# Experimentation / Exercise / Use

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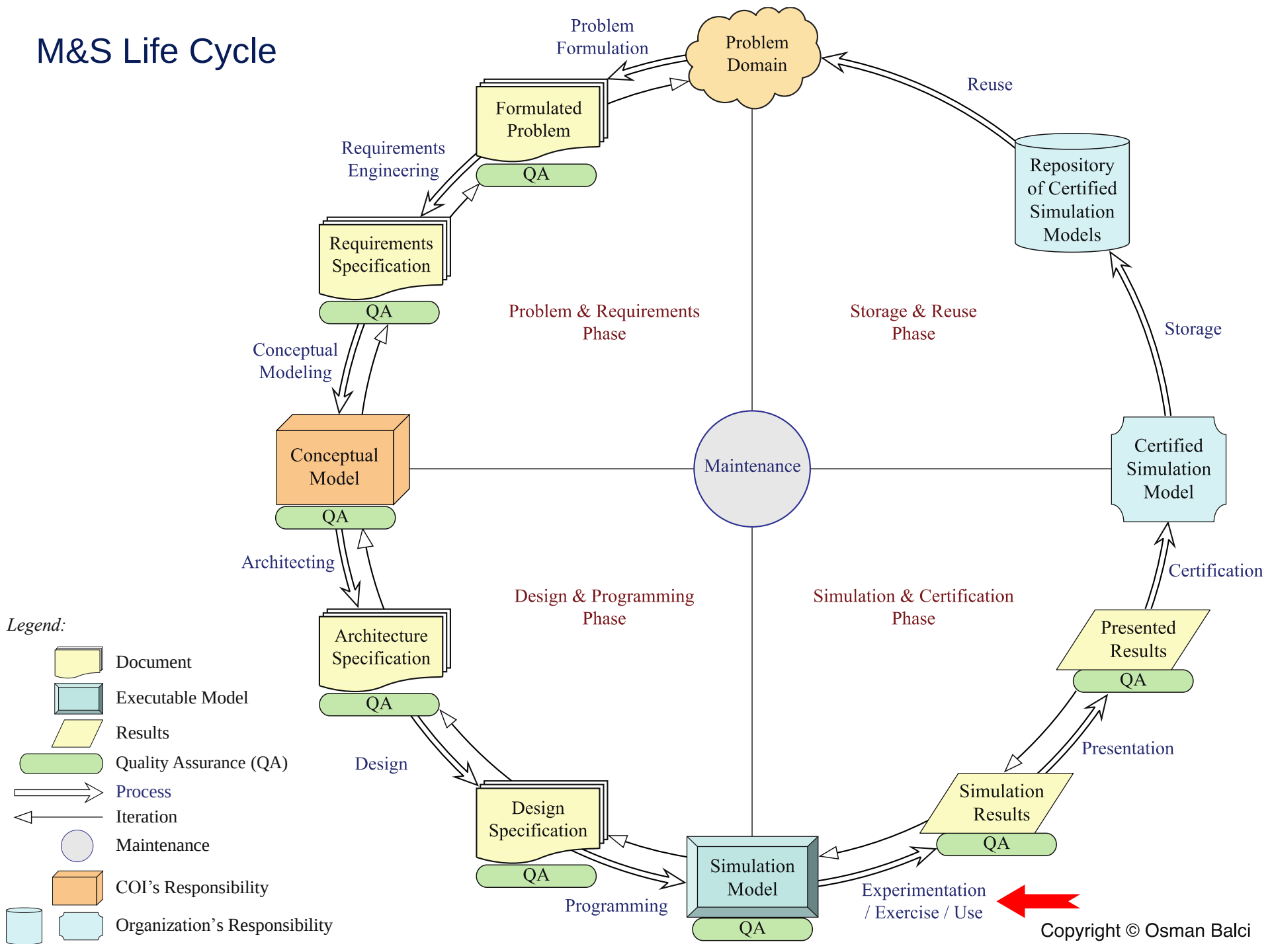
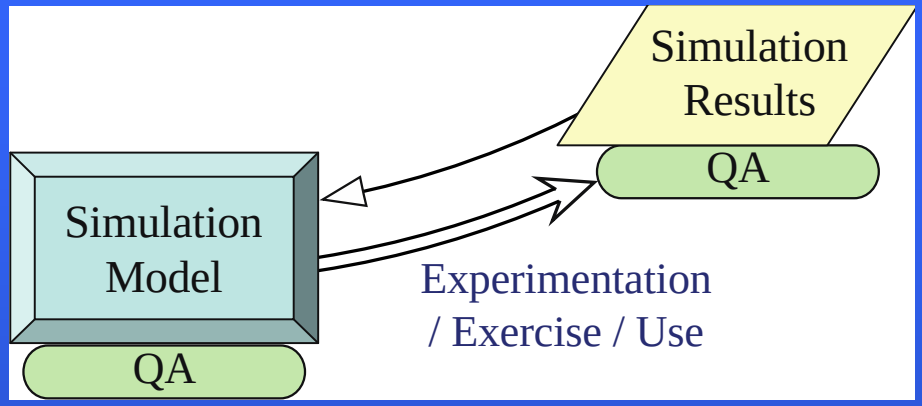
# M&S Life Cycle



# Experimentation / Exercise / Use



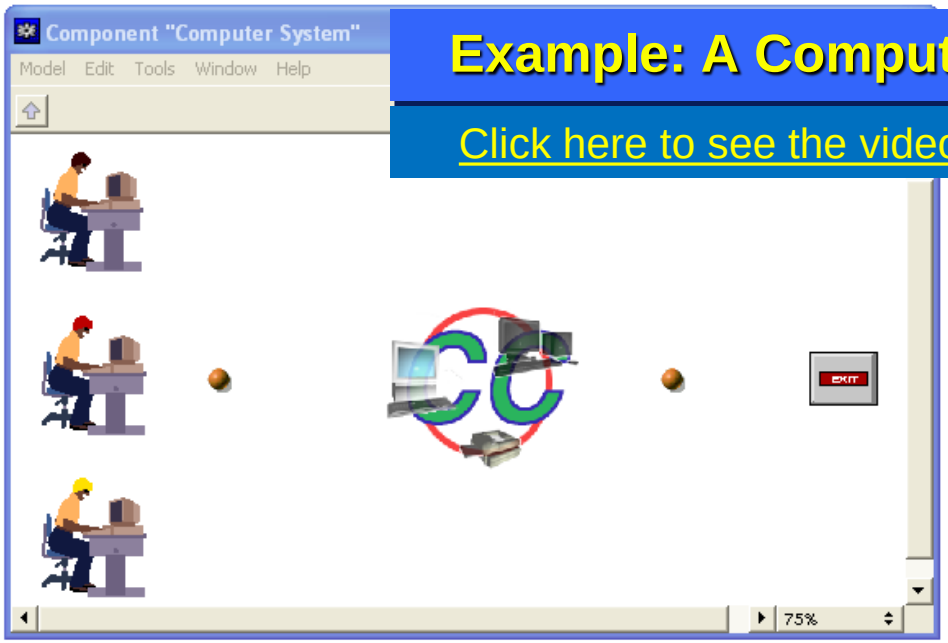

- **Experimentation / Exercise / Use** is the process in which the finished simulation model is
  - **experimented with** (for **problem solving**),
  - **exercised** (for **training** purposes), or
  - otherwise **used**.
- This process produces the simulation results based on the experimentation, exercise or use.
- The simulation results
  - make up the solution to the problem (for problem solving)
  - show effectiveness of training (for training purposes), or
  - indicate some benefit in using the simulation model (e.g., for research).

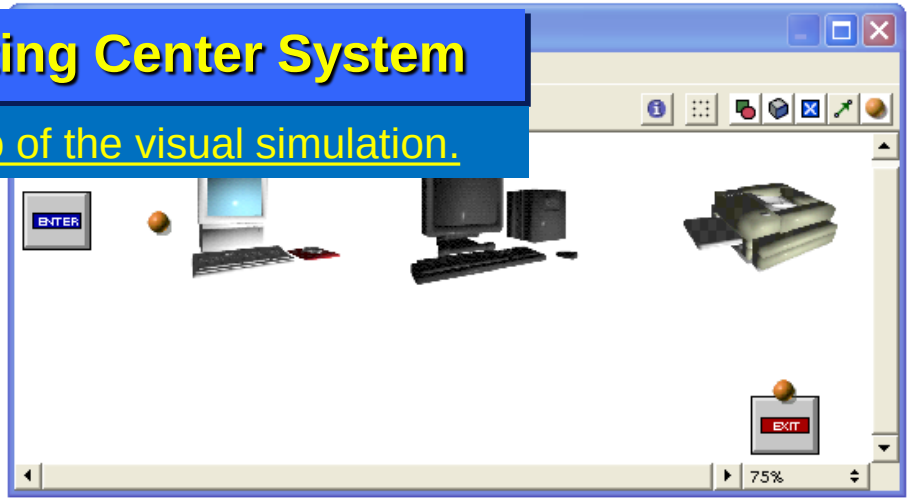
# Example Purposes of Experimentation

- **Evaluation:** e.g., Evaluation of the proposed system design for the purpose of assessing its quality characteristics such as operational effectiveness, integrated system effectiveness, deployment readiness, performance, interoperability, and security.
- **Comparison:** Comparing competitive systems designed to carry out a specified function, or comparing several proposed operating policies or procedures.
- **Prediction:** Forecasting the behavior of a system under some projected set of conditions.
- **Sensitivity Analysis:** Determining which of many factors are the most significant in affecting overall system behavior.
- **Optimization:** Determining exactly which combination of factor levels will produce the optimal overall behavior of the system.
- **Ranking and Selection:** Ranking *N* number of alternatives (e.g., operating policies) and selecting the best one.

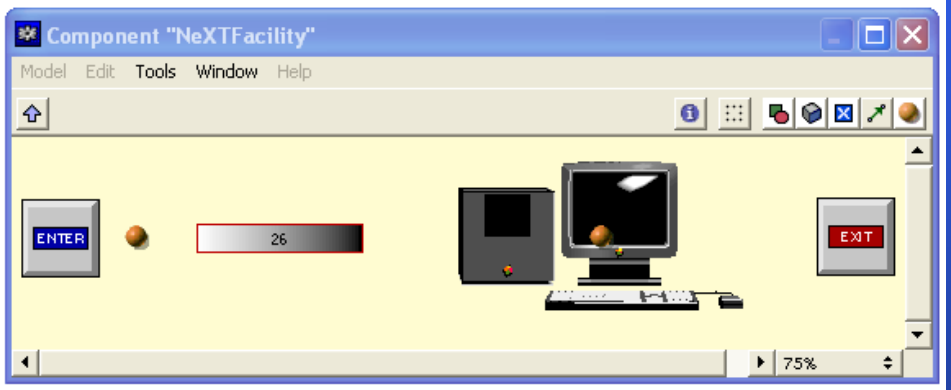
# Example: A Computing Center System

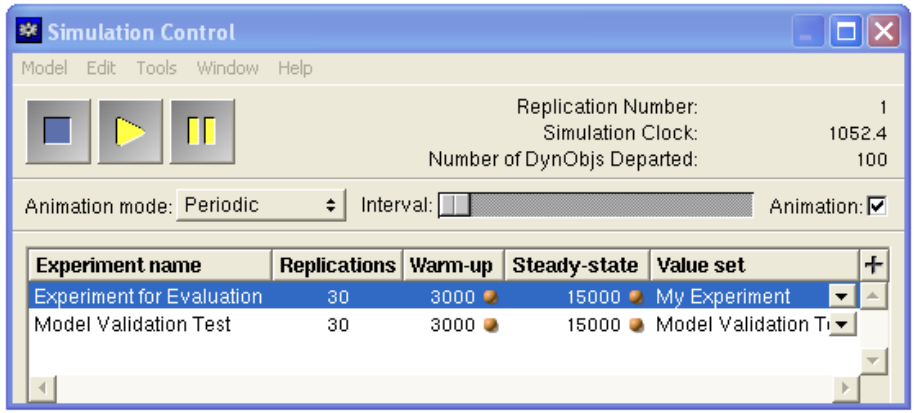
Click here to see the video of the visual simulation.

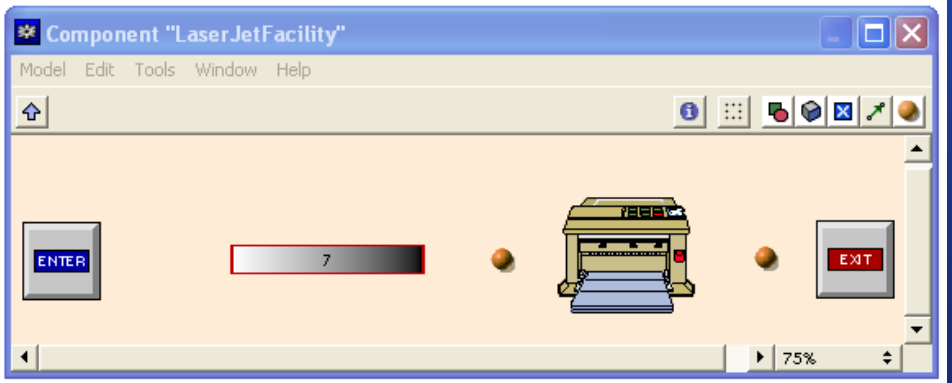






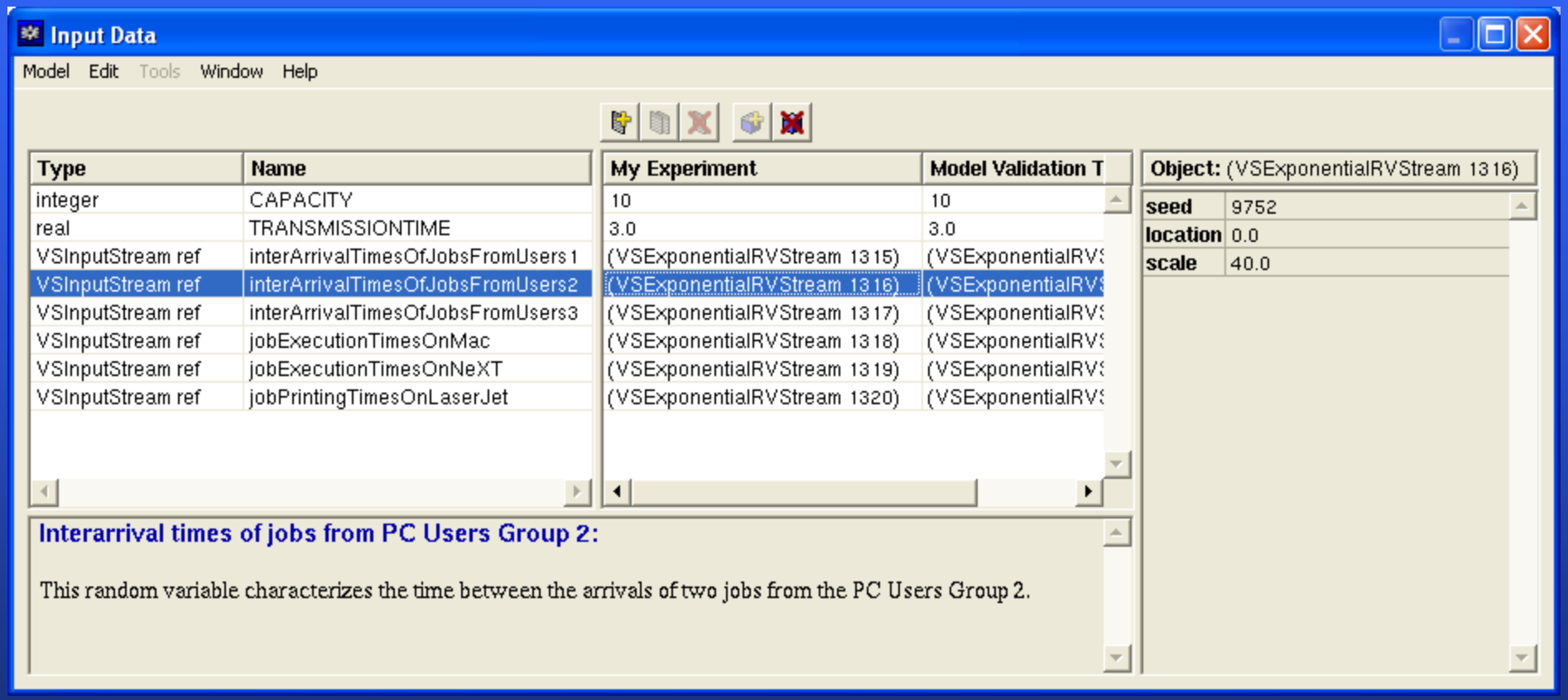



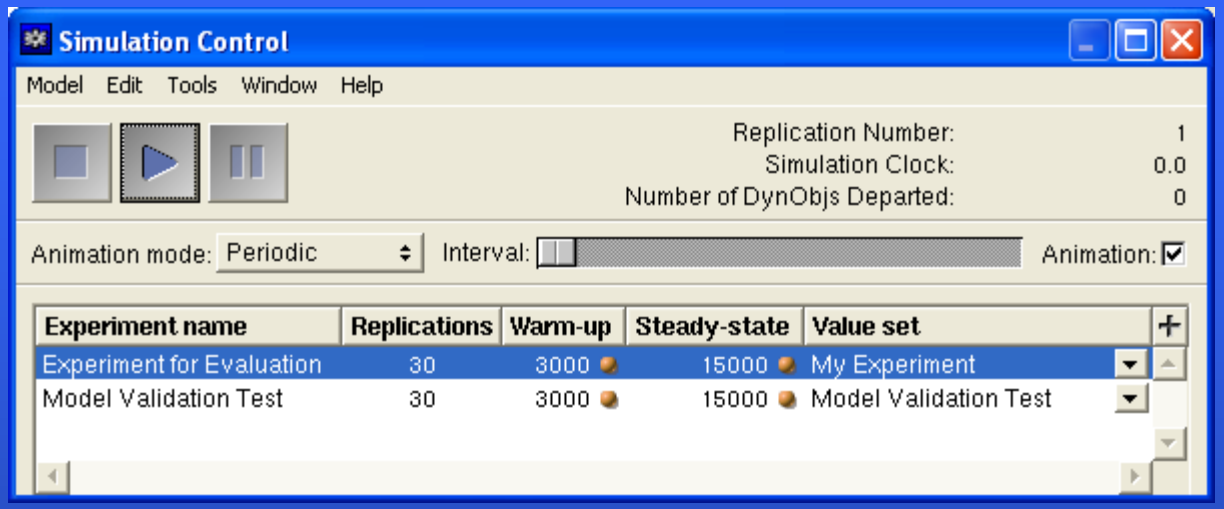
# Problem to Solve

- Estimate the following performance measures:
  1. Average Number of Jobs in the Computing Center
  2. Average Waiting Time of Jobs in the Computing Center
  3. Average Number of Jobs in the LaserJet Facility
  4. Average Number of Jobs in the Macintosh Facility
  5. Average Number of Jobs in the NeXT Facility
  6. Average Number of Jobs in the LaserJet Waiting Line
  7. Average Number of Jobs in the Macintosh Waiting Line
  8. Average Number of Jobs in the NeXT Waiting Line
  9. Utilization of the LaserJet Printer
  10. Utilization of the Macintosh Computer
  11. Utilization of the NeXT Computer
  12. Average Waiting Time of Jobs in the LaserJet Facility
  13. Average Waiting Time of Jobs in the Macintosh Facility
  14. Average Waiting Time of Jobs in the NeXT Facility
  15. Average Waiting Time of Jobs in the LaserJet Waiting Line
  16. Average Waiting Time of Jobs in the Macintosh Waiting Line
  17. Average Waiting Time of Jobs in the NeXT Waiting Line

# Input Variables and Parameters

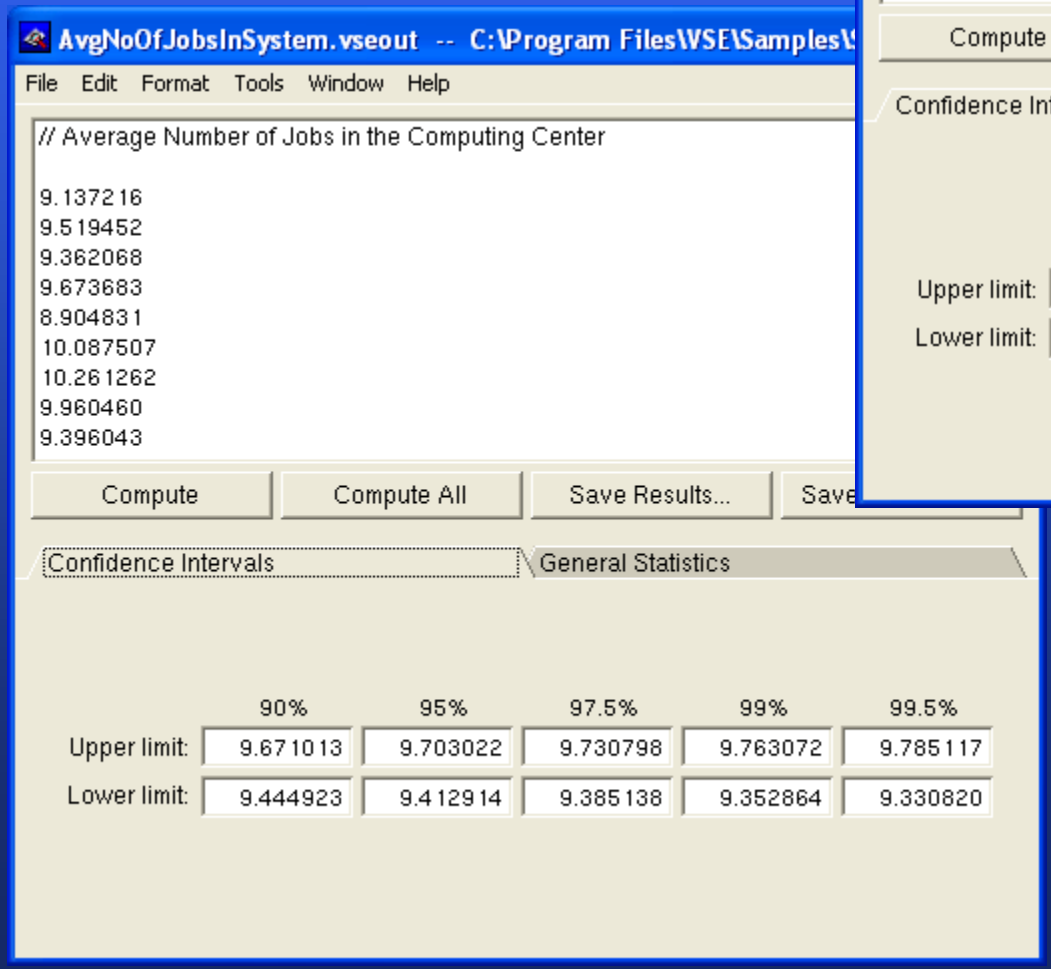


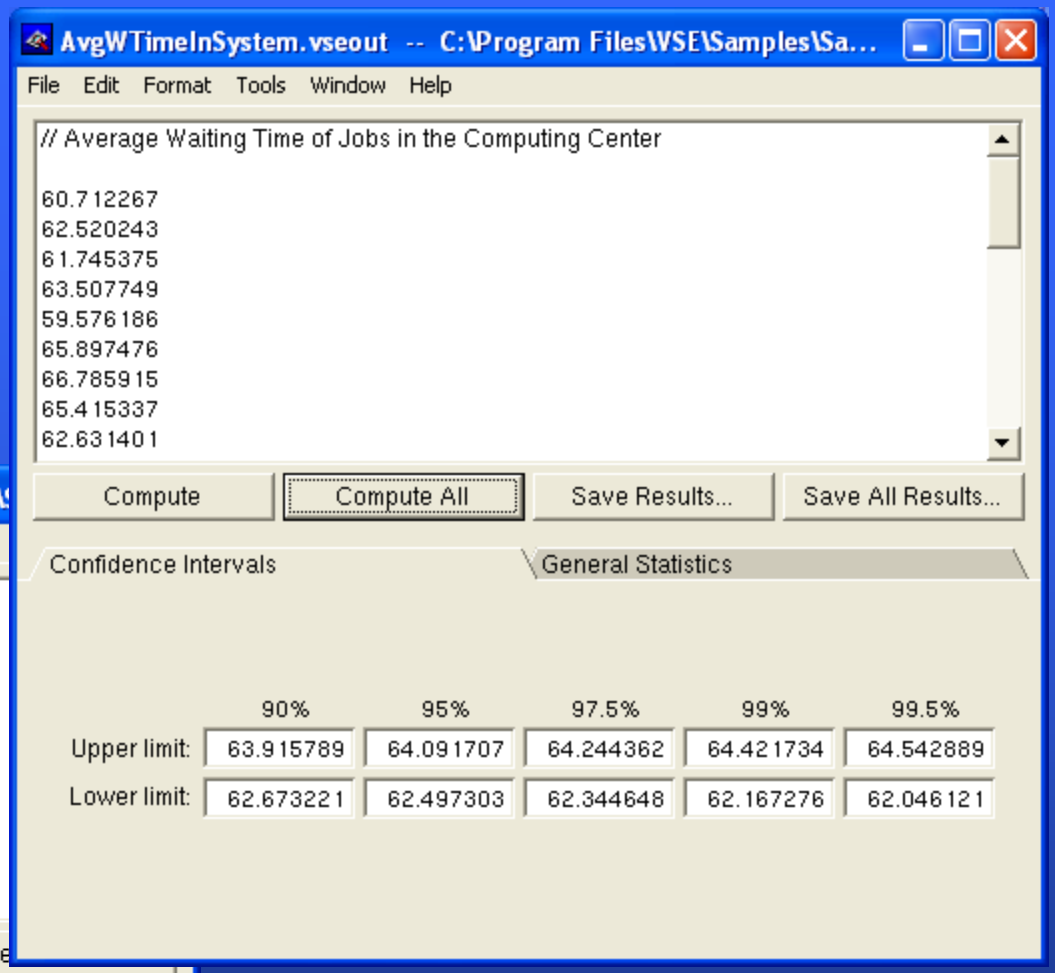
# Experiment Design




- **Method of Replications is used for experimenting with the model.**
- **30 simulation runs (replications) are performed.**
- **Each replication consists of**
  - **3,000 jobs leaving the computer system to warm up the model; and**
  - **15,000 jobs leaving the computer system to collect data in steady state for constructing confidence intervals for the performance measures to be estimated.**

# Experimentation Results



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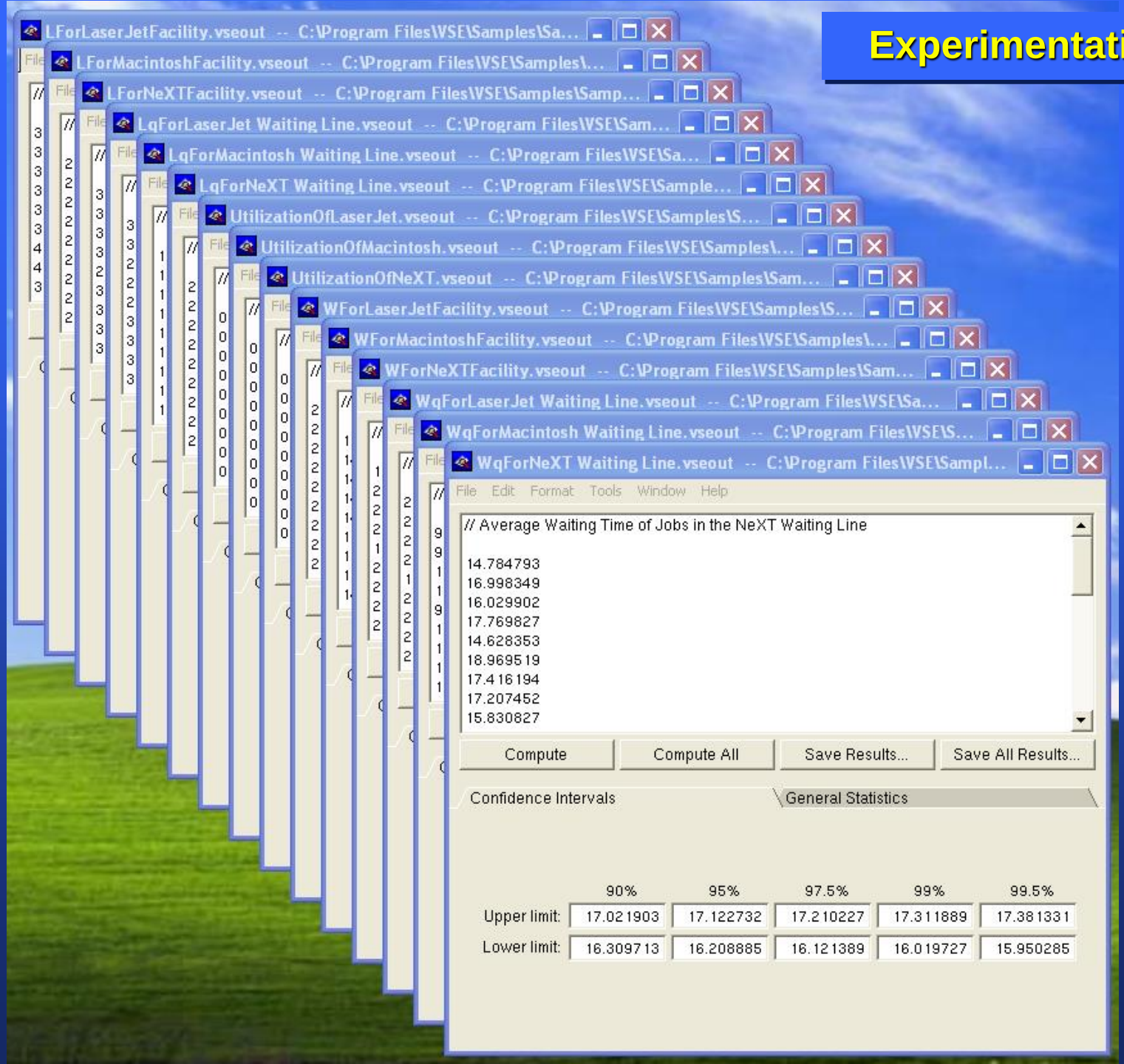

# Design of Experiments

- **Design of Experiments** (for problem solving/analysis) is the process of formulating a plan to gather the desired information at minimal cost and to enable the analyst to draw valid inferences.

- Some of the techniques used for the design of experiments:
  - **Response-surface methodologies** can be used to find the optimal combination of parameter values which maximize or minimize the value of a response variable.
  - **Factorial designs** can be employed to determine the effect of various input variables on a response variable.
  - **Variance reduction techniques** can be implemented to obtain greater statistical accuracy for the same amount of simulation.
  - **Ranking and selection techniques** can be utilized for comparing alternative systems.
  - **Method of replications**, **method of batch means**, **regenerative method**, and others can be used for statistical analysis of simulation output data.

# Example Indicators for Assessing Experimental Design

- Are the algorithms used for random variate generation theoretically accurate?
- Are the random variate generation algorithms translated into executable code accurately?
- How well is the random number generator tested?
- Are appropriate statistical techniques implemented to design and analyze the simulation experiments?
- How well are the underlying assumptions satisfied?
- Is the problem of the initial transient (or the start-up problem) appropriately addressed?
- For comparison studies, are identical experimental conditions replicated correctly for each of the alternative operating policies compared?