



# 5.0 Introduction to Simulation

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# Simulation: More than just a game

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# OUTLINE

- I. Simulation Defined
- II. Simulation Application
- III. Advantages of Simulation
- IV. Simulation Methodology
- V. Systems Concept
- VI. Some Examples
- VII. Workshop



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# Simulation Defined

“Imitation of the operation of a real-world process or system over time”-Wikipedia.com

“Representation of the behavior or characteristics of one system through the use of another system” –Dictionary.com

# Simulation Defined

“Involves the generation of an artificial alternate of a system and generating inferences of the real system” –Banks et al.

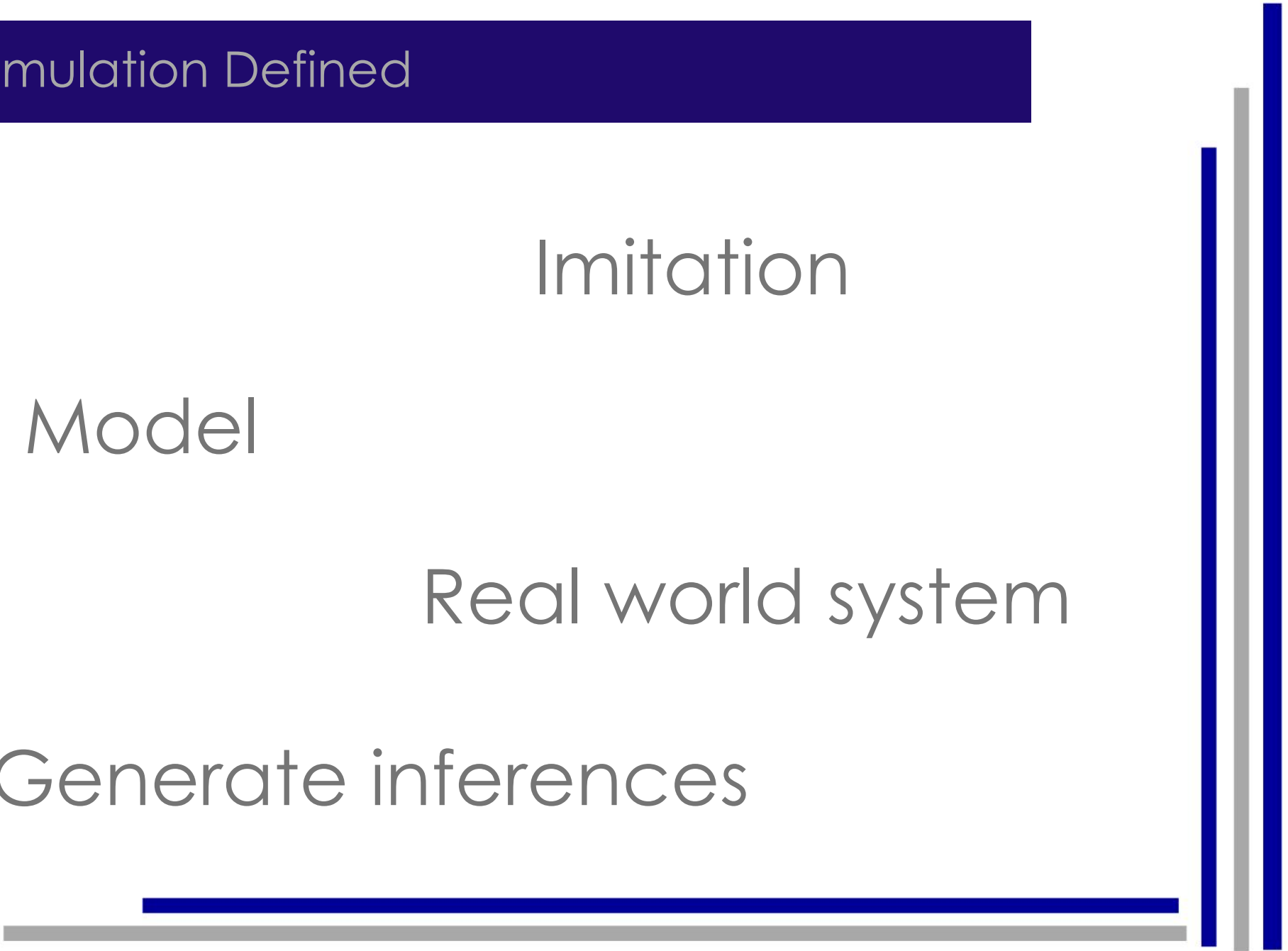
“Creation of an artificial system history from which analysts draw inferences”

Imitation

Model

Real world system

Generate inferences





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# Simulation Applications

## Frequency of Use of Various Management Science Methods

1. Economic analysis (payback, breakeven, discounted PW, etc.)
2. Statistical analysis (probability, inference, decision theory, etc.)
3. Simulation
4. Linear Programming
5. Inventory models
6. PERT/CPM
7. Other mathematical programming  
(integer, goal, dynamic, etc.)
8. Search techniques
9. Queuing models
10. Game theory

## When is Simulation Appropriate?

1. Study the internal interactions of a complex system or subsystem
2. Study the effect of alterations in the system
3. To verify or reinforce a solution or an improvement

## When is Simulation Not Appropriate?

1. When you can use common sense
2. When you can solve a problem analytically
3. When direct experiments are easier to be done
4. Cost is too great
5. No time or resources
6. Insufficient data
7. You are unable to verify a model
8. System behavior is too complex

# Simulation Applications

## Some Applications of Simulation

1. Manufacturing (plant design, scheduling, material handling)
2. Transportation (Railroad, Ikot-toki, Air traffic control)
3. Project Planning and Control (marketing, product planning)
4. Financial Planning (cash flows, econometric models)
5. Environment (flood, energy flow)
6. Health Care (inventory, manpower planning)

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# Advantages of Simulation

## Why Simulate?

1. Permits controlled experimentation
2. Allows Real world complications
3. Permits time compression or expansion
4. Simulation data is less costly to obtain
5. Does not disturb real world system
6. Testing can be done resource free
7. Analytic Solutions can be verified
8. Insights on interactions of systems can be obtained
9. Visual

# Advantages of Simulation

## The down side ☹️

1. Sometimes costly and time consuming
2. May require special training
3. Parameters may be difficult to initialize
4. Does not generate an optimal solution
5. There may be hidden critical assumptions
6. Does not gurantee a useful result
7. Results may be difficult to interpret



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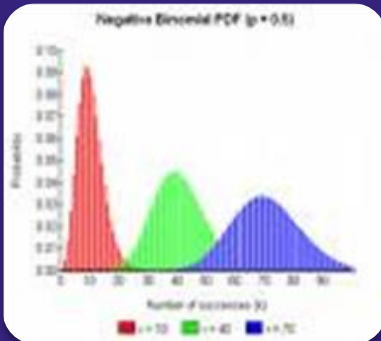
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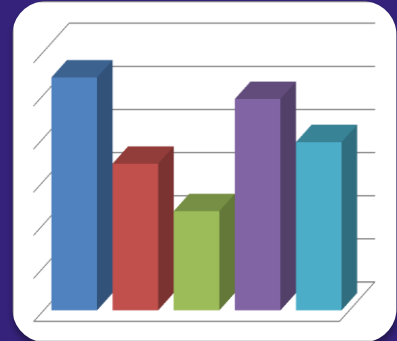
VII. Workshop



# Simulation Methodology



`=rand()`



## Capture

- Data Gathering. Input Analysis.

## Imitate

- Random number and random variate generation for dummy data generation.

## Run and Replicate

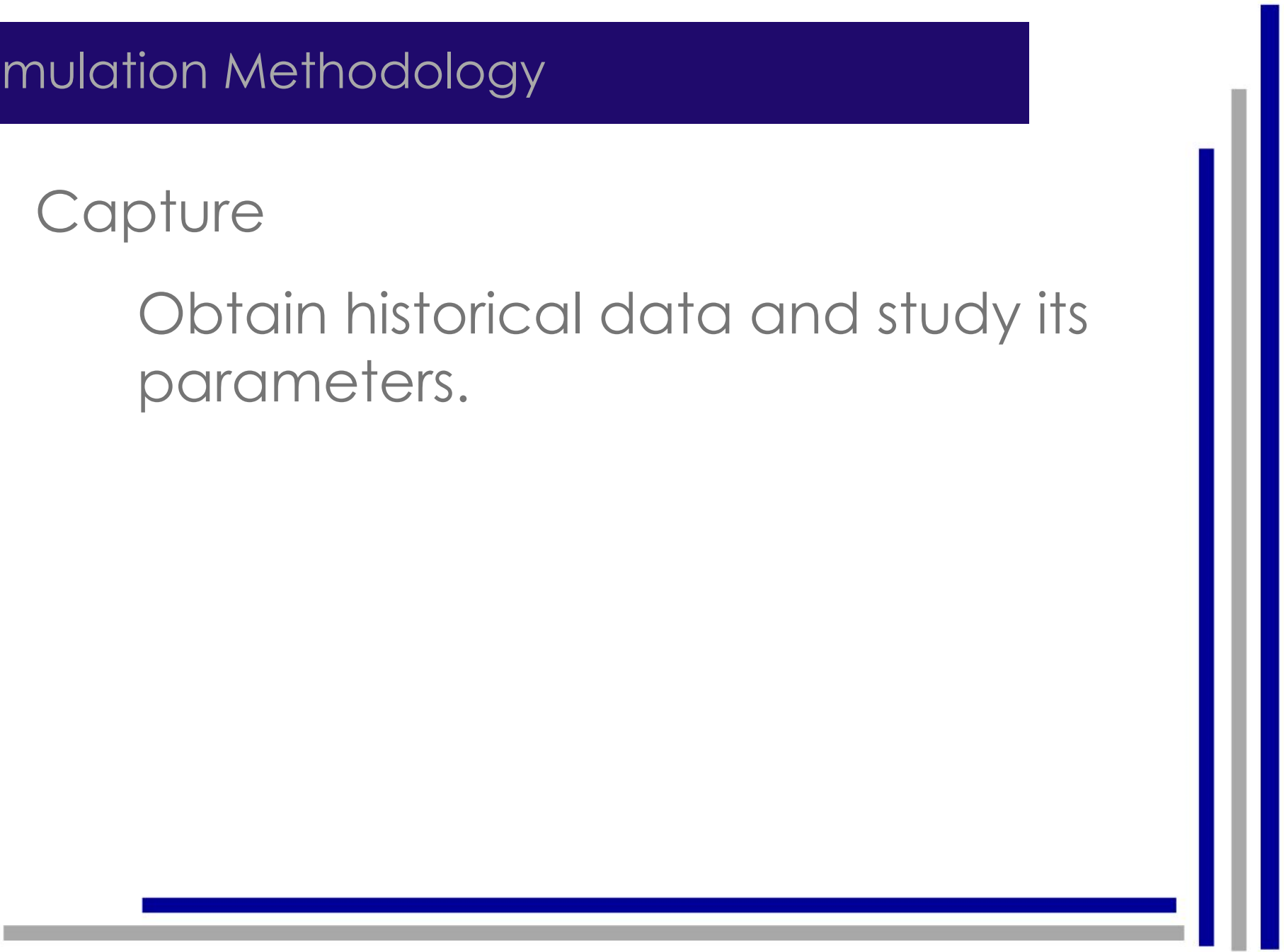
- Artificial History.

## Test and Evaluate

- Output Analysis. Statistical Tests of Hypotheses.

## Capture

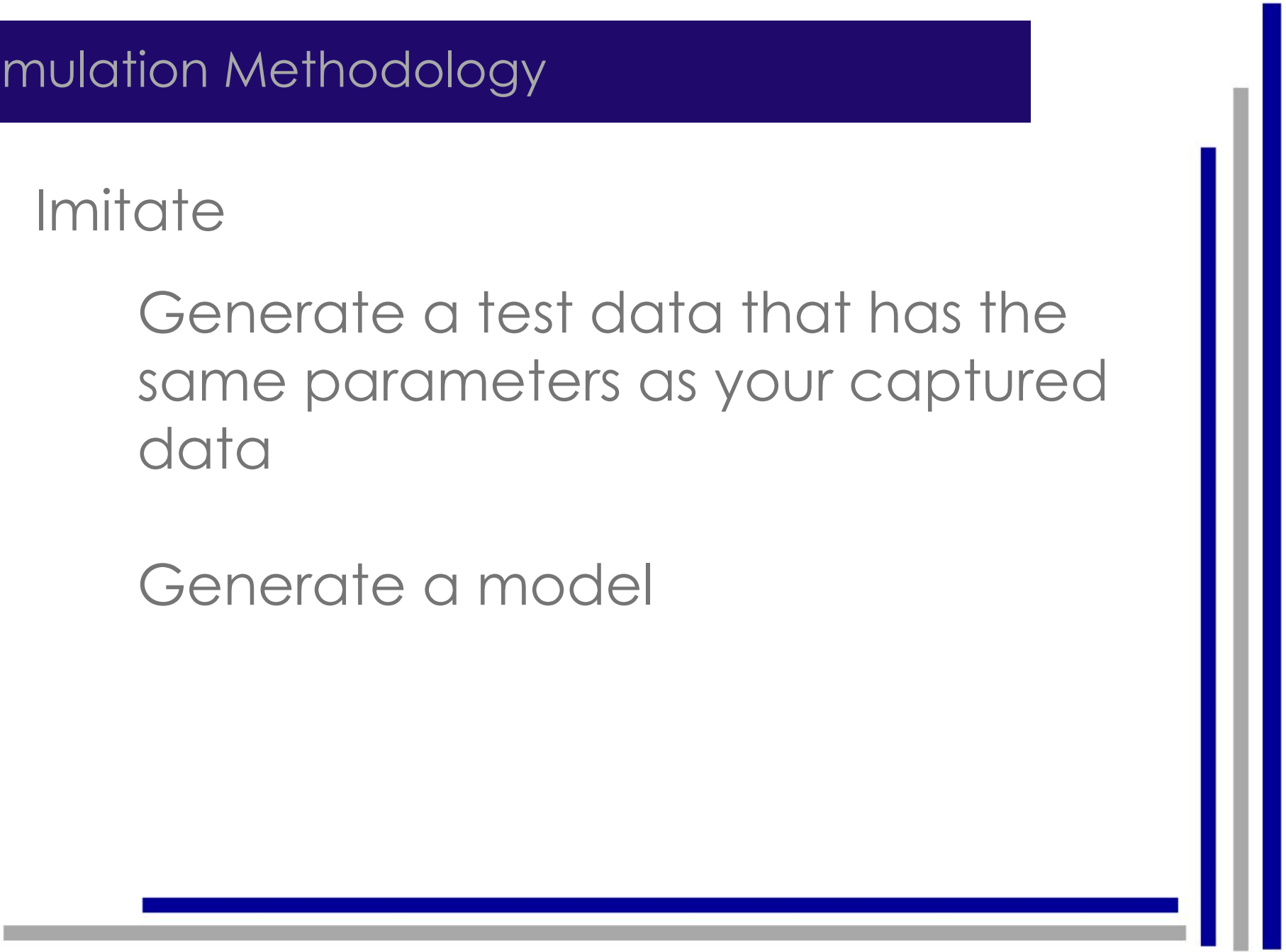
Obtain historical data and study its parameters.



Imitate

Generate a test data that has the same parameters as your captured data

Generate a model



## Run and Replicate

Run your model.

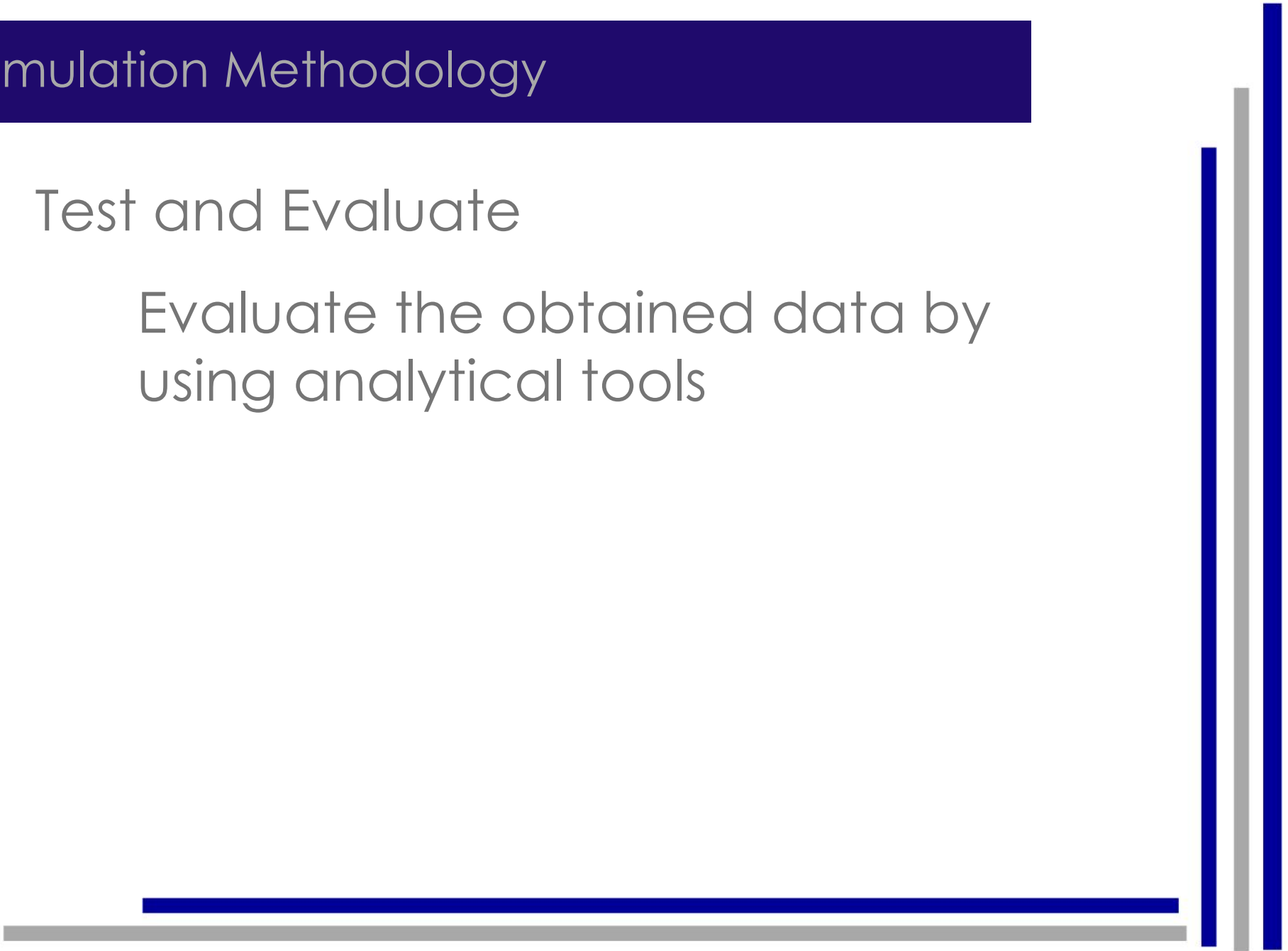
At this stage you may include proposed changes and study its results

Be sure that your model is already verified before you input changes

# Simulation Methodology

## Test and Evaluate

Evaluate the obtained data by using analytical tools



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## What is a system?

Group of interrelated processes or tasks that work together to achieve a common purpose

A system must have a defined boundary.  
Any element outside that boundary is the environment

A system may be affected by the environment



## Components of a System

Entity-object of interest in a system

Attribute-property of an entity

Activity-a time period, length of time

State-property of a system

Event-an instantaneous occurrence that changes the state of a system. (may be endogenous or exogenous)

# Systems Concept

## Model

Representation of a system created for the purpose of studying the system

### Static Model (Monte Carlo)

- represents a system at a certain point in time

### Dynamic Model

- represents a system as they change over time

## Model

Representation of a system created for the purpose of studying the system

### Deterministic

- models that do not contain random numbers
- known set of input leads to known set of output

### Stochastic

- at least one random number as input
- random inputs lead to random outputs

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# Some Examples



ProModel



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# Workshop

Model a 6 sided die



# Workshop

Suppose you are a toy shop. A customer buys a number of toys ranging from 1-5, each equally probable. However there are cases when not all the orders are achieved due to stockout. You reorder a 15 toys every time there is 3 toys left in your stock.

What is your average stockout?  
Suggest a new reorder point scheme.