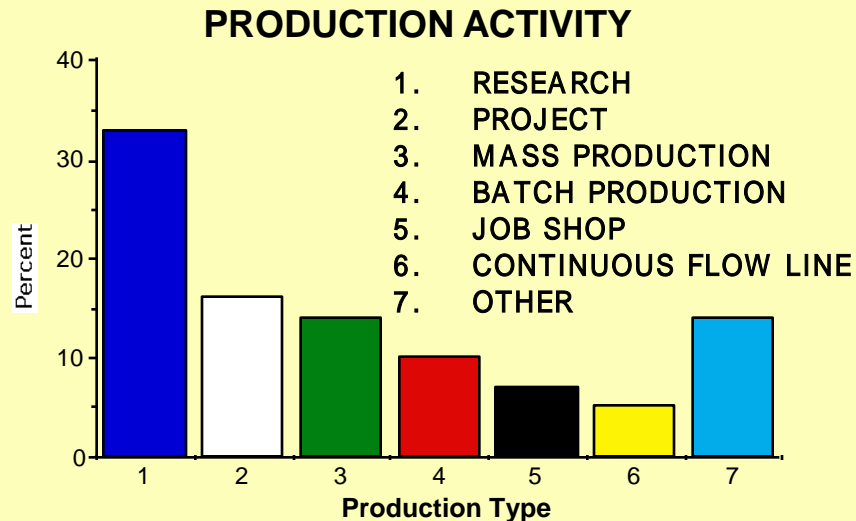
Step 3: System Definition

Identify the small subset of characteristics or features of the system to include



1992											
			1	2	3	4					
5	6	7	8	9	10	11					
12	13	14	15	16	17	18					
19	20	21	22	23	24	25					
26	27	28	29	30	31						

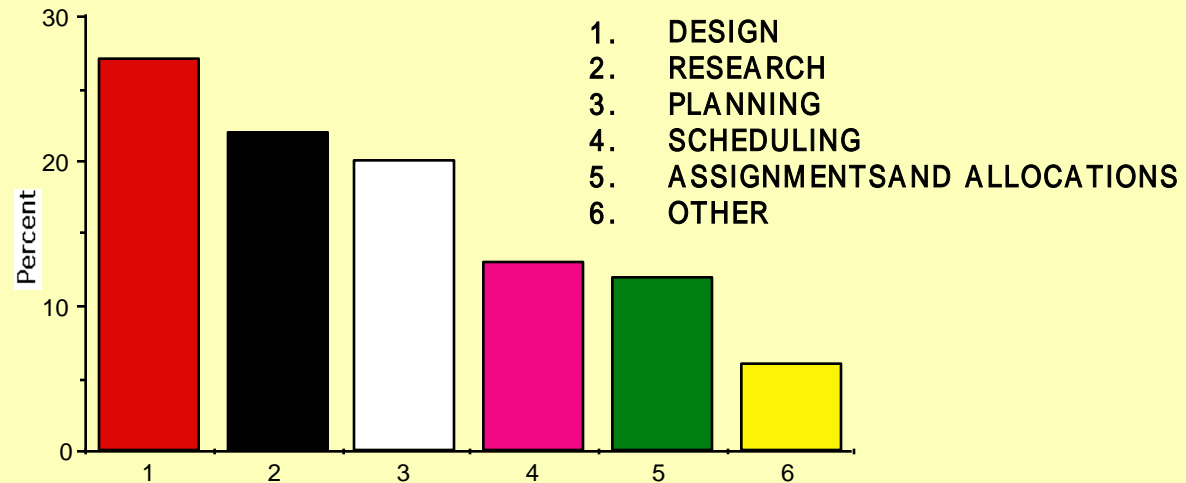
Organizational Activities and Simulation



One third of practitioners perform simulation research

Organizational Activities and Simulation

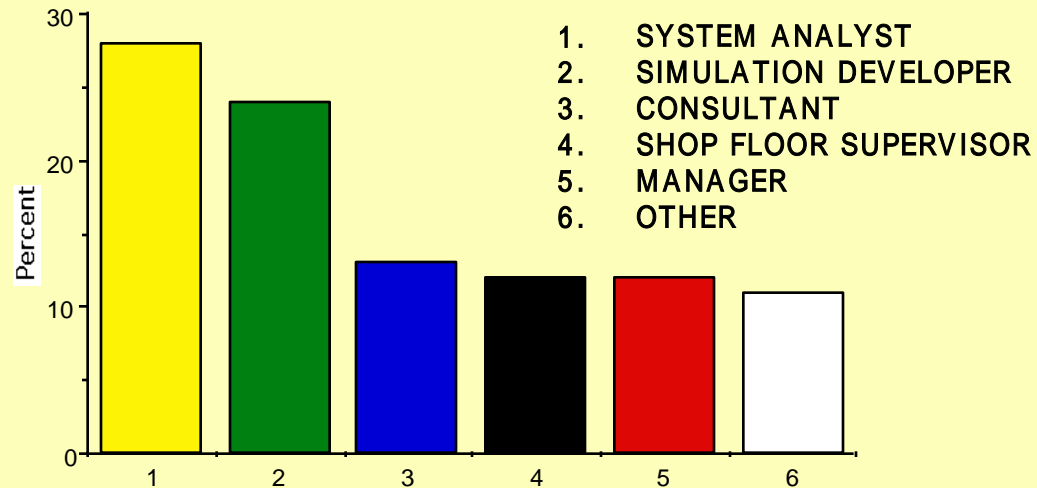
USE OF SIMULATION - PURPOSE



Simulation is highly used for design, research, and planning
Industry uses simulation most for design and planning

Project Contributors

SIMULATION TEAM MEMBERS



Simulation developers and systems analysts usually lead the analysis team

The Simulation Process

Step 4: Conceptual Model Formulation

Develop the preliminary model

Step 5: Preliminary Experimental Design

What output do you want?



Step 6: Input Data Preparation

Collect data and fit probability distributions to it

The Simulation Process

Step 7: Validation

Does the model describe the real system?



Step 8: Model Translation

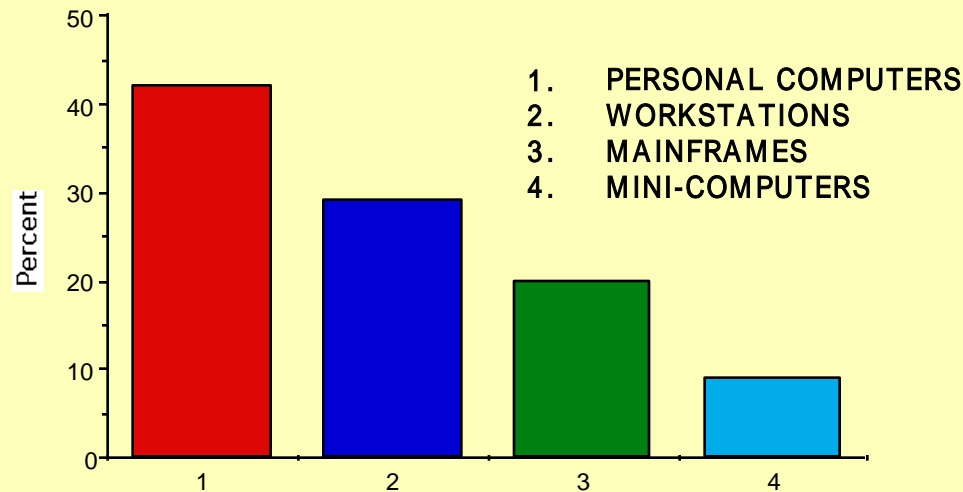
Formulate the model in an appropriate language

Step 9: Verification

Does the computer simulation model execute as intended?

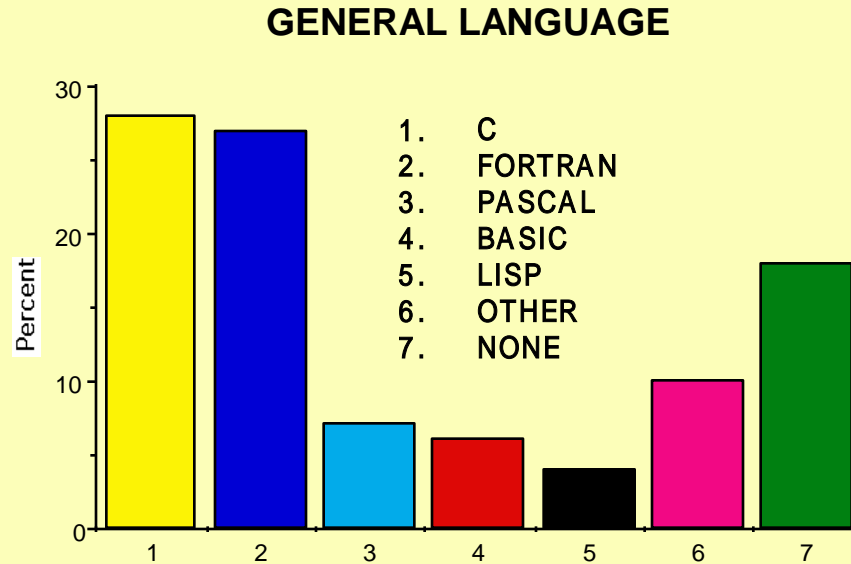
Hardware Configuration

COMPUTER HARDWARE



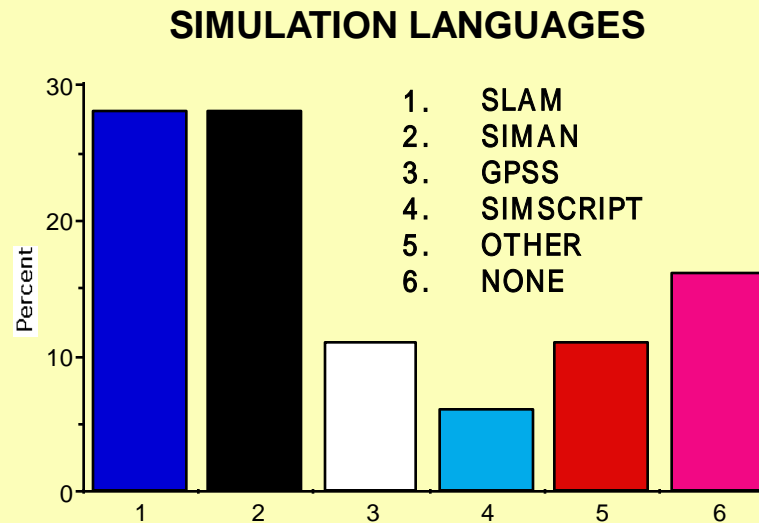
PCs and workstations are widely used simulation platforms
Mainframes are least preferred by industry

Simulation Software



C and FORTRAN are widely used, PASCAL is not used in industry

Simulation Software



SLAM and SIMAN are equally popular
Industry prefers SIMAN to SLAM, Universities prefer SLAM to SIMAN

A Banking System



**Customers arrive
according to an
exponential distribution
with a mean of 2 minutes**

**Service time is
between 2 and 5
minutes**

SIMAN Simulation Model

```
CREATE: EXPON(2):MARK(ArrivalTime)  
QUEUE, WaitTellerQ;  
SEIZE: Teller;  
    DELAY: UNIFORM(2,5);  
RELEASE: Teller;  
TALLY: TimeInSystem, INT(ArrivalTime);  
DISPOSE;
```


The Simulation Process

Step 10: Pilot Runs

Collect a small quantity
of output



Step 11: Validation

Does the simulation model approximate what
would be expected?

Step 12: Final Experimental Design

Design an experiment to yield the desired output

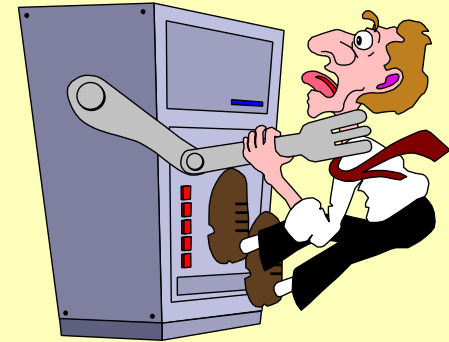
The Simulation Process

Step 13: Make Production Runs

Step 14: Output Data Analysis

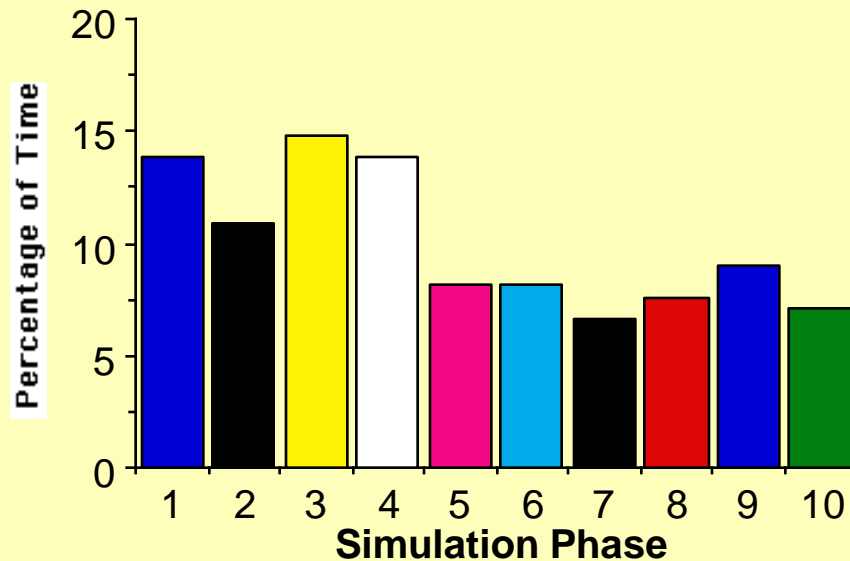
Compute averages, standard deviations, and confidence intervals on performance variables

Step 15: Documentation, Presentation, and Implementation



Project Effort Allocation

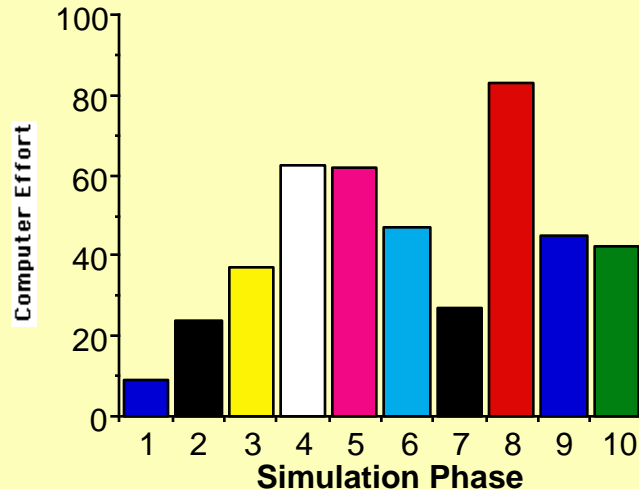
TIME FOR EACH PHASE



1. MODEL FORMULATION
2. MODEL BUILDING
3. DATA ACQUISITION
4. MODEL TRANSLATION
5. VERIFICATION
6. VALIDATION
7. STRATEGIC AND TACTICAL PLANNING
8. EXPERIMENTATION
9. ANALYSIS OF RESULTS
10. IMPLEMENTATION AND DOCUMENTATION

Available Computer Assistance

COMPUTER EFFORT FOR EACH PHASE



1. MODEL FORMULATION
2. MODEL BUILDING
3. DATA ACQUISITION
4. MODEL TRANSLATION
5. VERIFICATION
6. VALIDATION
7. STRATEGIC AND TACTICAL PLANNING
8. EXPERIMENTATION
9. ANALYSIS OF RESULTS
10. IMPLEMENTATION AND DOCUMENTATION

What You Should Remember



**Simulation only provides an
estimate of the true
performance characteristic, not
the characteristic itself**

**Simulation DOES NOT give an
exact answer!**