# MMA/MMAI 861
# ANALYTICAL DECISION MAKING

# Simulation

Classes Three and Four

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# Simulation Models

The earlier models we have studied create a mathematical abstraction to represent reality.

Simulation creates a virtual mirror of reality.

E.g. Modeling a new aircraft wing:

- A set of equations can describe analytically how the wing should perform: a mathematical model
- A balsa wood scale model can be tested in a wind tunnel to verify and test actual performance: a simulation model

# Simulation Models (continued...)

Simulation creates models with elements which correspond directly to elements in the real world.

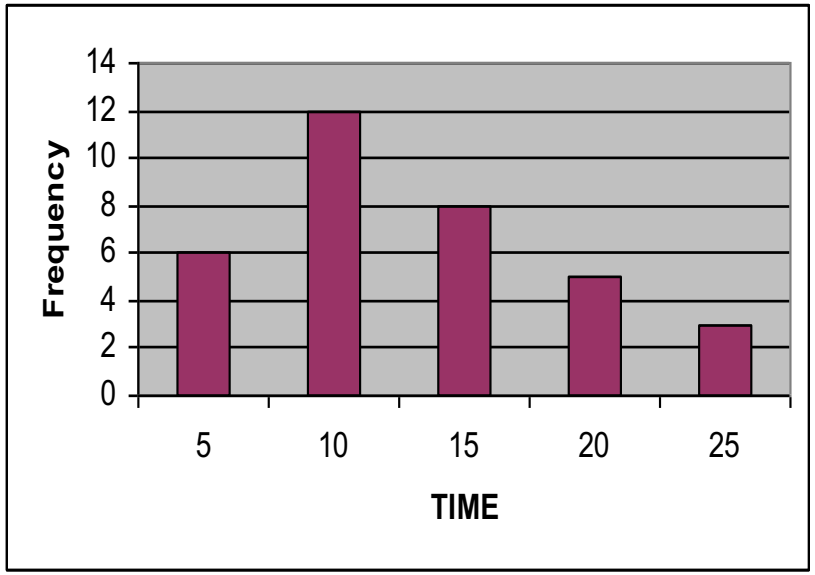
Creates a model which "looks like", or replicates, reality.

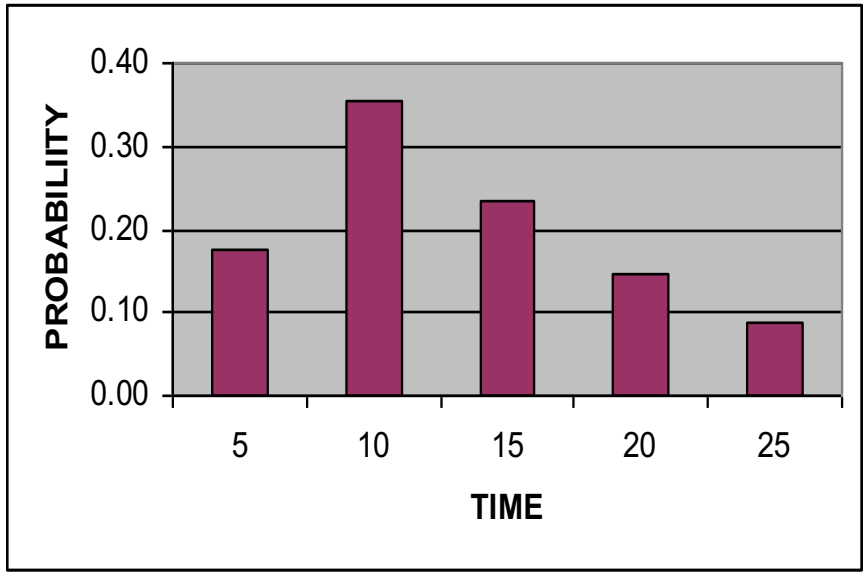
E.g. Suppose we are building a new factory, and want to explore how a machine shop area will function.

A ProModel version of a simulation.

# Simulation Models (continued...)

Simulation models need a way to replicate random events in the real world. We can do this by observing some event times and constructing a frequency distribution, and then expressing it as a probability distribution.



# Simulation Models (continued...)

Then we can replicate observations of the actual event by choosing randomly from this probability distribution.

Note that we won't replicate any specific set of observations, but over the long run the sequence of times we will generate from this distribution will "look like" observations of the actual process.

Aside: this means that simulation models cannot be verified by comparing model results with a small snapshot of real observations: the strength of simulation is its ability to randomize, which will not replicate any particular snapshot of data.

# Simulation Advantages

Advantages of simulation models:

- Models are simple and easy to follow
- Can model complicated dynamic processes beyond reach of other methods
- Versimilitude: one-to-one correspondence of model elements to real world: model is believable
- Time compression: can model years in a few hours
- Results are descriptive: statistics on process reveal randomness and possibility of extreme fluctuations

# Simulation Disadvantages

Disadvantages of simulation models:

- Time consuming to construct, verify, and analyze
- Ease of adding detail means over-complexity
- Little analytic insight, since models are "one-off" (although good for testing insight)
- Sensitivity analysis very difficult: strictly an experimental approach
- Danger of conclusions based on "small" samples – how many 'runs' are needed to draw valid conclusions?
- Extending results to real world needs faith

# Steps in Simulation Modeling

- Define the point of the simulation: allows for focus on required detail, and how complex
  - May describe current situation
  - Explore a hypothetical case
  - Design an improved system
- Formulate model: components, variables, parameters and relationships
  - Remember the Pareto Principle: the extent to which a problem is understood is inversely proportional to the number of variables required to describe it!
  - Tendency is for too much detail!

# Steps in Simulation Modeling (continued…)

- Parameter estimation: a typical hurdle, data is never completely adequate or reliable – often use a reasonable theoretical distribution versus extensive data collection; with sensitivity
- Programming: spreadsheet? Special purpose language? General purpose language?
- Validation: does simulation "behave" properly?
  - Does model act as we expect (and want) it to?
  - Does model produce observations which we would see in practice?

# Simulation with @RISK: Basic Functions

- RISKSIMTABLE (*list*, *name*). Specifies a decision variable for which you want @RISK to try various different values.
- RISKOUTPUT (). Keeps statistical output information on some quantity *value* computed by the model.
- RISKBINOMIAL (*n*, *p*). Number of heads counted in *n* flips of a coin, with each flip having a chance *p* of being heads.

  Use: When each of a known number *n* of items has an independent chance *p* of having some property.
- RISKDISCRETE (*List1*, *List2*). Will produce each value in *List1* with probability equal to the corresponding element of *List2*.

  Use: Generating random values from a table giving values and probabilities. The two lists must have the same length. The values in *List2* should add up to 1. If not, @RISK scales them proportionally so they do.

# Simulation with @RISK: Basic Functions (continued…)

- RISKEXPON (*m*). The time between successive arrivals of customers at a service facility such as a store, telephone call center, etc. The average time between arrivals is 1/*m*.
- RISKNORMAL (*m*, *s*). The classic "bell curve" with mean value *m* and standard deviation *s*.

  Use: Random variables that are sums or averages of large numbers of other, independent random variables.
- RISKPOISSON (*m*). Number of customers arriving at a facility in a given span of time, when the average number is *m*.
- RISKUNIFORM (*m*, *M*). A random quantity equally likely to take a value the computer can represent between *m* and *M*, specifically any *x* with $m \leq x < M$.